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Climate Change Adaptation Strategies by Paddy Growing Farmers : A Case Study in Tungabhadra Command Area of Karnataka, India

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ABSTRACT

The present study is an effort to analyse paddy-growers' adaptation methods in the Tungabhadra command area of Karnataka state, India, over time in response to the climate change. Various adaptation techniques have been identified in the study including changes in farming practices such as adjusting planting dates and strategic approach in fertilizer management. According to the respondents, using these adaptation measures helps to reduce vulnerability and improve their 'socio-economic status'and 'quality of life'. Farmers on the other hand adapt to the changing climate to ensure long-term productivity. The area under paddy crop experienced a substantial negative growth rate owing to Tungabhadra Command area's erratic irrigation water flow in the taluk. In the three water regimes, various coping techniques were used by sample farmers in the research area to overcome irrigation shortages caused by climate change are reported separately. Change of sowing dates based on releasing canal water and increased use of application of water management methods, followed by the use of groundwater for irrigation, were significant factors that were used as coping strategies. Migration was another technique used by the respondents to sustain their incomes, but it was not as important as it had been previously.

Keywords : Climate change, Irrigation water shortage, Adaptation strategies, Climate crisis, Paddy cultivation, Tungabhadra command area

CLIMATE change could put extra strain on India's natural and social systems, which are already under enormous strain as a result of rising population, urbanisation, industrialisation and economic growth. India ranks fifth among 181 countries in terms of vulnerability to climate change with its poorest citizens being the most vulnerable (Eckstein *et al*., 2019). Due to its little arable land in relation to larger population and greater reliance on agriculture, monsoon-dependent farming and low technological and financial development for climate change adaptation. Thus making India as one of the most affected countries in terms of climate change and natural hazards (Birthal *et al*., 2014). Developing countries are more vulnerable to climate change than the developed countries due to predominance of agriculture in their economies and their warmer baseline climates (Ningoji *et al*., 2021). Crop productivity, in particular is anticipated to suffer. In the context of abundance of literature on climate change adaptation tactics, this study is one of the few that analyses farmer-led adaptation solutions and this research contributes to a greater understanding of the importance of farmer-led adaptation techniques, which in turn aid in the development or modification of existing climate change adaptation technologies. In this climate change scenario, farmers must be able to adapt coping strategies to ensure long-term output and these adaptation measures can help people minimize their susceptibility and improve their 'socio-economic status' and 'quality of life'. Suchfarmer-led adaptation measures that deal with climate change must be documented. There is a growing interest in the potential implications of climate change on agricultural, economic growth and sustainable development in the command areas. Changes in soil moisture, soil quality, crop resilience, timing/length of growing seasons, crop productivity, air temperatures, unprecedented droughts and other effects of climate change are only a few examples (Ozor and Nnaji, 2011) that necessitates adaptation strategies. Widespread poverty, over-reliance on rain-fed agriculture, inequitable land distribution, restricted access to employment

suplementing and technology, inadequate public infrastructure such as roads, long-term weather forecasts and inadequate research and extension exacerbate the situation. (Watson *et al*., 1998). Climate stresses will push the most vulnerable people over an all-too-low threshold into insecurity and poverty that violates their rights (Devkotaa and Paijab, 2020). Rice is an essential agricultural commodity and a key staple meal for more than half of the world's population (Darekar and Reddy, 2017). Paddy crop holds the key for food security of the country (Bora *et al*., 2021). Around 90 per cent of the world's paddy farming and output production takes place in Asia (Rani *et al*., 2014). Therefore, the purpose of this research is to analyze the agricultural adaptation tactics used by farmers of TBP command area to mitigate the effects of climate change on productivity and farm incomes.

Definition of Adaptation Strategies : Adapting to climate change means making the necessary modifications and changes to mitigate the negative effects of climate change. Changes or remolding of techniques or practices used by farmers in their farming, such as crop production, soil and water management, drought management, land use of farms, labour use, livestock management, income and financial management and family management to cope with losses or take advantage of climate change are operationally defined as adaptation strategies (Shanabhoga *et al*., 2020). Adaptation is defined by the Intergovernmental Panel on Climate Change (2007) as changes in natural or human systems in response to present or anticipated climatic stimuli or impacts, which mitigates harm or maximizes benefits. It also refers to the steps that individuals, countries and societies take to adapt to the effects of climate change. Therefore, adaptation can have three goals : Lowering the risk of damage; increasing the capacity to deal with unavoidable damages and taking advantage of new opportunities due to changes in climate situations.

Problem Statement : Karnataka is one of the most water-stressed States in India, with 61 per cent of the state and having the fifth highest drought prone area in 2003. Tungabhadra command area is considered as a lifeline for Koppal, Bellary and Raichur districts in Karnataka. The Tungabhadra Left Bank Canal (TLBC) provide irrigation water to these districts and irrigated agriculture in TLBC is constrained by climatic, technical and institutional factors. Climate change is one of the important factors which have a negative impact on crop output due to long-term changes in rainfall patterns. The variation in the rainfall pattern in the region over the years is depicted in Fig. 1. The inflow of water to the reservoirs is affected by these changes in rainfall patterns and there was asignificant decrease in rainfall which impacted on inflow of water into the reservoir. This in turn has negatively influenced on the water storage and the release by the Tungabhadra command area (TCA) committee resulting in farmers not receiving adequate irrigation water for paddy crop and forced them to change cropping pattern and crop operation calendar. Fig. 2. depicts the decreasing trend in inflow of water to the TCA reservoir. This was further complicated by frequent drought in semi - arid region.

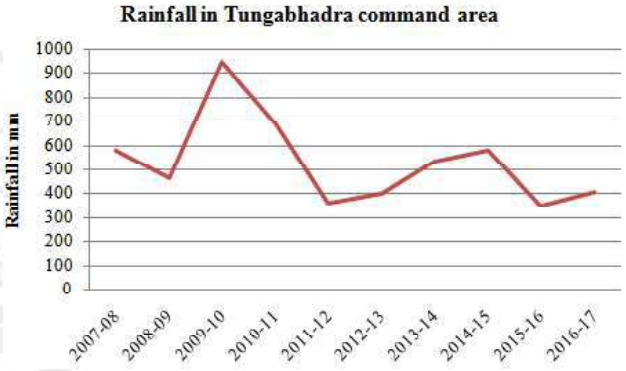

Fig. 1: Rainfall in Tungabhadra command area

Source : District at a glance (2015-2016), Department of Agriculture, Government of Karnataka

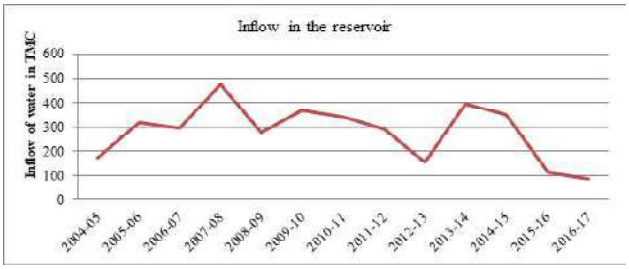

Fig. 2 : Inflow of water into the Tungabhadra reservoir over the years

Source : Annual report of command area development authority. Tungabhadra Project, Munirabad (2019)

(*Note* : TMC-Thousand Million Cubic Feet)

According to the Revenue department, districts in the downstream of Tungabhadra sub-basin especially the Koppal, Bellary and Raichur which have faced serious drought for more than 10 years in the last 16 years. (Anonymous, 2019). The population growth in Sindhnaur, Gangavati, Manvi and Raichur lead to farm fragmentation thereby resulted in increased cropping intensities, increased demand for irrigation water far beyond the original design capacity significantly. In future, *kharif* season irrigation water supplies face greater threat due to water stress on account of climate change, this may result in greater water shortages in the long-run. Severe temperature resulted in increased evaporation from storage reservoirs and higher crop water requirements.

Even though the TCA is canal fed, the farmers in this region are facing irrigation water shortage for the past three years. Canal water in TCA area is released every year in the month of july only after monsoon rains with rise in water level in the Tungabhadra reservoir. Paddy being a water intense and predominant crop in the TCA of Gangavathi taluk, the propects of the crop depends on the stored water in the reservoir, thereby looking into the above issues, the study on paddy growers to analyze the adaptation strategies to the climate change.

If farmers start raising paddy nursery after release of canal water (July month), transplanting will be delayed to August-September and then every operation is delayed and the yield will get affected. Due to this problem, farmers are cultivating only one crop instead of two paddy crops in a year. This has led to problems like decreased paddy production in the region, thereby causing decreased household income and employment opportunities. In any large-scale irrigation system like Tungabhadra Command Area, there will be inequality in distribution of irrigation water. The head reach farmers and the tail-end reach farmers are in very different positions. Narrowly selfish head reach farmers would ignore the shortage that they generate for those lower in the system (Ostrom and Gardner, 1993). But if the head reach farmers get most of the water, those at the tail end farmers will have lesser access to the irrigation water. Hence, to document the adaptation strategies from the paddy growers, the total TBP command area was divided into three water access regimes based on the extent availability of water.

Methodology

The present study is an attempt to document all the adaptation practices, practiced by paddy-growers over time to mitigate the climate crisis in the TCA of Karnataka state. A cross-sectional and questionnaire-based survey was conducted to collect primary data. A total of 120 paddy-growing farmers of the region were selected as respondents for the survey and 40 each from three different water regimes *i.e.,* head, middle and tail end reach. The descriptive statistics was used to analyse and interpret the collected data.

Results and Discussion

The results and discussion parts are mainly divided into three parts for better documentation of the adaptation strategies by the paddy growing farmers in the study area. First part documents the socio-economic characteristics of the sample respondents, second part deals with the coping strategies adopted by the sample respondents to overcome irrigation water shortage and the third part deals with the coping mechanisms adopted by the sample farmers in the study area to sustain farm household income. In both the cases the strategies were documented separately for the three water access regimes as there is inequality in the availability of irrigation water.

Socio-economic Features of Sample Respondent's : Socio-economic characteristics of the sample respondents like family size, education level, landholdings and income of the households across different irrigation water regimes have been recorded in Table 1. The family size of mid-reach farmers was bigger than both head and tail-end reach farmers indicating that more number of family labour availability. The sample respondents had an average land holding of 4.77, 4.96 and 6.06 acres in the head, mid and tail-end reach, respectively which showed that average land holding of tail-end reach farmers was more compared to head and middle reach farmer

TABLE 1

Socio-economic features of sample respondents

Particulars	Head reach (n=40)	Middle Reach (n=40)	Tail-end reach (n=40)	Significance (F test)
Family size (no.)	4	6	5	6.53*
Education level of family head (No. of years of schooling)	7	6	8	2.09^{NS}
Landholding (acres)	4.77	4.96	6.06	3.36**
The area under paddy (acres)	4.77 (100)	4.76 (95.97)	5.9 (97.36)	-
No. of crops taken in a year	2#	2#	1	-
Annual household income (Rs)	6,35,293	6,25,163	5,66,263	0.06^{NS}
Change in household income over head reach	100.00	-1.60	-10.87	-

Note: Figures in parentheses indicate per cent to total sample respondents
* Significance at 5%; ** Significance at 1%; # With supplementary irrigation

implied of a significant difference among the three regimes. Both head and middle reach sample respondents had taken two crops in a year with the help of supplementary irrigation but due to water shortage, many farmers in tail-end reach were able to take only one crop in a year (Table 1). The annual household income of head, mid and tail end reach farmers were Rs.6,35,293, Rs.6,25,163 and Rs.5,66,263, respectively which indicated that the household income of the tail end reach farmers was low compared to head and middle reach farmers. The difference in income between two canal regimes over head regime implied of only 1.60 per cent lower income in middle reach while, it was 10.87 per cent decline in tail reach over head reach showed of high reduction in tail reach. This indicated the need for equity in water distribution and income level.

Out of the total respondents in different water access regimes, 32.50, 25 and 42.50 per cent respondents had primary education in the head, middle and tail end reach farmers, respectively. A total of 17.50, 10 and 22.50 per cent of respondents had education up to pre-university level in the head, mid and tail end reach regions, respectively. In the head, mid and tail reach, 12.50, 30 and 7.50 per cent of respondents were illiterate (Table 2). This indicated that in mid reach, the education level of farmers was less compared to head and tail-end reach. Number of farmers who gave their land for lease was more in tail-end reach because the farmers in tail-end reach were in high risk of getting irrigation water to their lands and hence gave their lands for lease on a rental basis to avoid the risk.

Coping Strategies Adopted by the Sample Respondents in the Study Area to Overcome Irrigation Water Shortage

Karnataka is the second largest state of India and it is characterized by severe climatic effects such as droughts and floods in the recent past. However, the presence of major irrigation projects allowed the farmers to cultivate the different food crops and predominantly paddy. The major irrigation project Tungabhadra area is referred to as the 'Rice Bowl of Karnataka', as nearly 65.00 per cent of the total (3.63 lakh ha) area of paddy in Karnataka including the Tungabhadra Project (TBP) command area (Ballari, Koppal and Raichur districts). Farmers use several methods to adapt to water scarcity: changing cropping patterns, crafting collective irrigation rules, reusing agricultural drainage water, practicing deficit and light irrigation and over-irrigating owing to availability of water.

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TABLE 2

Age, education and land holding classification of sample respondents

Classification	Head-reach		Mid-reach		Tail-end	
	No. of respondents (n=40)	Average	No. of respondents (n=40)	Average	No. of respondents (n=40)	Average
Age group (years)		*Age*		*Age*		*Age*
Below 35	04 (10.00)	29	004 (10.00)	30	11 (27.50)	29
35-50	32 (80.00)	42	32 (80.00)	40	28 (70.00)	45
Above 50	04 (10.00)	51	4 (10.00)	55	01 (02.50)	51
Overall	40 (100)	42	40 (100.00)	43	40 (100.00)	38
Education level (years of schooling)						
Primary	13 (32.50)		10 (25.00)		17(42.50)	-
High School	11 (27.50)		12 (30.00)		07(17.50)	-
Pre-university	07 (17.50)		04 (10.00)		09(22.50)	-
Degree	04 (10.00)		02 (05.00)		04(10.00)	-
Illiterate	05 (12.50)		12 (30.00)		03(07.50)	-
Landholding (acres)		*Land holding*		*Land holding*		*Land holding*
Own land	36 (90.00)	3.68	35 (87.50)	2.89	36 (90.00)	3.99
Leased in	03 (07.50)	03	07 (17.50)	1.3	03 (07.50)	0.37
Leased out	04 (10.00)	04	01 (02.50)	0.25	08 (20.00)	1.82
Overall	40 (100)	4.77	40 (100)	4.96	40 (100)	6.06

Note : Figures in parentheses indicate per cent to total sample respondents

Use of Groundwater for Irrigation (Bore wells) : It is evident from Table 3 that 25.84 per cent farmers have used groundwater (bore wells) for irrigation of paddy crop. In head-reach, 12.5 per cent used groundwater (bore wells) for irrigation purpose in the summer season to irrigate the second paddy crop while 30 per cent of farmers in middle reach and 35 per cent farmers in tail-end reach. The highest number of farmers using groundwater to cope up with the irrigation water shortage was found in tail-end reach followed by middle and head reach. It was due to inequitable water distribution in three different water access regimes. In the tail-end, paddy growing farmers were aware of the insufficient water supply hence they had

TABLE 3

Coping mechanisms adopted by the sample farmers in the study area to overcome irrigation shortage

Particulars	No. of farmers (n=120)			Overall
	Head-reach (n=40)	Mid-reach (n=40)	Tail-end reach (n=40)	
Use of groundwater for irrigation (Bore wells)	5 (12.50)	12 (30.00)	14 (35.00)	31 (25.84)
Use of water from farm ponds	9 (22.50)	6 (15.00)	4 (10.00)	19 (15.83)
Growing light irrigated crops	2 (05.00)	3 (07.50)	6 (15.00)	11 (09.17)
Leaving the land fallow	2 (05.00)	7 (17.50)	9 (22.50)	18 (15.00)
Changed sowing dates according to release of water from dam and increased water management practices	18 (45.00)	10 (25.00)	7 (17.50)	35 (29.17)

Note : Figures in parentheses indicate the percentage contribution to the total respondents

more bore wells as a source of irrigation water but in head reach, since they had access to sufficient irrigation water supply depending on groundwater was less.

Use of Water from nearby Farm Ponds : Many farmers in the study area used water from nearby farm ponds to irrigate their paddy fields during the irregular supply of irrigation water especially during summer season when the supply of irrigation water was inadequate. Farm ponds add value to farming activities by means of water supply to domestic as well as for livestock. Farm ponds serve irrigation facilities not only for growing crops but also support rising of fishes in TBP (Tungabhadra Project) command area (Venu *et al*., 2015). A total of 15.83 per cent farmers used water from nearby water ponds. Some farmers had ponds in their fields and some farmers used tank water which were naturally present nearby their fields.

Canal water in the study area is released in the month of July after the onset of monsoon rains and the rise in the water level in Tungabhadra reservoir. Paddy being predominant crop in TBP command area, if farmers start raising paddy nursery after the release of canal water, transplanting will be delayed to August-September. Hence, farmers use farm pond water stored during the previous year to raise paddy nursery in the month of June for *kharif* crop. By the time water is released into canals, paddy seedlings will be ready for transplanting. Hence, farmers construct farm ponds and store available canal water during July to March after meeting irrigation needs of the crop. Thus, stored water is also used for *rabi/summer* crop after canal water is closed in the monthof March- April.

In head-reach, nine farmers used water from farm ponds constituting 22.50 per cent of total farmers in the study area. While, in middle reach a total of 15 per cent of farmers and in tail-end reach, 10 per cent of farmers used irrigation water from nearby ponds to cultivate the second crop during the summer.

Growing Light Irrigated Crops : Paddy was the major crop which was cultivated during *kharif* and *summer* season in the command area. However, due to water shortage, 15.83 per cent of the farmers reduced area under paddy cultivation and shifted towards light irrigated crops like *rabi* jowar, maize and chickpea. Results from Table 3 showed that 5 per cent farmers in head reach, 7.50 per cent farmers from middle-reach and 15 per cent farmers from tail-end reach shifted towards light irrigated crops to overcome water shortage. Due to shortage of irrigation water in the tail-end reach, more farmers in tail-end reach shifted to light irrigated crop than in head and middle reach.

Leaving the Land Fallow : Owing to the water shortage, many farmers have left the land fallow especially during the *summer* season for the second crop. In head reach 5.00 per cent farmers left the land fallow without any cultivation, in middle reach 17.50 per cent and in tail-end reach 22.50 per cent of farmers left the land fallow which was quite high when compared to head and middle reach farmers (Table 3). A total of 15.00 per cent of the total farmers left the land fallow mainly because of the shortage of irrigation water and irregular supply of canal water from Tungabhadra Command Area. Few large farmers cultivated paddy only in few acres where they were able to get water from other sources and left the remaining land holdings as fallow.

Change of Sowing Dates Based on Canal Water Supply from Reservoir and Increased Water Management Practices : The *kharif* paddy crop was grown from June to November in the study area. However, water was released from Tungabhadra reservoir in the last week of July to the first week of November / December. For the *summer* crop which was grown from December to February, the command area did not release water regularly and adequately. Even though TBP (Tungabhadra Project) area is a canal fed, the release of canal water varies with the onset of monsoon rains and water level in TB dam. Hence, it is very much difficult for paddy growing farmers for raising paddy nursery before the releasing of canal water and after the closing of canal water during the months of April-June (Venu *et al*., 2015). Some farmers during survey expressed that they had to adjust the sowing dates of paddy to the release of water. Farmers who planted paddy as per regular timings did not get good yields, the crop has failed due

to unavailability of water in time. A total of 87.50 per cent farmers started water management practices for efficient use of available water. In head-reach 45.00 per cent of farmers, in middle reach 25.00 per cent farmers and in tail-end 17.50 per cent farmers adjusted their sowing dates (Table 3). A total of 35 farmers in the study area managed to change the timings of sowing paddy crop and started efficient utilization of available irrigation water (29.17 %).

Coping Mechanisms Adopted by the Sample Farmers in the Study Area to Sustainfarm Household Income

Due to the problem of water shortage, farmers in the study area were able to take up only one paddy crop over two crops in a year, which is one of the main cause of low income. To sustain their household income, farmers started engaging in other activities. Many farmers engaged themselves in petty businesses and in allied activities, worked under Government work schemes such as MGNREGA, migrated to urban areas in search of jobs, gave their lands on lease and even some of the farmers went for off-farm employment labour just to sustain their household income during water shortage problem.

Went for Other Labour Works : The farmers in the study area, especially small farmers engaged in non-farm labour employment activities like construction works, daily wage labour works etc. in their villages and also nearby cities and towns, to sustain their household income due to water shortage. In head-reach,15 per cent of the total households in the head-reach regime went for labour works. Similarly, in the middle and tail-end reach, eight and 12 households went for other labour works constituting 20 per cent and 30 per cent of the total households in their respective regimes. A total of 26 households (21.61 %) went for other labour works in order to sustain their family income and to meet the basic needs of the household during water shortage.

Engaged themselves in Petty Businesses : To sustain the family income during summer season the households in the command area were engaged themselves in some petty businesses. In head-reach, three households (7.5 %) of the total households in head-reach started petty businesses in the villages, opening of hotels and becoming sales persons for daily essentials etc. In middle reach 15.00 per cent of households and in tail-end reach 10.00 per cent of households engaged themselves in such petty businesses to fulfill their family needs. A total of 32.50 per cent of households started some petty businesses in order to sustain their respective family income.

Table 4

Coping mechanisms adopted by the sample farmers in the study area to sustain farm household income

Particulars	No. of farmers (n=120)			Overall
	Head-reach (n=40)	Mid-reach (n=40)	Tail-end reach (n=40)	
Went for other labour works	6 (15.00)	8 (20.00)	12 (30.00)	26 (21.60)
Engaged themselves in petty businesses	3 (07.50)	6 (15.00)	4 (10.00)	13 (32.50)
Worked under Udyog Khatri Yojana (Govt. work schemes) which comes under gram panchayats.	6 (15.00)	3 (07.50)	7(17.50)	16 (13.30)
Migration to urban areas in search of employment (especially for construction works)	2 (05.00)	4 (10.00)	5 (12.50)	11 (09.16)
Giving land for lease	1 (02.50)	2 (05.00)	4 (10.00)	7 (05.83)
Working in others farms as wage labour	9 (22.50)	15 (37.50)	13 (32.50)	37 (30.80)
Engaging in allied activities (Livestock, poultry, fisheries etc.)	4 (10.00)	3 (07.50)	6 (15.00)	13 (10.80)

Note : Figures in parentheses indicate the per cent contribution of sample respondents adopting the coping strategies

Worked under Udyog Khatri Yojana (Govt. Work Schemes) : The farmers in the study area during water shortage (summer season) worked under Udyog Khatri Yojana which was sponsored by Government to give employment to rural people. These programmes were provided to the villagers under gram panchayath of respective villages and many small farmers were able to do works under these programmes to earn the basic income for the family. In the head, mid and tail-reach the percentage of households worked under these programmes were 15.00 per cent, 7.50 per cent and 17.50 per cent, respectively. In the study area, a total of 13.30 per cent of households were able to find work under such programmes.

Migration to Urban Areas in Search of Employment (Especially for Construction Works) : Due to lack of employment opportunities in the study area, small farmers migrated to urban areas like Bengaluru for finding jobs in construction sector. There is a clear connection between water scarcity, food insecurity, social instability which in turn can trigger and intensify migration patterns throughout the world. Trends of increasing water scarcity show that this will impact heavily-dependent water jobs, threatening its sustainability. The increase of 'water-scarce' countries will affect income-generating opportunities (Anonymous, 2006). In head reach, five per cent of the households migrated to urban areas in order to find employment opportunities. In the middle and tail-end reach 10.00 per cent and five 12.50 per cent of households opted for migration and in that way, they tried to sustain their household income. In head reach, there was very less number of households compared to tail and middle reach households who opted for migration because those farmers in head reach were better in getting irrigation water than those of tail and middle reach farmers. A total of 9.16 per cent of households migrated to urban areas to find employment opportunities and to sustain their family income.

Leasing of Land and its Extent : The practice of leasing land for cultivation was a common in the study area. The lease out of land takes place on crop output sharing or either on rental payment of the land. A total of 2.50 per cent of households has given land for cultivation on crop output sharing basis in head reach and in middle and tail-end reach 5.00 per cent and 10 per cent of households, respectively had given their lands for lease. It was mainly to avoid the risk of lowering crop yields and income from crop production due to water shortage. The farmers in the study area found it better option to give their lands on lease so that they will be getting some fixed amount of income regularly from land. A total of 30.83 per cent of households worked on other farms to sustain their family income. In the head, middle and tail reach 22.50, 37.50 and 32.50 per cent of households, respectively worked on other farms to sustain their family income.

Dependence on Allied Activities : In order to sustain the family income, engaging in allied activities was another coping mechanism. Some of the farmers in the study area are engaged in various allied activities along with farming to supplement their income throughout the year specially to overcome water shortage. Allied activities such as livestock, poultry and fisheries were some of the promising enterprises for the farmers to sustain their family income. In head reach, 10.00 per cent of households engaged themselves in allied activities. Similarly, in middle and tail-end reach, 7.50 per cent and 15.00 per cent of households started allied activities to sustain their household income.

The area under paddy crop had a significant negative growth rate which was mainly due to the irregular release of irrigation water from the Tungabhadra Command Area in the Taluk. This is mainly due to the rainfall reduction which can be attributed to the climate change impact. Various coping mechanisms adopted by the sample farmers in the study area to overcome irrigation shortage which is due to climate change are documented separately for three water regimes and it was observed that the water shortage problem was severe in the tail end than in the middle and head reach farmers. Significant factor which was adopted as a coping strategy was changed the sowing dates according to the release of water from dam and increased water management practices followed by use of groundwater for irrigation (Bore wells). The study also summarizes the coping mechanisms adopted

by the sample farmers in the study area to sustain farm household income and it was found that majority of the respondents (32 %) engaged themselves in petty businesses followed by working in others farms as wage labour. Migration was another strategy by the respondents to sustain the income but it was not significant as it only attributed to around nine per cent of the respondent's strategies.

Awareness among farmers needs to be created regarding advantages of diversified farming and also there is a need for evolving suitable crop plan with modern farming practices. Farmers should engage themselves in allied activities such as livestock, poultry, fisheries etc., along with crop production to sustain their household income. Farmers should be educated regarding the research-based recommendations and water saving technologies on the farm which would enhance crop productivity and income, thereby strengthening livelihood security of the farmers in command areas.

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