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Adaptation Strategies to Climate Change Along the East Coast of India

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Abstract **- The Intergovernmental Panel on Climate Change states that the "Warming in the climate system is unequivocal and since 1950 many changes have been observed throughout the climate system that are unprecedented over decades to millennia. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since1850". The changing climate resulting in unprecedented monsoon and high intense extreme weather events along the coast of India had created serious effects on the coastal communities. This study is conducted in Lower Vellar basin, Tamil Nadu, India which is vulnerable to floods along the coast witnessing series of cyclones during the north east monsoon and droughts along the plains since the plain region is the tail end of the deltaic zone. The main objectives of the study are to identify the peoples' perception on climate change and the adaptation strategies by the people in the forest, agricultural and coastal areas of the Lower Vellar Basin to the changing climate. The primary data collection involved the usage of participatory rural appraisal tools like questionnaire, group discussions and key person interviews. The peoples' perception recorded has shown the change they have felt in the changing climate for the past 15 years. The traditional farmers and fishermen were considered to be the key focal point, since they had witnessed the changing climate over a decade. The factors contributing to the choice of adaptation strategies were analyzed using Multinominal logit modelling to estimate the most influencing factor in the choice of adaptation strategy. Lack of financial support and lack of knowledge on adaptation techniques were the major hindrances to adaptation. This indicates that a people centered development approach at the decentralized level is essential in order to withstand the changing climate and achieve the 2030 sustainable agenda.**

Keywords: **Adaptation, Climate Change, Livelihoods, Perception, Multinominal Logit Modeling**

I. INTRODUCTION

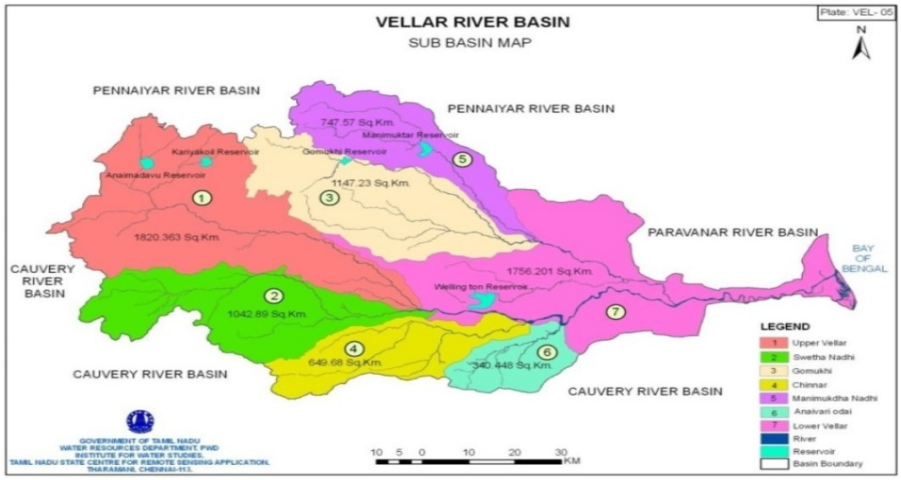
Climate change, being a recent trend in the area of natural resource management and the impacts being severe, either mitigation or adaptation measures should be carried out. The variation in precipitation and temperature are most the visible factors in identifying climate change [4]. Developmental activities result in emission of Green House Gases which alter the pattern of climate. Complete mitigation of developmental activities could not be achieved, so adapting to the change is the next step ahead. The state of Tamil Nadu has been working to predict the future climate change and develop appropriate strategies in response. These strategies are grouped as 'Climate Response Strategy'. The key elements of this strategy include accelerating inclusive economic growth, promoting sustainable development, securing and diversifying livelihoods and safeguarding ecosystems (*Organization for Economic Co-operation and Development 2009).* The action plan mentions that "Adaptation will be the predominant philosophy and component of the climate response strategy of Tamil Nadu". The state of Tamil Nadu has worked on the available climate data to predict the future climate and the changes. Climate change impacts and responses are presently observed in physical and ecological systems [8]. Adaptation to these impacts is increasingly being observed in both physical and ecological systems as well as in human adjustments to resource availability and risk at different spatial and societal scales [1]. Perceived climate changes and impacts differed significantly even within a small geographic area [2]. People at high altitudes appear more sensitive to climate change than those at low altitudes [3].

Climate change is a threat to human health and life, both now and in the future. It is concluded that people typically do not consider the issue a priority concern or a direct, personal threat [9]. Despite considerable studies on the impact of climate change on aquatic ecosystems and fish stocks, the macro scale fishery-dependent economies and their people, and on vulnerability and adaptation in agricultural communities, there has been insufficient examination of the vulnerability and adaptation of small-scale fishing communities to climate variability and change. Climate impacts such as changes in temperature and rainfall patterns resulting in drought, flooding, all exert significant effects on forest ecosystems and their provision of goods and services, which form the safety nets for many African rural low-income households [7].

Farmers in the Sahel have always been facing climatic variability at intra- annual and inter-annual and decadal time scales. While coping and adaptation strategies have traditionally included crop diversification, mobility, livelihood diversification, and migration, singling out climate as a direct driver of changes is not so simple. Finding the right indicators and separating climate effects from other impacts have been dealt with by combining household surveys and group interviews and taking an open-ended approach when asking questions [6]. In adapting to climate change indigenous people cultivate different/varieties of crops which are tolerant to climate change and shortening of growing season as adaptation strategies.

II. STUDY AREA

Vellar is a river which originates in the Shevaroy Hills and runs through the districts of Tamil Nadu such as Villupuram, Salem, Namakkal, Perambalur and Cuddalore. The river drains into the Bay of Bengal near Parangipettai. The Lower Vellar River starts from Tholudur Anicut and finally falls into Portnova in Bay of Bengal. The basin is situated between latitude 11°13'N- 12°00'N and Longitude 78°13'E-79°47'E. The total area of this basin is 1753 Sq Kms. The total length of lower Velar River is 128 kms. The annual average rainfall of the sub basin is 1165mm. Out of seven sub basins, the Lower Vellar sub basin was selected for this study. Since the study involves forest, plains and coastal regions the Lower Vellar sub basin is most appropriate. Since climate impacts are more evident in the Lower Vellar Basin, the study could reveal the adaptation strategies by the people. Based on the pilot survey conducted and also with meetings after Block development officer the study area for forest, plains and coast were selected as Nangur, Kozhiyur and Chinnur village respectively. Nangoor reserve forest is situated in Tittakudi tehsil and located in the Cuddalore district of Tamil Nadu. Kozhiyur is a Village Panchayat in the Tittagudi block. The livelihoods are found to be diversified with agriculture being the major option. The major source of water for agriculture is from the Wellington Lake. The village also has a threat of Sand Mining in the Vellar River.



(Source: Multi-Disciplinary Project Unit, Chepauk, 2013)

Fig. 1 Sub Basins of Vellar

(a)

(b)

(c)

Fig. 2(a) Kozhiyur Sand Mining, 2(b) Nangur Reserve Forest, 2(c) Chinnur Google Earth Boundary

Lands which were once rain fed now has tube wells and some farmers practice DRIP irrigation. Chinnurisa Village Panchayat in Parangipettai block with a population of about 290 households. The village is a coastal area with a distance of 1.5km to the Bay of Bengal with the major livelihood being fishing. The village has major population of small-scale fisherman who possess boats of a length of 28 feet approximately. Chinnur also faces a threat from newly established Thermal power plant. People of the village consider that after the drastic effects of Tsunamis, the changing trends in catching season, catch size, and rainfall patterns have all changed. The effluent discharge from Cuddalore State Industries Promotion Corporation of Tamil Nadu SIPCOT is polluting the sea which has resulted in reducing the fish catch. The use of the 'Suruku fishing net' (Capable of catching even smaller fish) and 'Rettai madi' (Sediment trap) used by trawlers from Cuddalore and Nagapattinam has majorly impacted the livelihood of the fishermen of smaller communities.

TABLE I PERCEPTION OF THE COMMUNITY ON THE CLIMATE CHANGE

Villages/ Parameters	Time line	Monsoon	Rainfall	Temperature	Extreme Weather Events	Anthropogenic activities
Nangur	15 years ago	October –December The cycle of cropping activities was in line with the monsoon	Appropriate for the crops to grow and also the right quantity at the right duration was observed	Sunshine hours were optimum	No sign of drought till 2002	Nangur had varieties of crops like Paddy, Sesame, millets, Groundnut and Maize. Enough water to cultivate and crop rotation was practiced
	Now	November-December This year was even worse were the crops have all damaged since the monsoon failed	Decreasing trend, Increased drought	Crops have damaged due to increase in temperature	Increased number of drought years	Predominantly Maize. People find it difficult to prepare the land for a variety of other crops. They get rice grains for free through Public Distribution System. Some land has been left fallow
Kozhiyur	15 years ago	October - December, the cycle of cropping activities were in line with the monsoon	Appropriate for the crops to grow and also the right quantity at the right duration was observed	Sunshine hours were optimum for the crops to grow	No sign of drought till 2002	Crop diversification was practiced. Sugarcane, maize, paddy was grown with enough water from the canal
	Now	November-December This year was even worse, the crops have all been damaged since the monsoon failed. Yield has reduced to 4 to 5 bags.	Decreasing trend, Increased drought	Crops have damaged due to increase in temperature	Increased number of droughts years	Rapid urbanization is observed since Kozhiyur is the nearest village to Tittakudi Taluk Headquarters. The canal for irrigation which is the primary source of surface water for the village from Wellington Lake has been used as a waste dump yard. Sand mining activity has reduced the flow regime in the river
Chinnur	15 years ago	October – December Fishing activity begins in mid-January after the rough season (October to December)	Appropriate for the fish to breed	Optimum amount of temperature for the fishes to grow.	Rare frequency of occurrence and also less intense	SIPCOT had few industries and the use of the 'Suruku' fishing net was less frequent People were respectful of nature
	Now	November-December Till date no sign of fishing activity	Decreasing trend reported by the fishermen. Not conducive for the fishes to breed	Increased warmer currents hence certain fish species are found to have moved farther into the ocean.	Severe floods and cyclones experienced	Too much pollution and large fisherman in Cuddalore and Nagapattinam use Trawlers leading to reduced breeding of fish

III. METHODOLOGY

The study involves the selection of three villages and understanding the perspectives and impacts of climate change of the people in all three villages for a period of one year in 2017. An intense field study was conducted to relate the adaptations to climate change, the sample size being divided into two groups. The first group could be the people affected by extreme weather events and the other would be those who didn't have a direct impact. The primary data was collected using Participatory Rural Appraisal tools like Questionnaire survey, Focused group discussion, Key person interviews [5]. The data was further analyzed by Multionminal Logit Modelling using Statistical Package for the Social Sciences. Multinomial regression is used to describe data and to explain the relationship between one dependant nominal variable and one or more continuous-level independent variables. Chi square test was chosen, since the results were accurate in terms of relating the factors and adaptation methods. In this study the adaptation strategies adopted by the people would be the dependant variable and the explanatory variables would be various factors like the level of education, gender, age and income of the head of household, information on climate, etc.

IV. RESULTS AND DISCUSSION

The trend in peoples' perception on climate change was recorded in all the three villages and presented in a tabular column. The perceptions were gathered from the entire community, apart from identifying the traditional farmers and fisherman who had witnessed the change in climate conditions over 15 years.

A. Nangur

In Nangur, people were aware of the drip irrigation and had chosen it to be an adaptation measure since they had received training from the government and other organizations. The age and gender had a maximum influence on the people to choose drip irrigation as an adaptive measure. This indicates that people of younger age have a higher probability of adapting to drip irrigation since they are able to work harder and also wish to take risks in moving from traditional irrigation practices. It is observed that the women in Nangur had enough knowledge on drip irrigation systems and were practicing it.

Fig. 3 Drip Irrigation adopted in Nangur Village

TABLE II PARAMETER ESTIMATES – NANGUR

Explanatory Variables	Drip Irrigation		
	Chi Square Value	Coefficient	P Value
Age (< 40 Years)	2.787	-1.466*	0.022
Gender (Male)	-0.153	-0.537	0.689
Education (1 To 10 Std)	0.821	0.351**	0.002
Income/Year (<50000)	2.502	-1.540*	0.015
Information on Adaptation	0.047	-1.792*	0.097
Affected by Extreme Weather events	0.000	-0.288	0.827

Reference category: No Adaptation No of Observations: 25 households
**,* Significant at 1%, 5% level of significance

B. Kozhiyur

The results show that female land holders tend to adapt since most of the men have moved on in search of other livelihood options. The farmers with low education qualification are not aware of irrigation techniques and prefer no adaptation which resulted in the loss of crop yield and lower income generation. The size of the farm is a more predominant factor since it is observed that large farmers tend to adapt since they are able to invest in adaptation and

they are much more confident in adapting techniques. The study also identified that large farmers after adapting improved their yield. This factor plays a prominent role since any adaptation technique is possible only if the income generated is sufficient to spend on any adaptation technique. In the case of Kozhiyur, people tend to adapt to drip irrigation and tube well since the rainfall has dramatically decreased and is not appropriate for the crops to grow and the canal from Wellington reservoir is dry for most parts of the year. In this case everybody is aware of climate change since they are traditional farmers whose major livelihood depends on climate but still, they find it very difficult to adapt to the changing trends of the climate.

TABLE III PARAMETER ESTIMATES - KOZHIYUR

Explanatory Variables	Irrigation		
	Chi Square Value	Coefficient	P Level
Age (0 – 40 Years)	9.300	0.482**	0.002
Gender (Male)	0.001	-0.041	0.973
Education (1 – 10 Std)	1.081	-1.139*	0.291
Occupation (Farmer)	4.898	0.846**	0.003
Size Of The Farm (<5acre)	0.029	-0.214	.862
Distance To Market (<5 Km)	0.001	0.458**	0.003
Income (10000 – 50000)	4.577	-0.241*	0.050
Information on climate	1.788	0.421	0.855

Reference category: No Adaptation No of Observations: 50 households
**,* Significant at 1%, 5% level of significance

C. Chinnur

The factor indicates that people of ages less than 40 are significantly diverting from fishing activities. Most of them go abroad as laborers and a few as fishermen too. The next generation has now stepped out of traditional fishing activities. Traditional fishermen do not move on since they still believe fishing to be their birth right. Yet the option of adapting through methods such as exploring a wider range of species, using mechanized boats, etc. are not practiced since they work at a small scale and lack financial assistance.

On an average their income ranges from 10000 INR to 60000 INR per year where the fishing season is only up to 6 months. These fishermen have no access to adapt to any of the changes other than migrating and diverting, but the results indicate that traditional fishermen have no interest in a change of occupation.

TABLE IV PARAMETER ESTIMATES – CHINNUR

Explanatory Variables	Diversion Into Non-Fishing Activity And Migration		
	Chi Square Value	Coefficient	P Level
Age (< 40 Years)	12.255	2.281**	0.002
Gender (Male)	8.043	1.868*	0.010
Years Of Education	19.730	-2.294**	<0.01
Occupation (Fisherman)	2.458	-0.965*	0.127
Fishing Income/Year (< 50000)	1.340	-0.674*	0.251

Reference category: No Adaptation No of Observations: 50 households
**,* Significant at 1%, 5% level of significance

D. Hindrances to Adaptation

The study identifies that in all the three villages' people tend to adapt but the major hindrance was found to be lack of financial support. In the forest and plains people adopt irrigation. In Chinnur village it is found that diversion and migration cannot be sustainable. People of Chinnur village have the traditional knowledge of fishing techniques and they are able to predict the change in weather – (Fisheries dept.). Fishermen at Chinnur, working on a small scale, have equity issues in attaining financial assistance from the government.

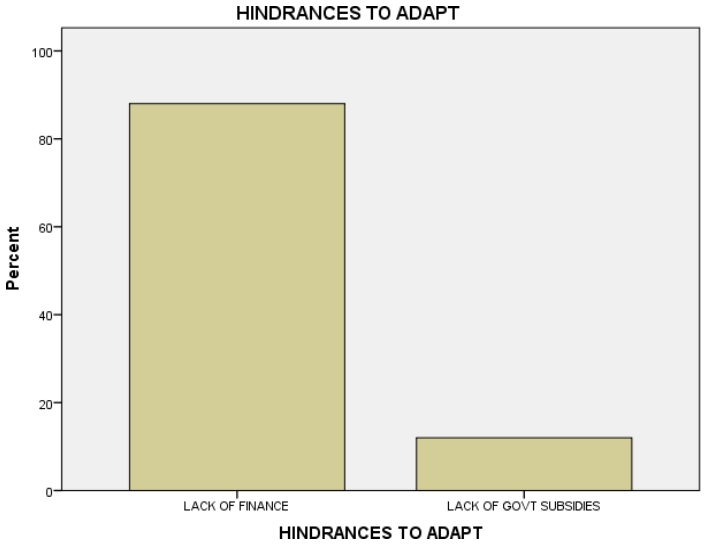


Fig. 4 Hindrances to adapt in forest and Plains

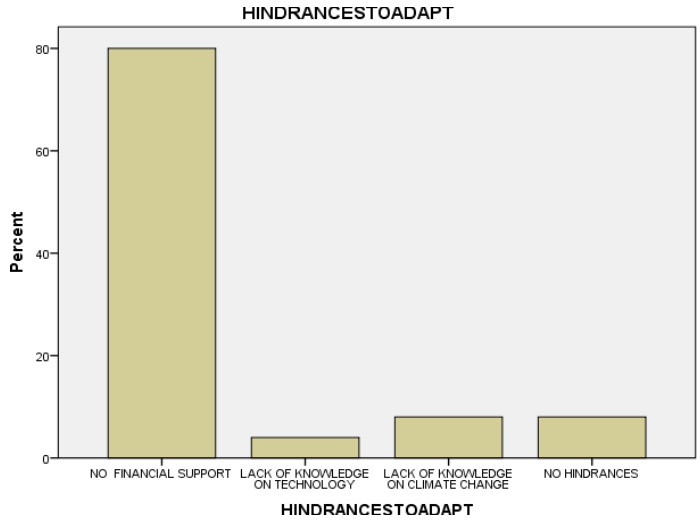


Fig. 5 Hindrances to adapt in Coast

V. CONCLUSION

The study analyzed the factors affecting the choice of adaptation methods to climate change based on a survey per data collected. The survey was conducted in three villages namely Nangur, Kozhiyur and Chinnur where the people were asked if they have observed any change in temperature and rainfall. Those who responded to have observed changes over the past years were asked if they have responded to climatic conditions through adaptation. Those who could afford to adapt indicated that they irrigate their farms to reduce the negative impacts of climate change. In the coastal region they mostly preferred to divert and migrate for other livelihood options. Those who did not adapt to any strategy mentioned lack of information on adaptation methods and financial constraints as main hindrances. The trend in climate change was studied in people's perspective in all three study areas where people have identified the change as increased temperature and reduction in rainfall. The monsoon has also not supported the people both farmers and fishermen. The results from the marginal analysis indicate that house hold characteristics such as education, age, income, which could be enhanced through policy intervention have a significant impact on the adaptation to climate change. Consequently, policies aimed at promoting adaptation to climate change need to emphasize the crucial role of providing information on better management techniques and on climate change (through extension) and creating the financial means through affordable credit schemes to enable farmers and fishermen adapt to climate change. Even though everyone is exposed to the various extreme weather events, they could not prefer adaption since they lack financial support, lack of knowledge of adaptation strategies and soon. Apart from the above-mentioned findings, the study also understood that support from any source would help people in adapting. People of Chinnur village who are traditional fishermen feel that if they receive any financial assistance from the government, they could purchase a large sized boat to travel more into the sea which would help them in catching a

wider range of species. This study has finally revealed the knowledge of the changing climate to people and also the various strategies to overcome this change and to protect their livelihoods.

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