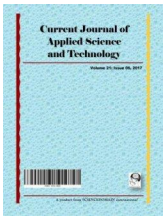

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Adaptation to Mitigate Climate-Induced Crisis by Farmers in Coastal Zone of Karnataka, India

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Authors' contributions

This work was carried out in collaboration between both authors. Author HMVK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MS is major advisor, he guided and corrected the draft. Both authors read and approved the final manuscript.

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ABSTRACT

Introduction: The impact of climate change and responses are presently observed in both physical and socio-ecological system. Farmers' vulnerability to climate-induced crisis refers to the inability of farm society to withstand adverse impact from multiple stress to which they are exposed due to climate change. However, climate-induced crisis introduced a new way of challenge not only because of an expected rise in temperature, CO2, the rise in sea level, etc. but failed to tackle adaptation strategies due to resource-poor, incompatibility, poor decision-making and incomplete information.
Objective: This paper examines the farmers' action and adaptation strategies to manage the climate-induced crisis in coastal Karnataka.
Place and Duration of Study: The investigation was conducted in Coastal Karnataka during October 2014 to May 2015.

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Study Design: 240 fishery-based farmers from 24 villages have been selected by applying proportionate random sampling technique for the investigation by adopting Ex-post-facto research design.
Results: The mean adaptation behaviour of crisis management groups with farmers' categories was significantly varied as revealed by F ratios 188.72 and 25.46, respectively and they are observed to be significant at 0.01 level of probability. Also, the critical differences worked out for all the crisis management groups, and farmers categories turned out to be important noting that mean adaptability score group was dissimilar to other groups. There are various potential adaptation options available for climate change; often it varies from place to place, situation to situation, socioeconomic, psychological and other climate-related factors. However, there are limits to their effectiveness, efficiency, and equity. The result shows that their adaptation strategy to cope with the climate-induced crisis and it is important to integrate their local knowledge and wisdom with unnatural situations into the future planning and development process of the coastal belt.
Conclusion: Policies and development of adaptation strategies should not only be a necessity but, also be accepted and adopted by the local community for sustainable development.

Keywords: Adaptation; crisis management; farmers; sustainable development; vulnerability.

1. INTRODUCTION

Climate change is currently documented as one of the most persistent global issues of our planet [1]. NAS, 2010 concludes "the Earth system is warming and that much of this warming is very likely due to human activities [2]. Also, new observations at the regional and global levels show severe observed impacts of climate change on many critical natural resources, production systems and communities [3-7]. Consequently, studies based on new observations and models suggest that the pressures from climate change are much more immediate and severe than anticipated before the decade [8].

The current concern is the extent and magnitude of climate change. It affects the balance of natural ecosystems (i.e. forests, river basins, sea level and physical infrastructure) and socio-economic systems (i.e. agriculture, fisheries, irrigation and allied activities). Additionally, due to its effects on livelihoods and food security the climate change is predicted to impose significant collective costs for society and farmers [9,10]. The impacts arise through varying temperature patterns, rising sea-levels, sea surface temperature and the intensification of natural disasters (i.e. flood, droughts, etc.) IPCC studies show that the vulnerability of a nation depends on a large degree of its wealth, inequality, and poverty that limit adaptive capabilities [11,12]. The socio- economic systems "typically are more vulnerable in developing countries where economic and institutional circumstances are less favourable." Consequently, policies promoting adaptation to climate change are severe in the coming years.

Developing countries like India are encumbered with huge developmental deficits with a significantly large segment of the population having meager incomes and lack of access to necessities of livelihood making them extremely vulnerable to the impacts of climate change. Subsequently, the resource requirement and policy direction for adaptation in these nations are expected to be given highest priority in their evolving policy discourses on climate change. The forecast of climatic changes has the potential to severely affect countries highly dependent upon farming livelihoods, resulting in food shortages, among other costs. Therefore, people who depend on farming activities will require a diversity of adaptation strategies to mitigate the adverse effects of climate change effects and maintain the livelihoods of agrarian families. Different modern technologies have been developed and introduced at the farm level to attain target measures of the Millennium Development Goals [13]. Precise and time-bound adaptation strategies to climate change effects include altering planting time and using heat and drought resistant varieties, integrated approach, etc. Swearingen and Bencherifa [14,15] with improved cultivars having been selected and applied for the same purposes [16,17]. Soil and water conservation practices [18], irrigation, fertilizer use [15,19] and diversified non-farm activities [20,21] similarly adaptation strategies that have been practiced at field level in response to climate change.

Numerous agricultural adaptation options have been advocated in the literature. They encompass a broad range of scales (indigenous, local, regional and global), actors (farmers, firms,

and other stakeholders), and types: (a) micro-macro level options, such as multi-cropping, crop diversification and altering the time of operations; (b) market strategies, such as income diversification and credit insurance schemes; (c) institutional linkages and changes (d) technological developments- new crop varieties and advances in water and natural resource management techniques [22-24]. Further, most of these possible or potential adaptation measures rather than ones Indeed adopted. There is no indication that these adjustment options are practicable, realistic, time-bound, or even likely to occur. Besides, they would only be possible with complete and precise knowledge of future climatic conditions, which is why these were appropriately named "clairvoyant farmer" scenarios [25,26]. Therefore, climate change impact studies often assume certain adaptations examination of how, when, why, where, who, and under what conditions adaptation occurs in social and economic systems.

With this backdrop, the focus on climate-induced crisis response is time sensitive, long-term disaster recovery data, mitigation, and preventions are also necessary. The developing countries are more vulnerable to any calamities as they do not have technological efficiencies and as well as socio-economic strength. So it is important for a developing country, in India, particularly coastal zones to develop and start planning with locally organized sustainable adaptation strategies for climate-induced crisis management. The objective of the study is to identify and analyze the climate adaptation strategies adopted by the marginal, smallholder and big farmers and examine the factors that determine the strategies adopted by farmers. To the best of our knowledge, there is no study on this in coastal Karnataka, India.

2. MATERIAL AND METHODOLOGY

2.1 Study Area

The investigation was conducted in Dakshina Kannada (12.87°N 74.88°E), Udupi (13.3389°N 74.7451°E) and Uttara Kannada (14.6°N 74.7°E) districts of Coastal Karnataka (Zone-10). This Zone is characterized by high and erratic rainfall (3548 - 4071mmy^{-1}) and increased temperature, with low to average productivity in both Agriculture and fishery. The whole coastal belt and the adjoining areas have a tropical monsoon. The area receives heavy rainfall. The average annual rainfall in Coastal Karnataka is more than the rainfall received in the other parts of the state. The coast stretches for 320 km along the three districts. Of these, Uttara Kannada has 160 km stretched coastline while 98 km is in Udupi district and the rest in Dakshina Kannada. Three diverse agro-climatic zones are ranging from coastal flatlands in the west with undulating hills in the middle, and high hill kinds in the east that separate from the peninsula. Four villages were randomly chosen from each of the selected taluks. Thus, 240 fishery-based farmers from 24 villages have been selected by applying proportionate random sampling technique for the investigation by adopting Ex-post-facto research design.

2.2 Survey of Data

Data was collected in January–February 2015 through interviews using the pre-tested structured climate-induced crisis management scale to elicit both qualitative and quantitative data on factors persuading farmers' adaptation strategies under adverse climate change situations. The household interview was conducted with the key decision-maker of the family, especially on crop production, horticulture, soil and water conservation, irrigation, fishery, livestock, land use pattern, flood, labour, financial and family management.

3. RESULT AND DISCUSSION

3.1 Adaptation Behaviour of Crisis Management Groups with Fishery Based Farmers' Categories

It is revealing from the Table 1 that the adaptation mean score of low crisis management group was the smallest (279.33) followed by medium (294.01) and high crisis management group (309.39). Among marginal, small and big farmers categories also mean adaptation scores showed an increase from low to high crisis management groups. Further, farmer crisis management Group wise analysis against all farmers' groups revealed marked differences concerning adaptation scores, where mean adaptation scores of marginal to big farmers were on the increase in all the crisis management groups. Added to these, the total mean adaptation scores of farmers followed a similar trend of increase from marginal to big farmers.

The Table 2a demonstrated that the mean adaptation behaviour of crisis management

groups with farmers' categories was significantly varied as revealed by F ratios 188.72 and 25.46, respectively and they are observed to be significant at 0.01 level of probability. Also, the critical differences worked out for all the crisis management groups, and farmers categories turned out to be important noting that mean adaptability score group was dissimilar to other groups (Table 2b).

Mean adaptation behaviour of farmers was on the increase from low to high crisis management group as well as from marginal to big farmers. Also, mean adaptability scores differed significantly among crisis management groups as well as farmers categories (Table 2a). However, there is no documented study to support the present findings. The observed results could be substantiated by the fact that closing the gap between desirable levels of living and the influence of negative environmental forces is the essence of man's struggle for existence and improvement on his quality of life. However, this adaptability to environment depends on both human resources (motivation, attitude) and material resources (capital, assets, etc.) possessed by farmers. These vary among the peasants' categories as well as crisis management groups.

3.2 Adaptation Pattern of Fishery Based Farmers Related to Agricultural Crop Production

To achieve sustainable yield level by taking advantage of limited soil moisture in summer and also to reduce the losses incurred in the cultivation of seasonal crops during inconsistent rainfall period, the farmers had resorted to several adaptive strategies. These adaptation patterns are presented in Table 3. As seen from the table, mixed cropping is a risk mitigation mechanism to overcome total loss with this crop combination farmer assures to get some yield in other crops. It was found that a good number of farmers had replaced their traditional varieties by improved one owing to low yield, late maturity, and less profit. Although a good percentage of farmers applied a balanced fertilizer to increase the crop production, more than half the respondents had reduced the quantity of application. Also, farmers considered it as a loss reducing strategy in summer to combat the impact of uncertain rains. Oilseed crops being high-income crops attracted a good number of farmers. The adaptation of drought-tolerant crop varieties is an encouraging trend. Further, when *Kharif* crop failed, farmers gave more attention to *rabi* crop and pre-pone sowing of rabi crops. These practices were adopted by a good number of farmers might be due to make up the loss incurred during the *Kharif*. The practices of increasing area under cash crops, adoption of short duration crop and mixed cropping were some of the other adaptive strategies.

3.3 Adaptation Pattern of Fishery Based Farmers Related to Soil and Water Conservation

A variety of adaptation measures initiated by farmers to conserve soil and water are summarized in Table 4. It could be observed that almost 40 percent of farmers have adapted bunds to conserve soil and water. Probable reasons may be that, were constructed under Government soil conservation programmes, farmers had maintained these bunds because of strong conviction that bunds conserve soil moisture. Fall ploughing was also one of the significant moisture conservation adaptive strategies. This is a traditional practice meant to increase the infiltration and in situ conservation of rainwater. Interestingly, only 47 percent of farmers sown across the slope, sowing on the same line lead to depletion of soil fertility thus reducing crop yields. The adaptation strategy of formation of ridges and furrows was seen among small percent of farmers. So also contour farming, intercropping and crop rotation. Perhaps, the importance of these practices might not have understood by the farm families. A negligible number of farmers adopted the methods of waterways construction, opening of dead furrows, farm pond construction, cover crops, construction of drop structures in waterways and gully plugging practices. This trend of reduced adoption was due to high labour, high cost, and complexity of these practices.

3.4 Adaptation Pattern of Fishery Based Farmers Related to Subsidiary Farm Enterprises

3.4.1 Adaptation pattern of fishery based farmers related to Fish rearing

An observation of Table 5 showed that fish farming business was an accepted adaptive strategy among respondents. However, unusual patterns of adaptation were recorded among fishery based farmers'. It was revealed that all farmers had opted fishery enterprise to

supplement their seasonal crops income. The fishing business facilitates to utilize time during off season (95 percent) and to meet livelihood (89.58 percent) and emergency financial need (87.92 percent) were attributed to adaptation strategy to the climate-induced crisis. Aquatic foods have great nutritional value and are one of the most widely marketed at the local level with a high cost. Some of the lacunas they face at the local level are processing, marketing, and distribution industries associated with fishing.

3.4.2 Adaptation pattern of fishery based farmers related to livestock management

Table 6 summarizes the findings on adaptation strategies of farmers related to livestock management. Nearly, thirty-one percent of the respondents were started rearing sheep/goat. Big, small and marginal farmers on this account were 53.75 percent, 25 percent, and 16.25 percent, respectively have adopted sheep/goat rearing. Category-wise analysis revealed that the ownership of animals was comparatively more among big farmers as compared to small and marginal farmers. Reducing straw fed to animals especially to growing animals was recorded as one of the survival strategies to extend their life for a longer period. Acceptance of sheep/goat rearing to meet future drought was seen among the majority of farmers. The strategy of investing in small animals was considered as 'saving bank' for quick encashment during the stress period. Also, saving fodder during the good year was a drought mitigation techniques found mainly among the big farmers. Scientific adaptation patterns like reduction of big animals by replacing with small animals and multi-species rearing were also reported. Also, rearing multispecies animals are like multiple cropping, a risk-spreading mechanism as the mortality among the farm animals varies. However, these patterns were found among a small number of farmers. The planting of fodder trees and improved fodder grass slips, encouraging adaptation patterns were also reported.

3.5 Adaptation Pattern of Fishery Based Farmers Related to Land Use

The adaptive strategies of farmers on land use are depicted in Table 7. Over half of the farmers applied organic sources of nutrients. On inquiry, it was found that it was a measure taken to conserve moisture and to avoid inorganic fertilizer. Also, it was noticed that they left the land fallowing because of financial problems. And also, non-availability of resources like seed, bullock pair to cultivate all the lands (marginal and small farmers). Crop rotation and mixed cropping as an adaptive strategy were found among a significant number of big farmers. This is a risk insurance mechanism where the owner will incur a minimum loss as against cultivator (crop rotation) taking a major risk. Further, to some degree, big farmers had intensified their cultivation in the irrigated area to maximize the yield to make good of losses incurred in dryland area.

3.6 Adaptation Pattern of Fishery Based Farmers Related to Labour Use

Adaptation patterns of farmers on labour use, farmers of the crisis-affected area had evolved patterns of adaptation to reduce hired labour cost or to increase the self-labour employment to adjust to the acute financial constraints impounded by the regular crisis. As it was summarized in Table 8, it was noteworthy that there was an enhancement of family labour contribution to the farms. Over 1/3rd of big farmers increased the family labourers contribution regarding more number of labourers as well as more number of hours of work. There was a considerable reduction in labour employed on the farm; about 71 percent of big farmers as compared to 15 percent and 16 percent of marginal and small farmers. Further, the adaptive strategies like using human labour- saving implements and diversification of labour use were found to opt to the least extent in that order.

3.7 Adaptation Pattern of Fishery Based Farmers Related Flood Management

The adaptive strategies of farmers on flood management are illustrated in Table 9 which provides a fascinating insight. Nearly, 63 percent of farmers adopted indigenous technology such as the wall of wood and stone or coconut leaf to avoid flood effects. Approximately, 79 percent of big farmers, 26 percent and 48 percent of marginal and small farmers had reported that they used sandbags to avoid flood effect. Another pattern associated mainly with the big farmer to the extent of 63 percent was improved drainage facilities, hazard insurance, and wetland restoration system. However, big farmers to a certain extent fared better by investing in flood management than the small and marginal farmers. Technological solutions have been adapted as instruments for reducing

the vulnerability of coastal communities to coastal hazards. This was done in three primary ways: protect (reduction in the probability of damage from a weather-related disaster), retreat (limit potential effects) and accommodate. Protective strategies involve defensive measures to protect coastal zones against the impacts of natural disasters such as flooding and salinity intrusion. Protecting strategies can include a combination of both hard and soft technologies. These include the building walls by using indigenous options such as wood, stone and coconut leaf which has been successfully implemented in the research area. Accommodate, these strategies include increasing society's ability to cope with the effects (e.g. insurance, emergency plans, modification of land use and agricultural practices).

3.8 Adaptation Pattern of Fishery Based Farmers Related to Sea Fishing

An observation of Table 10 showed that the fishing enterprise was an accepted adaptive strategy by the peasants. Climate change will affect fisheries via acidification, changes in sea temperature and the frequency, circulation patterns, severity of extreme events, sea-level rise and associated ecological changes. Both direct and indirect impacts include impacts on targeted populations' range and productivity, habitats and food webs as well as impacts on fishery costs and productivity and fishing community livelihoods and safety. Hence fishery based farmers were adopting some strategies to minimize the ill effect. Namely, insurance (73%), diversified income through non-fish activities (71%), improved product handling and processing and purchase of larger (53%), sophisticated vessels with multi-fisheries capabilities to travel more considerable distance (27%) and multiple licenses (5%) all these strategies mainly observed in big farmers comparatively negligible percent of small and marginal farmers. This is because of big producers favored with higher economic status, greater risk-bearing ability, scientific oriented, higher education and other factors contributed. Hence, big farmers are more advanced than small and marginal farmers.

3.9 Adaptation Pattern of Fishery Based Farmers Related to Financial Management

The financial management practices of farmers during crisis year and also to achieve economic viability during the anticipated future crisis are presented in Table 11. Over 73 percent of big farmers and about 16 percent and 7 percent of small farmers and marginal farmers save money during normal years. This was an adaptation commonly seen among big farmers, and small farmers typically grow commercial crops like groundnut, arecanut, and coconut. Some percent of farmers also borrows advance money from the traders. Traders are ascertaining their potential for production and credibility, advance money on the condition that product produced in the future good year should be sold to them. Although there is exploitation regarding high-interest rate and fixing the low price to the farmers produce, traders provide a solid support for farmers at a crucial period. However, concerning this facility, marginal farmers are in disadvantaged position, as they are not potential producers of commercial crops attributed to tiny holding and low resource use. Also, to raise cash for livelihood mainly marginal and small farmers' borrow money from the SHG's. Interestingly, the borrowing from the institutional sources for land development and bore wells as an adaptive strategy was found mainly among big farmers, indicated their urge for establishing permanent proof for drought crisis, nevertheless supported by institutional credit sources. The other strategies like an increased investment in cashable assets, crop insurance and seeking additional employment generating occupations were found among the small percentage of farmers.

Table 1. Adaptation behaviour of crisis management groups with farmers categories (n=240)

Crisis management groups	Mean adaptability score			
	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
Low	279.30	279.21	279.00	279.23
Medium	293.98	294.03	294.04	294.01
High	308.65	309.44	309.46	309.39
Total	288.84	293.81	302.56	295.07

χ^2= 64.521 Significant at 0.01 level, χ^2 (0.01, 2df) = 9.21

Table 2a. Two-way ANOVA on adaptation behaviour of different crisis management groups with farmers categories (n=240)

Source of variation	df	Sum of Squares	Mean Square	F ratio
Crisis management groups	2	16903.864	8451.932	188.726*
Farmers categories	2	2280.540	1140.270	25.462*
Error	235	10345.112	44.784	
Total	239	20953146.000		

** Significant at the 0.01 level.*

Table 2b. Comparisons of crisis management groups and farmers categories (n=240)

Sl. No.	Mean Comparison	Observed mean difference	Std. Error	C.D. Value
I	**Crisis management groups**			
1	Low vs Medium crisis management groups	14.20	1.04	2.56*
2	Low vs High crisis management groups	29.19	1.14	2.81*
3	Medium vs High crisis management groups	14.99	1.03	2.54*
II	**Farmers categories**			
1	Marginal vs Small farmers	3.38	1.05	2.59*
2	Marginal vs Big farmers	16.56	1.15	2.84*
3	Small vs Big farmers	13.17	1.02	2.51*

** Significant at the .01 level.*

Table 3. Adaptation pattern of fishery based farmers related to crops production (n=240)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Selection of appropriate crop/varieties	38(47.50)	45(56.25)	60(75.00)	143(59.58)
2	Use of short duration varieties	28(35.00)	41(51.25)	65(81.25)	134(55.83)
3	Adopting IPM methods for pest management	34(42.50)	47(58.75)	49(61.25)	130(54.17)
4	Adoption of inter cropping system during uncertainty	25(31.25)	36(45.00)	71(88.75)	132(55.00)
5	Applying balanced chemical fertilizer to rainfed crops	12(15.00)	35(43.75)	63(78.75)	110(45.83)
6	Increasing area under cash crops under assured irrigation/water supply	9(11.25)	19(23.75)	69(86.25)	97(40.25)
7	Alteration in sowing dates	22(27.50)	26(32.50)	45(56.25)	93(38.75)
8	Reducing plant population during stress periods	21(26.25)	28(35.00)	43(53.75)	92(38.33)
9	Intensified the Rabi crop cultivation during Kharif crop failure.	5(6.25)	21(26.25)	45(56.25)	71(29.58)

(Figures in parentheses depicts percentage)

3.10 Adaptation Pattern of Fishery Based Farmers Related to Family Management

The adjustments made by farmers within their family to thrive better during a crisis are described in Table 12. A vast majority of farmers reduced their spending on social functions and expensive food items to keep their expenditure at a minimum level, i.e., just to meet only essentials. Also, the very high percentage of small and marginal farmers ate two meals a day to prolong their life with the available food stock and also adjust to the reduced income level of crisis year. However, this extreme austerity measure was comparatively low among the big farmers apparently because of their inherent risk-bearing capacity and greater support received from their relatives regarding the supply of food grains. Added to these strategies, selling jewelry was prominently found in small and marginal farmers.

Table 4. Adaptation pattern of fishery based farmers related to soil and water conservation for field crops (n=240)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Application of farm yard manure	58(72.50)	61(76.25)	65(81.25)	184(76.67)
2	Leveling of the land in between the bunds	45(56.25)	53(66.25)	73(91.25)	171(71.25)
3	Adoption of intercropping	23(28.75)	35(43.75)	73(91.25)	131(54.58)
4	Construction of waterways along the slope for safe disposal of rainwater	32(40.00)	38(47.50)	54(67.50)	142(51.67)
5	Ploughing and sowing across the slope	28(35.00)	36(45.00)	49(61.25)	113(47.08)
6	Adoption of contour farming	24(30.00)	28(35.00)	59(73.75)	111(46.25)
7	Adoption of crop rotation	17(21.25)	23(28.75)	61(76.25)	101(42.08)
8	Adopting ridges and furrows for crop cultivation	17(21.25)	31(38.75)	52(65.00)	100(41.67)
9	Construction of bunds to conserve moisture	21(26.25)	32(40.00)	45(56.25)	98(40.83)
10	Adoption of drip or sprinkler to increase water-use efficiency	18(22.50)	17(21.25)	60(75.00)	95(39.58)
11	Planting cover crops	15(18.75)	27(33.75)	48(60.00)	90(37.50)
12	Adoption of soil mulching	15(18.75)	22(27.50)	45(56.25)	82(34.17)
13	Stabilization of the bund by planting grasses/ tree sp.	12(15.00)	18(22.50)	36(45.00)	66(27.50)
14	Gully plugging to avoid soil loss	8(10.00)	13(16.25)	25(31.25)	46(19.17)
15	Construction of farm pond to store rain water	6(7.50)	9(11.25)	19(23.75)	34(14.17)

(Figures in parentheses depicts percentage)

Table 5. Adaptation pattern of fishery based farmers related to Fish rearing (n=240)

Sl. No	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Adoption of fish farming in addition to field crops	80(100.00)	80(100.00)	80(100.00)	240(100.00)
2	Starting fish farming to utilize time during off season	80(100.00)	73(91.25)	75(93.75)	228(95.00)
3	Adoption of fish farming to meet livelihood	75(93.75)	71(88.75)	69(86.25)	215(89.58)
4	Adoption of fish farming to meet emergency financial need	72(90.00)	74(92.50)	65(81.25)	211(87.92)

(Figures in parentheses depicts percentage)

Table 6. Adaptation pattern of fishery based farmers related to livestock management (n=240)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Start rearing sheep/goats to meet emergency financial need	13(16.25)	20(25.00)	43(53.75)	76(31.67)
2	Supplementary feed to livestock	6(7.50)	13(16.25)	29(36.25)	48(20.00)
3	Grown fodder crop in a small portion of irrigated area	2(2.50)	4(5.00)	35(43.75)	41(17.08)
4	Preservation of fodder	3(3.75)	8(10.00)	22(27.50)	33(13.75)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
5	Increasing number of small animals (sheep, goat) and decreased the number of big animals (buffalos and cows)	3(3.75)	4(5.00)	9(11.25)	16(6.67)
6	Planting improved grass slips	2(2.50)	2(2.50)	6(7.50)	10(4.17)
7	Owning of multi specific holding of livestock (cows + buffalos + goats + sheep)	1(1.25)	1(1.25)	3(3.75)	5(2.08)

(Figures in parentheses depicts percentage)

Table 7. Adaptation pattern of fishery based farmers on land use (n=240)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Use of organic manure	45(56.25)	52(65.00)	46(57.50)	143(59.58)
2	Site-specific demand-driven and balanced nutrients	13(16.25)	25(31.25)	57(71.25)	95(39.58)
3	Zero tillage, crop rotation to increase the yield	3(3.75)	8(10.00)	53(66.25)	64(26.67)
4	Bringing more dry land under cultivation to increase total yield even when rainfall is scarce	2(2.50)	9(11.25)	46(57.50)	57(23.75)
5	Intensified the agricultural activities on irrigated land	1(1.25)	7(8.75)	40(50.00)	57(23.75)

(Figures in parentheses depicts percentage)

Table 8. Adaptation strategies of fishery based farmers on labour use (n=240)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Increase the number of family labourers to avoid waged labourers	39(48.75)	46(57.50)	41(51.25)	126(52.50)
2	Reducing the number of labourers employed on farm	12(15.00)	13(16.25)	57(71.25)	82(34.17)
3	Adoption of labour saving implements for cultivation	1(1.25)	5(6.25)	45(56.25)	51(21.25)
4	Developing wastelands through water and nutrient management	3(3.75)	6(7.50)	36(45.00)	45(18.75)
5	Diversification of labour use from crop to livestock	1(1.25)	4(5.00)	14(17.50)	19(7.92)

(Figures in parentheses depicts percentage)

Table 9. Adaptation pattern of fishery based farmers related flood management (n=240)

Sl. No	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Use of Indigenous options such as walls of wood, stone or coconut leaf and afforestation to overcome flood effects	53(66.25)	62(77.50)	35(43.75)	150(62.50)
2	Use of Sandbags proving to avoid flood effect	21(26.25)	38(47.50)	63(78.75)	122(50.83)

Sl. No	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
3	Construction of Stone breakwater	25(31.25)	33(41.25)	58(72.50)	116(48.33)
4	Practicing New agricultural practices by growing salt-resistant crops	4(5.00)	12(15.00)	47(58.75)	63(26.25)
5	Establishing Improved drainage facilities	2(2.50)	6(7.50)	51(63.75)	59(24.58)
6	Use of Hazard insurance	1(1.25)	4(5.00)	42(52.50)	47(24.58)
7	Use of Desalination systems in the land	0(0.00)	3(3.75)	15(18.75)	18(7.50)
8	Use of Wetland Restoration practices	0(0.00)	2(2.50)	14(17.50)	16(6.67)

(Figures in parentheses depicts percentage)

Table 10. Adaptation pattern of fishery based farmers related to sea fish catching (n=240)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Risk management through insurance	45(56.25)	59(73.75)	72(90.00)	176(73.33)
2	Diversifying income into non-fishing activities, which may include aquaculture and tourism	8(10.00)	21(26.25)	42(52.50)	71(29.58)
3	Improving operational efficiencies, such as fuel efficiency and improved product handling, storage and preservation	3(3.75)	15(18.75)	35(43.75)	53(22.08)
4	Development of flexible fish product processing capacity for utilizing emergent resources	2(2.50)	8(10.00)	27(33.75)	37(15.42)
5	Purchasing larger, more sophisticated vessels with multi- fisheries capabilities to travel farther to catch sea fish	0(0.00)	2(2.50)	25(31.25)	27(11.25)
6	Maintaining multiple licenses or permits to allow shifting from one target species to another	0(0.00)	0(0.00)	5(6.25)	5(2.08)

(Figures in parentheses depicts percentage)

Table 11. Adaptation pattern of fishery based farmers related to financial management (n=240)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Barrowing loan from SHG's	49(61.25)	53(66.25)	20(25.00)	122(50.83)
2	Starting to save money during normal year for using during drought year	6(7.50)	13(16.25)	59(73.75)	78(32.50)
3	Barrowing loan from commercial bank/ primary land development bank (PLDB) for land development	2(2.50)	9(11.25)	41(51.25)	52(21.67)
4	Insuring crops of rainfed and irrigated land	2(2.50)	9(11.25)	39(48.75)	50(20.83)
5	Barrowing crop loan in credit cooperative societies	0(0.00)	5(6.25)	35(43.75)	40(16.67)

(Figures in parentheses depicts percentage)

Table 12. Adaptation pattern of fishery based farmers related to family management (n=240)

Sl. No.	Adaptation pattern	Marginal farmers (n_1=80)	Small farmers (n_2=80)	Big farmers (n_3=80)	Total
1	Reducing expenditure for social functions and festivals	73(91.25)	75(93.75)	42(52.50)	190(79.17)
2	Reducing spending on costly food items	69(86.25)	64(80.00)	38(47.50)	171(71.25)
3	Selling jewellary during the distress year	59(73.75)	42(52.50)	21(26.25)	122(50.83)
4	Barrowing food grains from relatives	38(47.50)	35(43.75)	25(31.25)	98(40.83)

(Figures in parentheses depicts percentage)

4. CONCLUSION

The climate change impacts and vulnerability in the agricultural and fishery sector increasingly recognize the important role of adaptation. In valuations of the 'costs' of climate change, specialists attempt to estimate adaptations that are likely to occur. In programs and policies to reduce vulnerability, practitioners try to identify adaptations that would be effective. In this study, findings revealed many interesting adaptation strategies of farmers to mitigate ill effects like the selection of short duration crops/varieties, contingency planning, soil and water conservation practices, crop rotation, mixed cropping, balanced fertilizer application, labour and financial management, etc. Among these, the extension workers have to identify the practical mitigation strategies and propagate them to reduce the vulnerability of the farmers to the climate change. The study also revealed that adaptation strategies recommend were perceived as moderately appropriate by farmers and also not accessible primarily to small and marginal farmers. This is a valuable feedback to research system. The scientists have to re-examine the performance of adaptation strategies at field level critically. For better crisis management, farming system research with interdisciplinary approach has to be taken up seriously by research system. Agricultural adaptation options at all levels are part of a larger process, within which decisions are made continuously, in an on-going, 'incremental' fashion, in light of multiple climatic and non-climatic stimuli and conditions. Those seeking to encourage adaptation need to recognize that producers, in particular, consider climate change, if at all, as part of their on-going management decision-making for sustainable crisis management.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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