

Living on the Edge: Climate Change, Livelihoods and Adaptation Among Visakhapatnam's Small-Scale Fishermen

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ABSTRACT

The study examines the small-scale fishermen in Jodugallapalem, a coastal village in Visakhapatnam, India, about their perspectives and responses to climate change. The data from multi-generational fishing families were collected through primary interviews to analyse the understanding of fishermen about environmental changes and their impacts on livelihood, and adaptation strategies. The fishermen perceived significant climate-related changes including altered cyclone patterns, a rise in sea level, declining catches, and shifts in fish populations. These observations made by fishermen from place-based knowledge systems align with scientific observations. Occupational diversification, technological adoption, and migration patterns are few visible adaptation strategies. The need for integrating indigenous ecological knowledge with scientific approaches in developing climate adaptation policies is significantly highlighted in the findings. The immediate livelihood challenges and long-term sustainability concerns need to be addressed through contextually appropriate interventions to build climate resilience in vulnerable coastal communities.

Keywords: climate change adaptation, small-scale fisheries, indigenous ecological knowledge, coastal communities

Journal of Economic Literature (JEL) Classification Number: Q22, Q54, Q56

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1. INTRODUCTION

Impacts on marine ecosystems, weather patterns, and coastal landscapes due to climate change pose significant challenges to coastal communities worldwide, especially the scale fisheries making them particularly vulnerable sections of the society (Daw et al., 2009; Badjeck et al., 2010). Approximately 3.9 million people depend on fisheries for their livelihoods in India (Ministry of Agriculture, 2010), multiple non-climate stressors and climate change threatens already marginalized coastal populations.

While climate science provides evidence of environmental changes occurring in marine systems, understanding local perceptions and experiences of these changes is crucial for developing effective adaptation strategies (Eriksen et al., 2011; Orlove, 2022). Indigenous ecological knowledge offers valuable insights into local climate impacts and potential adaptation pathways that complement scientific assessment (Anik & Khan, 2012; Leonard et al., 2013).

This study examines the lived experiences and adaptation strategies of small-scale fishermen in Jodugullapalem, a fishing village in Visakhapatnam on India's eastern coast. Using a socio-ecological framework, we explore how fishermen perceive environmental changes, their impacts on livelihoods, and responses to these challenges. By analyzing local knowledge and adaptation practices, we contribute to understanding how vulnerable coastal communities experience and respond to climate change.

The objectives of this study are to:

1. Document local perceptions of climate change impacts in a coastal fishing community
2. Analyze adaptation strategies employed by fishermen facing environmental changes
3. Examine barriers and enablers to adaptation in the context of multiple stressors
4. Explore implications for developing contextually appropriate adaptation policies

2. CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

This study is situated within a socio-ecological resilience framework that conceptualizes adaptation as dynamic adjustments in human-environment systems in response to actual or expected climate stimuli or their effects (Smit et al., 2000). Following Adger et al. (2007), we understand adaptation as actions that reduce vulnerability or enhance resilience of social-ecological systems to climatic variability and change.

Literature on climate change adaptation has increasingly recognized the importance of local knowledge systems in understanding climate impacts and identifying appropriate responses (Green & Raygorodetsky, 2010; Lebel, 2013). Indigenous ecological knowledge provides insights into local environmental changes that may not be captured by conventional scientific monitoring (Huntington, 2000; Thornton & Scheer, 2012).

Studies of coastal fishing communities have identified various adaptation strategies employed in response to climate variability, including livelihood diversification, mobility, technological changes, and social networking (Coulthard, 2008; Cinner et al., 2018). However, adaptation capacity is not evenly distributed, with social, economic, and political factors creating differential vulnerability within communities (Adger et al., 2009; Jones & Boyd, 2011).

The distinction between autonomous adaptations undertaken by individuals and planned interventions implemented by governments and institutions has been highlighted through adaptation research (Noble

et al., 2014). The relevance is clearly visible in developing contexts where informal sectors implement adaptation measures with limited state support (Singh et al., 2018).

Recognizing that climate change interacts with multiple non-climate stressors created a need to examine adaptation within broader development contexts (Lemos et al., 2007; Ayers & Dodman, 2010). This initiates transformative approach to adaptation that address underlying vulnerabilities rather than simply responding to climate impacts (Pelling et al., 2015; O'Brien, 2012).

3. RESEARCH METHODOLOGY



3.1 STUDY AREA

Jodugullapalem is a small fishing area located close to the sea in Visakhapatnam, Andhra Pradesh. A community of fishermen in the village has experienced many changes to the environment and the economy over the years. There are constant cyclonic events in the location and it is at risk of rising waters and erosion along the coast.

3.2 DATA COLLECTION

The researchers conducted in-depth interviews with fishermen from Jodugullapalem for this study. Two interviews with semi-structure were set up and held with Perla Jaganadham (55 years old) and M. Appa Rao (65 years old), who both come from third-generation fishing families. The interviews explored perceptions of environmental changes, impacts on fishing activities and livelihoods, and adaptation strategies.

The interview guide included questions about:

- Length of residence and fishing experience
- Observed changes in climate, ocean, and coastal conditions
- Impacts on fishing activities, catch volume, and species composition
- Economic consequences and livelihood adaptations
- Generational perspectives on fishing as a profession

Interviews were conducted in the local language, recorded with permission, and later transcribed and translated for analysis.

Table 1: Demographic and Professional Information of Study Participants

Characteristic	Perla Jaganadham	M. Appa Rao
Age	55 years	65 years
Fishing Experience	Since childhood (40+ years)	Since childhood (50+ years)
Generational Status	Third generation	Third generation
Origin	Originally from Gangavaram	Multi-generational resident
Years in Jodugullapalem	More than 35 years	Since birth
Primary Fishing Method	Small boats, inshore fishing	Traditional and mechanized boats
Household Structure	Multiple income sources including fishing	Multiple income sources including fishing

3.3 DATA ANALYSIS

Interview transcripts were analyzed using thematic analysis (Braun & Clarke, 2006), combining inductive and deductive approaches (Fereday & Muir-Cochrane, 2006). Initial coding identified key themes related to environmental changes, livelihood impacts, and adaptation strategies. These were then organized into broader analytical categories aligned with the conceptual framework.

The analysis focused on:

1. Perceptions of environmental changes and attribution to climate change
2. Impacts on fishing practices and livelihoods
3. Adaptation strategies at individual, household, and community levels
4. Intergenerational perspectives on fishing as a sustainable livelihood

Following Chaudhary & Bawa (2011), local perceptions were compared with available scientific information on regional climate trends to identify convergences and divergences between scientific and indigenous knowledge.

4. RESULTS AND DISCUSSION

4.1 LOCAL PERCEPTIONS OF ENVIRONMENTAL CHANGES

Key Findings: Climate Change and Coastal Livelihoods in Visakhapatnam				
Based on interviews with fishermen from Jodugullapalem fishing village				
Perceptions	Livelihood Impacts	Adaptation	Barriers	Policy
Key Perceptions of Climate Change				
Cyclone Patterns "The cyclones in the past are bigger when compared to the present" (Jaganadham) "Now the cyclones are less but the fatality is more including the damage" (Appa Rao)				
				<i>Changing frequency and intensity</i>
Sea Level Rise "Water levels have actually raised when compared to the past. Here we cannot even see the beach after few years" (Jaganadham) "The ocean has come forward" (Appa Rao)				
				<i>Ocean advancement observed</i>
Fish Stocks "Back then we used to get pulasa, katikamenu, puli kanasa, otti para... all those fishes are gone with that generation" (Jaganadham)				
				<i>Species disappearance</i>
Fish Distribution "Now we need to go deep to get the fish. We are going more than 40-50 bars to get the fishes" (Jaganadham) "Back then fishes used to come to the shore" (Appa Rao)				
				<i>Need to travel further</i>
Coastal Changes "One day will come where we will park our boats on road" (Appa Rao)				
				<i>Beach loss and space constraints</i>
Source: Interviews with Perla Jaganadham (FS) and M. Appa Rao (FS), third-generation fishermen from Jodugullapalem				

4.1.1 CYCLONE PATTERNS AND WEATHER EVENTS

Both interviewees reported significant changes in cyclone patterns over their lifetimes. Jaganadham noted that cyclones have become more frequent but less severe compared to historical events: "the cyclones in the past are bigger when compared to the present" (Jaganadham, interview). He specifically recalled a devastating cyclone in 1996 that sank approximately 40 boats. Similarly, Appa Rao observed that "now the cyclones are less but the fatality is more including the damage is more for the boats is very severe" (Appa Rao, interview).

These perceptions align with scientific observations of changing cyclone patterns in the Bay of Bengal, where studies indicate shifts in cyclone frequency and intensity in recent decades (Cruz et al., 2007). Local observations provide temporal depth that complements instrumental records, illustrating how indigenous knowledge can contribute to understanding long-term environmental change (Byg & Salick, 2009).

4.1.2 SEA LEVEL RISE AND COASTAL CHANGES

Both fishermen described sea level rise and coastal erosion affecting their village. Jaganadham stated that "water levels have actually raised when compared to the past. Here we cannot even see the beach after few years" (Jaganadham, interview). Appa Rao similarly noted that "the ocean has come forward" and attributed this partly to coastal development: "When the fishing harbour started filling that place ocean started moving forward. Before the set up of fishing harbour the ocean used to be very far from this place" (Appa Rao, interview).

These observations correspond with scientific assessments of sea level rise in the Bay of Bengal (Bindoff et al., 2019) but also highlight local perceptions of anthropogenic factors exacerbating natural processes. The fishermen's accounts demonstrate how local communities often understand environmental changes as resulting from multiple interacting factors rather than climate change alone (Morchain, 2018).

4.1.3 CHANGES IN FISH STOCKS AND DISTRIBUTION

Both interviewees reported significant changes in fish availability, species composition, and distribution. Jaganadham noted that "now we need to go deep to get the fish. We are going more than 40-50 bars to get the fishes" (Jaganadham, interview). He also observed the disappearance of traditional species: "Back then we used to get pulasa, katikamenu, puli kanasa, otti para we used to even get large sorra now a days we don't even see them... all those fishes are gone with that generation" (Jaganadham, interview).

Appa Rao similarly reported that "back then fishes used to come to the shore. We used to pick the fishes just by standing at the shores, especially during the cyclones time" (Appa Rao, interview). These observations align with scientific projections of fish redistribution in response to ocean warming (Cheung et al., 2010; Doney et al., 2012), demonstrating how local ecological knowledge can provide fine-grained observations of species shifts that may not be captured in scientific monitoring (Gianelli et al., 2021).

Table 2: Summary of Observed Environmental Changes and Their Impacts

Environmental Change	Observed Characteristics	Impacts on Fishing Activities	Impacts on Livelihoods
Cyclone Patterns	Less severe than past but more frequent; better forecasting	Improved safety due to advance warnings; still causes disruption	Temporary loss of fishing days; boat damage costs
Sea Level Rise	Ocean "coming forward"; beach disappearing	Reduced space for boat parking; forced relocation during storms	Increased vulnerability; spatial displacement
Fish Distribution	Fish no longer come to shore; need to go deeper (40-50 bars)	Increased travel distance; higher fuel costs (₹2000 per trip)	Higher operational costs; reduced profit margins
Species Composition	Traditional species disappeared (pulasa, katikamenu, sorra, etc.); new species emerged	Changed fishing techniques required; uncertain knowledge of new species	Loss of traditional knowledge; market adaptation needed
Fish Abundance	Overall reduction in catch volume	Longer fishing trips for smaller catches	Reduced income despite higher fish prices
Coastal Development	Fishing harbor development; tourism infrastructure	Further reduced space for traditional fishing	Concerns about future displacement

4.2 IMPACTS ON LIVELIHOODS AND WELL-BEING

Key Findings: Climate Change and Coastal Livelihoods in Visakhapatnam				
Based on interviews with fishermen from Jodugullapalem fishing village				
Perceptions	Livelihood Impacts	Adaptation	Barriers	Policy
Livelihood Impacts				
Economic Challenges				<i>Income and operational costs</i>
"Back then fishes used to be cheap people do not use to buy much. Now the rates are high but spending have also gone up" (Jaganadham)				
"To reach that place we are burning the fuel of 2000 Rs" (Jaganadham)				
"There is no income, it has declined tremendously. Our investments have increased multiple times" (Appa Rao)				
Housing Insecurity				<i>Rent burden and displacement</i>
"Here we don't have our own house we are staying on rent... We need to pay 5000 rs as rent per month we should also raise our children" (Jaganadham)				
Intergenerational Changes				<i>Shift away from fishing</i>
"I don't think the next generation is going to pick up this profession... My son is in Centering (construction) work the other one works in plumbing work" (Jaganadham)				
"The youngsters go for the concrete works... they are preferring concrete works... in few years I cannot see fisherman in this place" (Appa Rao)				
Cultural Loss				<i>Traditional knowledge at risk</i>
As younger generations shift away from fishing, valuable indigenous ecological knowledge about weather patterns, fish behavior, and navigation techniques may be lost.				
Source: Interviews with Perla Jaganadham (55) and M. Appa Rao (65), third-generation fishermen from Jodugullapalem				

4.2.1 ECONOMIC IMPACTS AND CHANGING INCOME PATTERNS

Both fishermen described fundamental changes in their economic situation due to environmental changes and market factors. Jaganadham explained the complex economic dynamics: "back then fishes used to be cheap people do not use to buy much. Now the rates are high but spending have also gone up" (Jaganadham, interview). He noted increased operational costs: "To reach that place we are burning the fuel of 2000 Rs" (Jaganadham, interview).

Appa Rao made it clear that the income is gone and has declined to almost nothing. Mr. Appa Rao commented that our investments have a much bigger value than before (Appa Rao, interview). According to the fishermen, they are earning less income, despite rising fish prices since there are fewer fish and things have become more expensive. This aligns with studies showing how climate impacts can negatively affect fishing livelihoods despite rising market values (McClanahan et al., 2015).

4.2.2 HOUSING SECURITY AND DISPLACEMENT CONCERNS

Jaganadham highlighted housing insecurity as a significant concern: "here we don't have our own house we are staying on rent... We need to pay 5000 rupees as rent per month we should also raise our children" (Jaganadham, interview). Climate-induced migration in coastal areas due to the combination of economic pressures, rise in sea level, and coastal erosion creates conditions for potential displacement. (McLeman & Hunter, 2010).

4.2.3 INTERGENERATIONAL IMPLICATIONS AND CULTURAL LOSS

Both fishermen expressed doubt about fishing's future as a viable livelihood for younger generations. Jaganadham stated: "I don't think the next generation is going to pick up this profession... My son is in

Centering (construction) work the other one works in plumbing work" (Jaganadham, interview). Appa Rao similarly observed that "the youngsters go for the concrete works... they are preferring concrete works" and predicted that "in few years I cannot see fisherman in this place" (Appa Rao, interview).

These observations highlight how climate impacts can contribute to cultural losses when traditional livelihoods become unviable, leading to the erosion of indigenous knowledge systems (Adger et al., 2009). The potential loss of fishing knowledge represents not just an economic transition but a cultural transformation with implications for community identity and resilience (Wolf et al., 2013).

4.3 ADAPTATION STRATEGIES AND RESPONSES

Key Findings: Climate Change and Coastal Livelihoods in Visakhapatnam				
Based on interviews with fishermen from Jodugullapalem fishing village				
Perceptions	Livelihood Impacts	Adaptation	Barriers	Policy
Adaptation Strategies				
Technological Adaptations		Improved equipment and tools		
"Today we are getting information 10 days before the cyclone is arriving... We are having a compass like device which is providing us all weather-related information" (Jaganadham)				
"We have some mechanised boats they go deep into the sea. We can stay upto 12 hrs in sea using these mechanised boats" (Appa Rao)				
Livelihood Diversification		Alternative income sources		
"[Women] go for work as house maids and contributing to the income of the family" (Jaganadham)				
"During season we started to join the fishing boats... These boats go from here to Paradip and Kolkata" (Jaganadham)				
"Out of all the people in village only 10-20 people go for fishing rest all go for construction work" (Appa Rao)				
Indigenous Knowledge		Environmental monitoring		
"We used to use the tides and waves pattern to actually identify the shore. These waves actually come from very long they can guide our boats to find the shore" (Jaganadham)				
"We understand the weather very well just by looking at the sea and wind pattern we can sense how the weather is going to be" (Appa Rao)				
Spatial Adaptations		Changing fishing locations		
"Now we need to go deep to get the fish" (Jaganadham)				
"During extreme weather we don't even have place to keep our boats so we move towards sagarnagar since there is more place left" (Appa Rao)				
Source: Interviews with Perla Jaganadham (55) and M. Appa Rao (65), third-generation fishermen from Jodugullapalem				

4.3.1 TECHNOLOGICAL ADAPTATIONS

Both fishermen described technological adaptations to changing conditions. Jaganadham highlighted how communication technology has improved safety during cyclones: "today we are getting information 10 days before the cyclone is arriving. So, we are parking our boats much in advance. We are having a compass like device which is providing us all weather-related information" (Jaganadham, interview).

Appa Rao mentioned shifts in fishing equipment: "We have some mechanised boats they go deep into the sea. We can stay upto 12 hrs in sea using these mechanised boats" (Appa Rao, interview). These technological adaptations reflect how local communities actively respond to environmental changes rather than remaining passive victims (Berkhout, 2012).

4.3.2 LIVELIHOOD DIVERSIFICATION

Both interviews revealed significant livelihood diversification within fishing households. Jaganadham described how women in the community "go for work as house maids and contributing to the income of the family" (Jaganadham, interview). He also mentioned temporary migration for work on larger

commercial fishing vessels: "During season we started to join the fishing boats we used to get 10,000 to 15000 there for 15 days. These boats go from here to Paradip and Kolkata" (Jaganadham, interview).

Appa Rao noted that "out of all the people in village only 10-20 people go for fishing rest all go for construction work" (Appa Rao, interview). This diversification represents a common adaptation strategy in response to declining resource-based livelihoods (Ellis, 2000) but may also indicate transformation toward new livelihood systems when traditional practices become unsustainable (Pelling et al., 2015).

4.3.3 INDIGENOUS KNOWLEDGE AND ENVIRONMENTAL MONITORING

The interviews revealed sophisticated indigenous knowledge systems for environmental monitoring and prediction. When asked about predicting cyclones, Jaganadham explained traditional methods: "we used to use the tides and waves pattern to actually identify the shore. These waves actually come from very long they can guide our boats to find the shore" (Jaganadham, interview). Appa Rao similarly stated: "we understand the weather very well just by looking at the sea and wind pattern we can sense how the weather is going to be" (Appa Rao, interview).

These knowledge systems represent valuable adaptive capacity that could be integrated with scientific monitoring to improve climate resilience (Thornton & Scheer, 2012). However, with declining participation in fishing among younger generations, this indigenous knowledge faces the risk of being lost (Cruikshank, 2001; Green & Raygorodetsky, 2010).

4.3.4 SPATIAL ADAPTATIONS

Both fishermen described spatial adaptations in response to changing environmental conditions. Jaganadham noted that declining near-shore catches had forced them to fish further from shore: "now we need to go deep to get the fish" (Jaganadham, interview). Appa Rao mentioned relocating boats during storms: "During extreme weather we don't even have place to keep our boats so we move towards sagarnagar since there is more place left" (Appa Rao, interview).

These spatial adaptations demonstrate how fishermen actively respond to environmental changes but also highlight access constraints that limit adaptation options (Badjeck et al., 2010). The interviews revealed concerns about diminishing space for traditional fishing practices, with Appa Rao predicting that "one day will come where we will park our boats on road" (Appa Rao, interview).

Table 3: Adaptation Strategies Employed by Fishermen in Jodugullapalem

Adaptation Type	Specific Strategies	Reported by	Benefits	Limitations
Technological	Weather information devices; use of mechanized boats	Both participants	Improved safety; increased range	High cost (₹60,000 for weather device); fuel costs

Adaptation Type	Specific Strategies	Reported by	Benefits	Limitations
Livelihood Diversification	Temporary migration to commercial fishing vessels; construction work; women working as house maids	Both participants	Risk spreading; increased household income	Loss of traditional practices; cultural identity impacts
Spatial	Fishing in deeper waters; relocating boats during storms	Both participants	Access to more productive fishing grounds; reduced storm damage	Increased costs; space constraints
Knowledge-Based	Traditional weather prediction; wave pattern analysis	Both participants	Reduced risk; independence from technology	Knowledge loss in younger generation
Institutional	Sharing fishing costs and proceeds (4-5 members per boat)	Jaganadham	Risk sharing; reduced individual investment	Limited returns (₹100-200 per person)
Intergenerational	Supporting children's education; transition to non-fishing occupations	Both participants	Long-term household security	Loss of fishing knowledge and traditions

4.4 BARRIERS AND LIMITS TO ADAPTATION

Key Findings: Climate Change and Coastal Livelihoods in Visakhapatnam				
Based on interviews with fishermen from Jodugullapalem fishing village				
Perceptions	Livelihood Impacts	Adaptation	Barriers	Policy
Barriers to Adaptation				
Economic Constraints			Marginal returns limit options	
"Sometimes we get sometimes we don't, even if we get fish also they are like 1000 to 2000 rs only, if we share among ourselves (4-5 members per boat) we are left out with 100 to 200 per person" (Jaganadham)				
Space Constraints			Limited physical space	
"We don't have that much place here to park them" (Jaganadham) "We don't have place to park our boats" (Appa Rao)				
Knowledge Gaps			Uncertainty about mechanisms	
"They are not even born which means they are extinct" (Jaganadham) - showing uncertainty about specific mechanisms for fish species disappearance				
Governance Challenges			Skepticism about interventions	
"The beach that they are developing around that ship wont stay long... after some days the ocean will start coming forward and all that beach area will be in water and all the investment that they are doing will go in waste" (Jaganadham) "They will give small place some where in the corner to keep our boats and convert this place like rushikonds" (Appa Rao)				
Source: Interviews with Perla Jaganadham (55) and M. Appa Rao (65), third-generation fishermen from Jodugullapalem				

4.4.1 ECONOMIC AND RESOURCE CONSTRAINTS

Both interviews highlighted economic constraints that limit adaptation options. Jaganadham described the precarious economics of small-scale fishing: "sometimes we get sometimes we don't, even if we get fish also they are like 1000 to 2000 rs only. If we share among ourselves (4-5 members per boat)

we are left out with 100 to 200 per person" (Jaganadham, interview). These marginal returns make it difficult to invest in adaptive technologies or alternative livelihoods.

Space constraints also emerged as a significant barrier to adaptation. Jaganadham stated: "we don't have that much place here to park them" (Jaganadham, interview), while Appa Rao explicitly linked sea level rise to reduced space for fishing activities: "we don't have place to park our boats" (Appa Rao, interview). These observations align with research on adaptation limits in coastal communities where physical space constraints interact with economic and governance barriers (Dow et al., 2013b).

4.4.2 KNOWLEDGE AND UNCERTAINTY

While both fishermen demonstrated sophisticated environmental knowledge, their understanding of long-term changes contained elements of uncertainty. When asked about the disappearance of traditional fish species, Jaganadham attributed it to ecological changes: "they are not even born which means they are extinct" (Jaganadham, interview), but showed uncertainty about specific mechanisms.

This knowledge gap represents a barrier to planned adaptation, as local communities may struggle to anticipate future changes without access to scientific information that complements their experiential knowledge (Patt & Schroter, 2008). The interviews demonstrate the potential value of knowledge co-production approaches that integrate scientific and indigenous perspectives (Rathwell et al., 2015).

4.4.3 GOVERNANCE AND DEVELOPMENT CHALLENGES

Both interviews revealed skepticism about government interventions and development projects. Jaganadham criticized a beach development project near a shipwreck: "the beach that they are developing around that ship won't stay long, during this season the water is drawn backwards so everything seems good but after some days the ocean will start coming forward and all that beach area will be in water and all the investment that they are doing will go in waste" (Jaganadham, interview).

Appa Rao expressed concern about displacement from traditional fishing grounds: "They will give small place some where in the corner to keep our boats and convert this place like rushikonda" (Appa Rao, interview), referring to a nearby tourist area. These perspectives highlight how adaptation is situated within broader development politics and power relations (Eriksen et al., 2011; Sovacool, 2018).

Table 4: Barriers to Adaptation in Small-Scale Fishing Communities

Barrier Type	Specific Limitations	Supporting Quotations	Implications for Adaptation
Economic	High operational costs; unstable income; low profit margins	"Now we need to go deep to get the fish. We are burning the fuel of 2000 Rs" (Jaganadham)	Limited capacity to invest in adaptive technologies; forced to accept short-term coping strategies

Barrier Type	Specific Limitations	Supporting Quotations	Implications for Adaptation
Physical/Spatial	Reduced shore space; sea level rise; coastal erosion	"we don't have place to park our boats" (Appa Rao)	Constrained adaptation options; potential displacement
Knowledge	Uncertainty about causes of species changes; limited access to scientific information	"they are not even born which means they are extinct" (Jaganadham)	Difficulty planning for future changes; potential maladaptation
Governance	Perceived mismatch between development plans and local needs	"all the investment that they are doing will go in waste" (Jaganadham)	Reduced trust in institutions; limited participation in formal adaptation planning
Socio-cultural	Declining interest in fishing among younger generation; loss of traditional knowledge	"after our generation you cannot find any one in the ocean since no one knows how to do fishing" (Jaganadham)	Eroding knowledge base; cultural loss beyond economic impacts
Market-related	Increased living costs offsetting higher fish prices	"back then fishes used to be cheap... Now the rates are high but spending have also gone up" (Jaganadham)	Economic pressure despite rising market value; reduced adaptive capacity

5. CONCLUSION AND IMPLICATIONS

Key Findings: Climate Change and Coastal Livelihoods in Visakhapatnam				
Based on interviews with fishermen from Jodugullapalem fishing village				
Perceptions	Livelihood Impacts	Adaptation	Barriers	Policy
Policy Implications				
1	Knowledge Integration Integrate indigenous ecological knowledge with scientific monitoring for more effective climate adaptation planning.			
2	Address Multiple Stressors Design holistic interventions that consider how climate impacts intersect with economic pressures, spatial constraints, and development challenges.			
3	Intergenerational Knowledge Transfer Support programs that document and preserve indigenous knowledge while facilitating its transmission to younger generations.			
4	Transformation Pathways Recognize when traditional livelihoods may become unsustainable and support just transitions to alternative livelihoods while preserving cultural identity.			
5	Climate Justice Address procedural inclusion and equitable distribution of benefits and burdens in adaptation planning to avoid further marginalization.			
Source: Interviews with Perla Jagannadham (55) and M. Appa Rao (65), third-generation fishermen from Jodugullapalem				

This study provides insights into how small-scale fishermen in coastal Visakhapatnam perceive and respond to climate change impacts. The findings demonstrate that fishermen possess detailed environmental knowledge and actively adapt to changing conditions through technological innovation, livelihood diversification, and spatial adaptations. However, their adaptation capacity is constrained by economic limitations, resource access, and governance challenges.

Emergence of several implications for climate adaptation policy and practice are as follows:

Integration of ecological knowledge into monitoring and adaptation planning: The significant observations made by fishermen in identifying changing cyclone patterns, sea level rise, and fish distribution provide valuable place-based insights which further complement scientific monitoring. Scientific understanding and local adaptive capacity can be enhanced through knowledge co-production (Hernandez-Gonzalez & Corral, 2017).

Adaptation interventions should address multiple stressors: Climate impacts interact with economic pressures, spatial constraints, and development challenges affect fishing communities. Effective adaptation requires holistic approaches that consider these intersecting vulnerabilities (O'Brien et al., 2012).

Supporting intergenerational knowledge transfer: It can be considered crucial step for maintaining adaptive capacity. Valuable indigenous knowledge may be lost as younger generations tend to shift away from the fishing occupation. Community resilience could be enhanced through the programs designed to document and preserve knowledge through sustainable livelihoods (Ingty, 2017).

Adaptation planning should recognize potential transformation pathways: Transformational pathways should be identified through adaptation planning when traditional livelihood becomes unsustainable. Both fishermen expressed doubt about fishing's viability for future generations. Adaptation may require supporting transitions to alternative livelihoods while preserving cultural identity rather than focusing on current practises (Pelling et al., 2015).

Finally, the study highlights the importance of addressing justice dimensions in climate adaptation. Fishermen's concerns about displacement and marginalization illustrate how adaptation occurs within contexts of unequal power relations. Just adaptation requires attention to procedural inclusion and equitable distribution of benefits and burdens (Paavola & Adger, 2006).

In conclusion, this research demonstrates the value of engaging with local perspectives on climate change. By understanding how vulnerable communities experience and respond to environmental changes, we can develop more effective, contextually appropriate adaptation strategies that enhance resilience while addressing underlying vulnerabilities.

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Thematic Analysis Framework

Coding Structure from Analysis of Fishermen Interviews in Jodugullapalem, Visakhapatnam

Analysis Process

The thematic analysis followed these steps:

1. Initial coding of interview transcripts using both inductive and deductive approaches
2. Organization of codes into subthemes based on related content
3. Grouping of subthemes into primary thematic categories
4. Selection of representative quotes to illustrate each code
5. Comparison of themes with conceptual framework and existing literature

Perceptions of Environmental Changes

3 subthemes

Cyclone Patterns and Weather Events

Observations of changing frequency, intensity, and predictability of cyclones and other weather phenomena

Code	Representative Quotes
Cyclone frequency	<i>the cyclones in the past are bigger when compared to the present (Jaganadham)</i> <i>now the cyclones are less but the fatality is more (Appa Rao)</i>
Cyclone severity	<i>a devastating cyclone in 1996 that sank approximately 40 boats</i>
Weather predictability	<i>today we are getting information 10 days before the cyclone is arriving (Jaganadham)</i>

Sea Level Rise and Coastal Changes

Observations of changing coastlines, sea level, and physical changes to the beach environment

Code	Representative Quotes
Water level increase	<i>water levels have actually raised when compared to the past (Jaganadham)</i>
Beach erosion	<i>here we cannot even see the beach after few years (Jaganadham)</i>
Ocean advancement	<i>the ocean has come forward (Appa Rao)</i>
Anthropogenic factors	<i>When the fishing harbour started filling that place ocean started moving forward (Appa Rao)</i>

Changes in Fish Stocks and Distribution

Observations of changing fish abundance, species composition, and spatial distribution

Code	Representative Quotes
Fishing distance	<i>now we need to go deep to get the fish. We are going more than 40-50 bars (Jaganadham)</i>

Code	Representative Quotes
Species disappearance	<i>Back then we used to get pulasa, katikamenu, puli kanasa, otti para... all those fishes are gone (Jaganadham)</i>
Coastal availability	<i>back then fishes used to come to the shore (Appa Rao)</i>

Impacts on Livelihoods and Well-being

3 subthemes

Economic Impacts and Changing Income Patterns

Effects on income, expenses, and overall economic conditions for fishing families

Code	Representative Quotes
Price dynamics	<i>back then fishes used to be cheap people do not use to buy much. Now the rates are high (Jaganadham)</i>
Operational costs	<i>To reach that place we are burning the fuel of 2000 Rs (Jaganadham)</i>
Income decline	<i>there is no income, it has declined tremendously. Our investments have increased multiple times (Appa Rao)</i>

Housing Security and Displacement Concerns

Issues related to housing stability, rent burdens, and potential displacement

Code	Representative Quotes
Rental burden	<i>here we don't have our own house we are staying on rent... We need to pay 5000 rs as rent per month (Jaganadham)</i>
Place attachment	<i>we don't have place to park our boats (Appa Rao)</i>

Intergenerational Implications and Cultural Loss

Changes in occupational choices across generations and potential loss of traditional knowledge

Code	Representative Quotes
Occupational shift	<i>I don't think the next generation is going to pick up this profession (Jaganadham)</i>
Alternative livelihoods	<i>My son is in Centering (construction) work the other one works in plumbing work (Jaganadham)</i>
Future predictions	<i>in few years I cannot sea fisherman in this place (Appa Rao)</i>

Adaptation Strategies and Responses

4 subthemes

Technological Adaptations

Use of new technologies and equipment to respond to changing conditions

Code	Representative Quotes
Communication technology	<i>We are having a compass like device which is providing us all weather-related information (Jaganadham)</i>
Fishing equipment	<i>We have some mechanised boats they go deep into the sea. We can stay upto 12 hrs in sea (Appa Rao)</i>

Livelihood Diversification

Adoption of additional or alternative income sources

Code	Representative Quotes
Gender-based diversification	<i>women go for work as house maids and contributing to the income (Jaganadham)</i>
Temporary migration	<i>During season we started to join the fishing boats... These boats go from here to Paradip and Kolkata (Jaganadham)</i>
Shift to construction	<i>out of all the people in village only 10-20 people go for fishing rest all go for construction work (Appa Rao)</i>

Indigenous Knowledge and Environmental Monitoring

Use of traditional knowledge systems for environmental prediction and navigation

Code	Representative Quotes
Wave pattern knowledge	<i>we used to use the tides and waves pattern to actually identify the shore (Jaganadham)</i>
Weather prediction	<i>we understand the weather very well just by looking at the sea and wind pattern (Appa Rao)</i>

Spatial Adaptations

Changes in fishing locations and boat storage in response to environmental changes

Code	Representative Quotes
Fishing further offshore	<i>now we need to go deep to get the fish (Jaganadham)</i>
Boat relocation	<i>During extreme weather we don't even have place to keep our boats so we move towards sagarnagar (Appa Rao)</i>

Barriers and Limits to Adaptation

3 subthemes

Economic and Resource Constraints

Financial limitations and resource access issues that restrict adaptation options

Code	Representative Quotes
Marginal returns	<i>sometimes we get sometimes we don't, even if we get fish also they are like 1000 to 2000 rs only (Jaganadham)</i>

Code	Representative Quotes
Space limitations	<i>we don't have that much place here to park them (Jaganadham)</i>

Knowledge and Uncertainty

Gaps in understanding mechanisms of environmental change

Code	Representative Quotes
Species extinction uncertainty	<i>they are not even born which means they are extinct (Jaganadham)</i>

Governance and Development Challenges

Issues related to government interventions, development projects, and power relations

Code	Representative Quotes
Skepticism of interventions	<i>the beach that they are developing around that ship wont stay long... all the investment that they are doing will go in waste (Jaganadham)</i>
Displacement concerns	<i>They will give small place some where in the corner to keep our boats and convert this place like rushikonds (Appa Rao)</i>

Thematic Analysis Insights

- The thematic analysis revealed strong connections between environmental perceptions and livelihood responses
- Fishermen demonstrated sophisticated environmental knowledge despite limited formal education
- Adaptation strategies were both reactive (responding to immediate changes) and anticipatory (preparing for future changes)
- Economic constraints emerged as the most significant barrier to adaptation across multiple themes
- Intergenerational perspectives revealed a consistent pattern of occupational shift away from fishing

This thematic analysis framework was developed based on interview data from Perla Jaganadham (55) and M. Appa Rao (65), third-generation fishermen from Jodugullapalem, Visakhapatnam.