Studies in Economics and International Finance
ISSN: 2583-1526
Vol. 1, No. 2, 2021, pp. 107-120

ARF INDIA
Academic Open Access Publishing
www.arfjournals.com

MITIGATION AND ADAPTATION MEASURES IN THE CONTEXT OF CLIMATE VARIABILITY IN PALAKKAD DISTRICT, KERALA

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ARTICLE HISTORY

Received : 29 October 2021
Revised : 03 December 2021
Accepted : 11 December 2021
Published : 30 December 2021

TO CITE THIS ARTICLE

Sumathy, M., & Muraleedharan, S. (2021). Mitigation and Adaptation Measures in the Context of Climate Variability in Palakkad District, Kerala. *Studies in Economics & International Finance*, Vol. 1, No. 2, pp. 107-120.

Abstract: There are three sectors such as primary, secondary and tertiary sectors in the economy which have contributed to the GHGs emissions in the atmosphere. According to Lerner's note (FAO 2012), Energy (25.9 %), residential and commercial building (19.4 %), forestry (17.4%), agriculture (13.5%), transport (13.1%), industry (7.9%), and waste and waste water (2.8%) emit GHGs in the atmosphere. Therefore, the land utilisation pattern in the district has been undergoing drastic changes during the last 30 years in Palakkad. Primary data is used to study the adaptation and mitigation policies practised by the selected sample farmers in the district. From the study it was found that adaptation policies are effective than the mitigation policies to minimise the impact of climate variability in Palakkad.

Keywords: Land utilisation Pattern, IPCC, Mitigation, Adaptation, Climate variability and climate vulnerability

1. INTRODUCTION

Palakkad district is included in the north central lateriate agro-climate zone which is adjacent to the southern high hills. Sample for the study was selected from central and eastern plains of Palakkad district which is sub humid lateriate zone. The land use pattern of Palakkad district in 1980 and 2010 displayed that land used for residential purposes, commercial purposes, public programmes, park and open space, transportation and vacant land increased whereas land used for the purposes like agricultural, industrial and construction of water bodies declined during the sametime (Master plan of Palakkad Town, Department of Town & Country Planning, 2016). Above all a considerable diminution was noticed in the

case of land put for agricultural purposes. Therefore, the land utilisation pattern in the district has been undergoing drastic changes during the last 30 years in Palakkad.

The first part of the paper discussed about the introduction and significance of the study the middle part discussed about the methods and tools applied, analysis and result of the study. The last part deals about the findings and conclusion of the study.

There are many studies about the climatic impact on the agricultural land. Agricultural sector is vulnerable both economically and physically in the context of climate change (Gbetibouo& Hassan, 2004). In the agricultural sector, yields could be reduced considerably due to the impacts of climate change, having drastic consequences on farmer's production. Individual farming from an environ-economical perspective need to be studied indepth in order to explore the possibility to mitigate and adapt to climate change in Kerala especially Palakkad. Climate change has significantly affected global agriculture in the 21st century and the Intergovernmental Panel on Climate Change (IPCC,1996) assessment report indicates that "most countries will experience an increase in average temperature, more frequent heat waves, more stressed water resources, desertification, and periods of heavy precipitation". In the agricultural sector, variability in rainfall and temperature could have considerable impact on the yield and thereby the socio-economic conditions of the farmers because it is an important contributor to employment and food security. The rising temperature and low rainfall would expose millions of people to drought and hunger in Kerala especially Palakkad because it is one of the most vulnerable districts (Kerala State Disaster Management, 2008). Therefore the crops cultivation in Palakkad is in critical situation. Climate variability is expected to affect the production of different crops leads to vulnerability. By climate Vulnerability we mean the future damages due to climate change.

1I. METHODS AND METHODOLOGY

The study used both qualitative and quantitative analysis The analysis is mainly based on the primary data. A structured questionnaire is used to collect the required data from357 farmers in Palakkad district. Palakkad district consists of 13 blocks. Out of these, four blocks were selected on the basis of predominance of crop cultivation. Palakkad district holds the first position in the production of rice (seasonal crop) and banana (annual crop). Coconut (perennial crop) is a traditional crop widely cultivated in the district. Mango is selected on the criteria that the mango city of Kerala (Muthalamada) is situated in Palakkad and its production is export oriented. Therefore, the selected crops are rice, banana, coconut and mango. The selected blocks consist of Chittur, Kollengode, Malampuzha and Kuzhalmannam. These blocks are selected on the basis of predominance of the

cultivation of selected crops. Applying the finite sample equation[1], the sample drawn is 357 from a population of 10101 farmers (four percent of the rice farmers and three percent each from all the other crops).

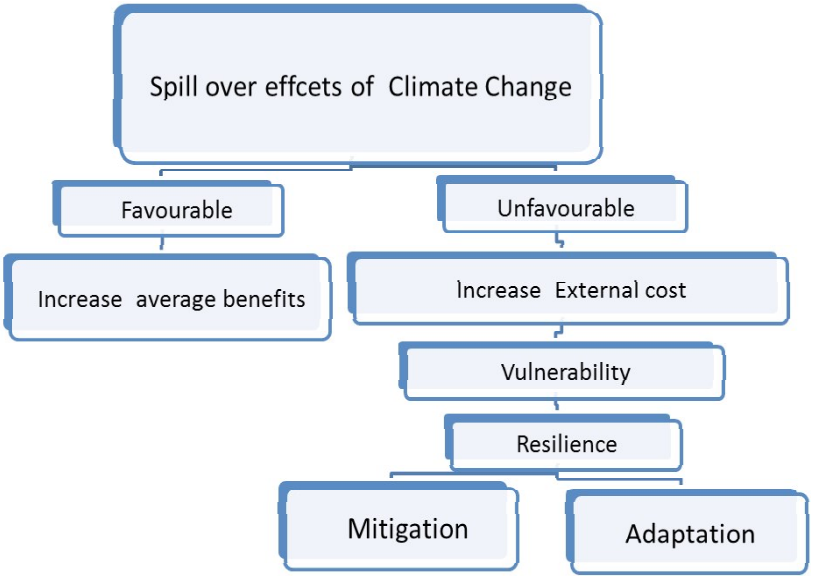

Chart 1: Theoretical Approach of Climate Variability

Chart 1 explains the spill over effects of climate variability. Climate variability creates negative and positive externalities. The negative impact of climate variability causes vulnerability in the agricultural sector. To minimise the negative impacts adaptation and mitigation policies are essential.

III. LAND UTILISATION PATTERN

Palakkad district comprised of 13 blocks. Out of which 6 are selected for the study the selected blocks are Alathur, Chittur, Kollengode, Kuzhalmannam, Malampuzha and Palakkad. Paddy is cultivated more in Alathur, Kuzhalmannam,Chittur and Kollengode. Banana is mainly cultivated in Palakkad, Chittur and Alathur. Alathur and Kollengode have more areas in mango cultivation.In the case of coconut, it is widely cultivated in Alathur, Chittur and Malapuzha blocks. The detailed numerical information is given in the table 1.

IV. MITIGATION STRATEGY

The three sectors such as primary, secondary and tertiary sectors in the economy have contributed to the Green House Gases (GHGs) emissions in the atmosphere. According to Lerner's note (FAO 2012), energy (25.9 %), residential and commercial

Table 1: Blockwise Area of Crops 2010-11 in Palakkad (Area in Hec)

Name of Blocks	*Paddy Area in Hec*	*% to district total Area in Hec*	*Banana area in Hec*	*% to district total Area in Hec*	*Mango area in Hec*	*% to district total Area in Hec*	*Coconut Area in Hec*	*% to district total Area in Hec*
Alathur	13037.26	14.9	481.65	3.38	766.04	9.84	5328.99	9.33
Chittur	9090.41	10.39	418.76	2.94	447.19	5.74	8003.05	14.02
Kollengode	7883.94	9	7.79	0.05	850.65	10.9	2900.52	5.08
Kuzhalmannam	16544.95	18.91	35.81	0.25	435.25	5.59	2531.66	4.43
Malampuzha	10250	11.71	133.15	0.94	462.96	5.94	4111.31	7.2
Palakkad	5959.96	6.81	516.95	3.63	420.72	5.4	2433.5	4.26

Source: Panchayath level Statistics, Palakkad 2011

Table 2: Number of Farmers Practising Mitigation and adaptation Strategies -Block Wise

Sl. No.	*Mitigation strategies*	*Policies practising by the selected sample Farmers*				
		Chittur Banana farmers only	*Kollengode Mango farmers only*	*Malampuzha Rice and coconut farmers only*	*Kuzhalmannam Rice, coconut and banana farmers*	*Total*
1	Soil conservation scheme	10	28	69	70	177 (49.58%)
2	Changed crop variety	5	7	20	23	55 (15.41%)
3	Planted trees	12	15	30	24	81 (22.69%)
4	Rainwater harvesting	5	13	20	26	64 (17.93%)
5	Off farm activities	2	10	46	33	91 (25.49%)
6	Late planting	9	0	17	29	55 (15.41%)
7	Earlier planting	5	0	15	29	49 (13.73%)
9	Construction of bunds across rivers	13	29	28	32	102 (28.57%)
10	Good agricultural practices	11	35	15	57	118 (33.05%)

Source: field survey.

building (19.4 %), forestry (17.4%), agriculture (13.5%), transport (13.1%), industry (7.9%), and waste and waste water (2.8%) emit GHGs in the atmosphere. Mitigation

strategies include actions aimed at reducing GHG concentration and creating carbon sinks through carbon sequestration in soils below and above ground. One type of mitigation strategy is to imposing tax on countries for carbon emission on the basis that those who emit more will pay more. IPCC (2014) synthesis report states that the measures of mitigation help to reduce the national, institutional and individual risk, willingness to change behavioural patterns and practices and to adopt social and technological innovations to reduce emissions. To minimise the climate change impacts adaptation and mitigation innovations are needed by farmers (Joshua Zake, 2015).

Table 2 shows the mitigation strategy introduced by the selected blocks in the district and the percentage of respondents who benefitted through these policies. The numerical figure inside the table shows the number of sample respondents' who pronounced about their mitigation activities.

V. MITIGATION MEASURES IN PRACTICE

1. Soil conservation scheme: Salau *et al.*, (2016), Prokopy *et al.,* (2008), Knowler and Bradshaw (2007) argued that soil conservation reduced the vulnerability of climate change. Table 2 shows that 10 respondents in selected panchayats in Chittur block opined that soil conservation scheme reduced the vulnerability pursued by a number of 28 mango farmers in the selected panchayaths from Kollengode block. The same was argued by 69 respondents in selected panchayaths in Malampuzha block and 70 respondents in selected panchayaths of Kuzhalmannam block. Altogether 49. 58 per cent of farmers practised soil conservation strategy to mitigate the climate vulnerability in the district.This type of mitigation strategy was more practised in the case of rice in Malampuzha and Kuzalmannam panchayats.
2. Construction of bunds across rivers: Construction of bunds and check dams across rivers help to avoid large flow of water in rivers (Brien *et al.,* 2006; Zhu *et al.*, 2010). The resultant stored water can be used for irrigation purpose. Of the sample respondents, 13, 29, 28 and 32 selected farmers from Chittur, Kollengode, Malampuzha and Kuzhalmannam blocks respectively received benefits through construction of bunds. Thus, 28.57 per cent farmers favours this mitigation policy.
3. Planted trees: Deforestation is one of the reasons for deficit rainfall& water conservation issues and therefore planting more trees helps toincrease rainfall and the ground water table (Cunningham *et al.*, 2015; UNFCCC, 2015). From the sample farmers, 12 from Chittur block, 15 from Kollengode block, 30 farmers from Malampuzha block and 24 respondents from Kuzhalmannam block are practising this policy. Therefore 22.69 per cent of sample farmers practising the policy of planting trees as a mitigation measure.

4. Off farm activities: Shifting from agricultural activities to other non-agricultural activities with regular salaried income was reported as a mitigation measure by 2, 10, 46 and 33 respondents from Chittur, Kollengode, Malampuzha and Kuzhalmannamblocks respectively. Therefore 25.49 per cent of respondents are engaged in other activities by avoiding agricultural practices.

VIII. MITIGATION AND ADAPTATION- A MIXED STRATEGY

1. Changed crop variety: Application of drought tolerant and more resistant crops help to avoid the loss arising due to lack of rainfall or high temperature (Attri and Rathore 2003,Mall *et al.*, 2004). From among the farmers interviewed, 5 from Chittur block, 7 from Kollengode block, 20 from Malampuzha block and 23 from Kuzhalmannam block have adopted this strategy for minimising the impact of climate variability. Therefore 15.41 per cent farmers applied different varieties of seeds. As a precautionary measure krishibhavan(krishibhavan is an intuitional set up among the farmers at local level) initiated awareness about the benefits of changed crop variety and the farmers executed the plan. This falls in the border line between mitigation and adaptation.
2. Rainwater harvesting: From the sample respondents, 5, 13, 20 and 26 farmers from Chittur, Kollengode, Malampuzha and Kuzhalmannam blocks respectively adopted various rainwater harvesting programmes for reducing the impact of climate variability. Altogether 17.93 per cent of farmers are practising rainwater harvesting programmes for reducing the vulnerability. Salau *et al.*, 2016 suggested that it as an adaption measure but in the case of Palakkad district adaption and mitigation measures are complementary to each other because these are like the two sides of the same coin.

VI. ADAPTATION STRATEGY

1. Late planting: Only limited number of farmers practised this policy for reducing the impact. Only 9 farmers in Chittur block and none of the farmers in Kollengode block follow such a measure because this panchayat is mainly concentrated on mango (a perennial crop) in which case regular planting is absent. 17 from Malampuzha block and 29 from Kuzhalmannam block engaged in late planting. 15 per cent farmers reported practising of late planting to avoid the vulnerability. Changing planting date is one of the best adapting policies to overcome the vulnerability of climate variability (Attri and Rathore, 2003; Salau *et al.*, 2016).
2. Earlier planting: On the contrary, 5 sample farmers from Chittur block, 15 from Malampuzha block and 29 farmers from Kuzhalmannam block engaged in the earlier plantingsystem of cultivation. None of the farmers from Kollengode block has practiced earlier planting because this panchayat is

mainly concentrated on mango (a perennial crop). Therefore, 13.73 per cent farmers engaged in earlier planting to reduce the vulnerability. Changing planting dates is one of the best policies to overcome the vulnerability of climate variability.(Attri and Rathore, 2003 Salau *et al.*, 2016).As per the information received from the Indian meteorological department (IMD), Krishibhavans of concerned Grama Panchayath gave instruction to the farmers for cultivating short or long duration crops. As per this some farmers practiced and avoided the vulnerable situation.

3. Good agricultural practices: Good agricultural operations like application of high yielding seeds, organic fertilisers, timely use of irrigation facilities and proper management of crops, etc. help to minimise the loss(World Bank report 2010, Kumar et. al., 2013). As regards practising such good measures, more farmers from Kollengode (35) and Kuzhalmannam (57) blocks follow such measures. It is less in Chittur (11) and Malampuzha (15) blocks. Therefore 33.05 per cent sample farmers argued that adaptation measure like good agricultural practices help to reduce the vulnerability of climate variability in the district.

Among these soil conservation strategies, good agricultural practices, benefits of construction of bunds across rivers and planting trees are the important strategies practiced by most of the farmers. Apart from this, rainwater harvesting, changing crop varieties, late planting and earlier planting also practised.Some of the respondents, however,discourse that it is not helpful to reduce the vulnerability though mitigation strategies are being practised. Therefore, it is necessary to test the effectiveness of mitigation strategies; for which, Kruskal Wallis test is performed by forming the hypothesis as:

H1: The Mitigation Strategies are Effective to Reduce the Vulnerability

Kruskal Wallis Test

The *Kruskal-Wallis test* is a nonparametric (distribution free) test, which is used to compare *three* or more groups of sample data. Here this test is used to evaluate the effectiveness of mitigation and adaptation strategies among rice, banana, coconut and mango farmers. As per this test, the variance of the opinion of the farmers (rice, mango,coconut and banana) is evaluated. Accordingly, the activities under each adaptation and mitigation are ranked by assigning lowest to highest values for highly effective to ineffective activities respectively. As per this scaling method, mean rank was interpreted as those crops take lowest mean rank is highly effective to mitigation and adaptation strategies. The result of the analysis is made known in the tables 3 & 4.

From the analysis it is found that the test result is not significant. So alternative hypothesis has rejected. Therefore, it can be agreed upon that the mitigation

Table 3: Farmer's Mean Rank for Mitigation Strategy

Mitigation Strategy	*Crop*	*No. of Farmers*	*Mean Rank*
	Rice	210	184.19
	Mango	50	182
	Coconut	55	151.67
	Banana	42	185.25
	Total	357	

Source: Field data

Table 4: Kruskal Walli's Test Result for Mitigation Strategy

Kruskal Wallis Test statistic	
chi-square	5.169
Df	3
Asymp.Sig.	0.16

strategies adopted by farmers with the help of *krishibhavans which* areassociated with relevant grama panchayat in the district are not helpful to reduce the vulnerability.There was no variance in the acceptance of the various mitigation policies among farmers as the mean rank farmers are more or less same for all types except coconut (table 3). All farmers in the sample have practiced same mitigation policies irrespective of the types of crops (seasonal, annual and perennial). But actually, different crops need different types of policies especially when the mitigation policies of seasonal crop are different from the policies of annual or perennial crops. But in Palakkad district, same types of policies are practised across crops. Therefore, the district has not been able to escape from the impact of climate induced vulnerability. Now the effectiveness of the adaptation strategies can be evaluated.

VII. ADAPTATION STRATEGIES

Adaptation measures reduce the negative effects of climate change on agricultural production and boost the positive ones through their impact on the ecological, social or economic systems (IPCC 2007). The United Nations Framework Convention on Climate Change refers to adaptation in several of its articles: For instance, Article 4.1(f) of it says: All Parties shall "take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessments, formulated and determined nationally, with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or

adapt climate change." For developing countries like India good adaptation and development policies are necessary and should be included in the national planning process (Stern 2007). Mainly there are three broad adaptive strategies that are suggested by Stern (2007). They are:

1. Agricultural adaptation
2. Water adaptation
3. Institutional adaptation

There are various activities under each adaptation strategy. To understand the preference of the farmers to each activity under various adaptation strategies, mode (highest frequency) is calculated.

1. Agricultural Adaptation: Under the agricultural adaptation strategy, such activities undertaken by farmers and the percentage of farmers in terms of their opinion about the effectiveness of such activities are reported in table 5.

Table 5: Measures Taken for Agricultural Adaptation and Farmers' Opinion on Their Effectiveness

Agricultural adaptation activities	*Percentage of respondents reporting effectiveness*				
	Highly effective	*Effective*	*Neither effective nor ineffective*	*Less effective*	*Ineffective*
Changing crop	28.0	23.0	12.0	26.3	10.1
Changing planting date	21.0	23.5	15.4	27.2	12.9
Changing farming practices	49.0	41.2	9.8	0.0	0.0
Rotation of cultivation	24.1	30.0	14.0	20.4	11.5
Application of machineries	5.6	5.6	14.3	48.7	25.8
Targetedpests and diseases	46.2	44.3	8.1	1.4	0.0
Integrated soil fertility management	41.7	49.3	7.8	0.6	0.6

Source: field survey 2016

As seen in table 5, 28 per cent of sample farmers opined that changing crop is highly effective for reducing the vulnerability, while an almost similar percentage (26.3 per cent) felt it to be less effective. It seems that changing the crop is suitable only in certain areas and not fit to other areas. The same is seen in the case of changing the planting date as well. But in the case of changing farming practices, almost half of the farmers (49 per cent) felt that it is highly effective for adapting to the climate impact. While 24.1 percent of sample farmers opined that rotation of cultivation will be effective, most of the farmers do not feel that the application

of machineries in agricultural land will reduce the impact of climate variability. As per the opinion of the most of the sample farmers, targeted practices for pests and diseases management as well as integrated soil fertility management are highly effective for reducing the negative impact of climate variability. Therefore changing crop, changing farming practices, targeted management of pests and diseases and integrated soil management policies are important agricultural adaptation activities (Kumar *et al.*, 2013; Attri and Rathore 2003).

2. Water Adaptation: Another adaptation strategy relates to water adaptation. Table 6 shows various activities taken by farmers under this strategy and the percentage of farmers who preferred these activities for adapting to climate vulnerability**.**

According to a lion shire of the farmers, water storage through activities such as increasing pond size, digging additional ponds near to the agricultural land is effective for reducing the vulnerability. Nearly half (44 per cent) of respondents consider this measure as highly effective. Increasing the canal size was rated as highly effective only to 12.9 percent of the farmers but about 60 percent of them rated as effective. The least effective method, as per the farmers, is giving new pipe connection to farmers as 14.3 per cent of them find it least effective while 40.1 per cent find it to be less effective. But rainwater harvesting and modern irrigation system are two measures that help to reduce the impact more effectively as preferred by most of the farmers. Water adaptation policies like water storage and increasing pond size are also effective. This reminds the argument of World Bank that more tactical use of dwindling groundwater for supplementary irrigation could be a useful strategy to cope with dry spells (World Bank Report 2010; Agricultural Development Policy, 2013).

Table 6: Measures Taken for Water Adaptation and Farmers' Opinion on their Effectiveness

Water adaptation measures	*Percentage of respondents reporting effectiveness*				
	Highly effective	*Effective*	*Neither effective nor ineffective*	*Less effective*	*Ineffective*
Water storage	44.0	47.6	8.4	0.0	0.0
Increasing canal size	12.9	59.1	28.0	0.0	0.0
Pipe connection	4.2	19.9	21.6	40.1	14.3
Rain water harvesting	43.7	46.8	7.3	2.2	0.0
Modern irrigation system	49.0	49.0	1.7	0.3	0.0

Source: field survey 2016

3. Institutional Adaptation: Another important adaptation strategy is institutional adaptation (Mobaya *et al.*, 2017;Mase *et al.*, 2017;Ness *et al.*, 2005). As seen in table 7, it is clear that provision of subsidies helps to reduce the impact of climate variability. Almost all the farmers favour provision of subsidies with half of them (51 per cent) rating this activity as highly effective. However, it is the provision of crop insurance to farmers that has been rated as most effective with all the farmers concurring to it and as high as three-fourth (74.5 per cent) express the view that the measure is highly effective to adapt to climate vulnerability. Provision of loans, accessibility of markets and research are highly effective tools for minimising the negative impact. Diversification of the products is seen to reduce the impact to a lesser extent. But urban migration is not a solution to overcome the adverse impact due to climate variability.

To understand the overall effectiveness of these adaptation strategies among the farmers, Kruskal Wallis test statistic is calculated based on the alternative hypothesis formulated:

H1: Adaption strategies are effective to reduce the vulnerability among farmers

From the Kruskal Wallis test, it is found that (table 8) all the adaptation strategies are significant at five per cent level.

On the basis of mean rank that was obtained from this test, crop wise impacts of these strategies are appraised (Table 9). Banana and coconut are most benefitted through agricultural adaptation policies as the mean ranks of these crops are low which implies that most of the farmers strongly agreed this adaptation policy as effective. The perennial crop mango and seasonal crop rice are benefitted through this adaptation but the benefit is lower than coconut and banana.

Table 7: Measures taken for institutional adaptation and Farmer's Opinion on their Effectiveness

Institutional adaptation measures	*Percentage of respondents according to reported effectiveness (%)*				
	Highly effective	*Effective*	*Neither effective nor ineffective*	*Less effective*	*Ineffective*
Subsidies	51.0	46.5	2.5	0.0	0.0
Insurance	74.5	25.5	0.0	0.0	0.0
Diversification of products	35.3	25.2	19.6	16.8	3.1
Provision of loans	49.9	17.6	0.3	28.9	3.4
Accessibility of markets	53.5	44.5	2.0	0.0	0.0
Research	56.3	43.1	0.6	0.0	0.0
Urban migration	0.0	0.0	19.6	52.7	27.7

Source: field survey 2016

Table 10 shows that the effectiveness of water adaptation strategy on rice, mango, coconut and banana farmers, as per the mean rank obtained for each crop through the Kruskal Wallis test. Water adaptation strategy is more effective to the rice farmers as the mean rank (163.87) for rice is the lowest, followed by mango (179.06), banana (195.55) and coconut (224.08). Adaptation of seasonal crop is more effective (as the mean rank of it is low) through the water adaptation strategy in the context of climate variability. Water adaptation is also effective for mango, coconut and banana but it is less than that of rice.

Table 8: Statistical Significance of Agricultural, Water and Institutional Adaptations

Adaptation Strategy	*chi-square value*	*level of significance*
Agricultural adaptation	13.537	0.004
Water adaptation	19.284	0.000
Institutional adaptation	10.843	0.013

Table 9: Mean Rank of the Farmers for Agricultural Adaptation

Agricultural adaptation strategy	*type of crops*	*no of farmers*	*mean rank*
	Rice	210	186.05
	Mango	50	203.67
	Coconut	55	158.98
	Banana	42	140.6
	Total	357	

Table 10: Farmer's Mean Rank for Water Adaptation Strategy

Strategy	*Type of Crop*	*No. of Farmers*	*Mean Rank*
Water adaptation	Rice	210	163.87
	Mango	50	179.06
	Coconut	55	224.08
	Banana	42	195.55
	Total	357	

Table 11: Farmers' Mean Rank for Institutional Adaptation Strategy

Strategy	*Type of Crop*	*No. of Farmers*	*Mean Rank*
Institutional adaptation	Rice	210	169.14
	Mango	50	198.74
	Coconut	55	206.87
	Banana	42	168.31
	Total	357	

The impact of institutional policies on selected crops to reduce their climate vulnerability is reported in table 11. Institutional policies are more effective to the banana and rice farmers as the mean rank is lowest for these crops. The mean rank of banana farmers (168.31) was the lowest, followed by the rice (169.14), mango (198.74) and coconut (206.87). Rice and banana farmers seem to be getting more institutional support than mango and coconut farmers.

All the three adaptation strategies are effective to solve the vulnerability arises due to climate. But particular type of crop is more benefitted through these different adaptations. Rice and banana have more benefits (based low mean rank in the table 11) and coconut gets the least benefits from these three adaptations based on lower and higher means rank values. Therefore, farmers shall be more aware about the type of activities followed in their crop cultivation.

VIII. CONCLUSIONS

From the study it was found that all the initiatives under adaptation are very helpful to the farmers to reduce their problems due to climate variability. Because of the mitigation and adaptation policies in Palakkad district crop failure during the drought year (especially 2016) could be lessened, to some extent. As per the opinions of the agricultural experts in Krishibhavans "the loss during last drought year is only one per cent in Chittur municipality and even that happened because some farmers did not cultivate as per the directions of Krishibhavan".

The main drawback noticed was lack of implementation of rain water harvesting system. Therefore, initiatives must be undertaken by the panchayats through Krishibhavans for harvesting rain water. Each farmer must set up rain water harvesting system. This will help them to use water even when dam water is not provided during cultivation period. Therefore, the district must introduce various policies apart from the ones presently introduced. The correct information from the meteorological department will also be helpful for the farmers to take necessary measures. The goal of maximising societal welfare under future climate risk would likely involve a mix of both mitigation and adaptation (Howden *et al.*, 2007).

Notes

1. Finite sample equation -$n = n_0N \div n_0 + (N-1)$ (n_0– sample, N-population)

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