*Original Research Article*

# Farmer's perception towards climate changeandextent of adoption of adaptationstrategies in North Eastern Transition Zone of Karnataka state in India during the period 1979-2019


**Abstract**

A primary survey was carried out among the 240 farmers of Bidar and Gulbarga districts of North Eastern Transition Zone in Karnataka using the percentage analysis, Garrette ranking, five year moving averages and logitanlaysis to assess the farmer's perception on climate change and validate their opinion. About 74 percent of farmers opined that, there is a decline in crop yield and 83 percent of farmers expressed is a shift of employment from farm to non-farm activities. Most of the farmers practiced alteration of sowing dates of crop as adaptation strategy followed by using of drought tolerant varieties and mixed cropping.Socio-economic attributes of households influencing adaptation strategy were age of the farmer (negative), climate information (positive) and size of area(positive). Majority of farmers (79 percent) stated the lack of funds as major challenge towards low adoption of adaptation approaches.


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**Keyword**:Adaptative strategies ,Climate change, Farmer perception , Karnataka ,North eastern transition zone ,Validation


## Introduction

India experienced at least one drought in every three years in the last five decades. However, the main concern is the increase in the frequency and spatial extent of prolonged droughts (Mishra and Singh, 2010). In India, about 50.8 Million ha of the geographical area is arid and nearly 123.4 Million ha is semi-arid zone (Kar et al., 2009). Semi arid zone contributes about 42 percent of total food grain production, supporting 60 percent of livestock population and employing nearly 37 percent of marginal farmers through agricultural activities. It consist states like Andhra Pradesh, Karnataka, Tamil Nadu, parts of Gujarat and Maharashtra. The regions are dominated with cultivation of major crops like rice, wheat, sugarcane, pulses, sorghum and Tur. This zone is susceptible with famine , water shortages and land degradation. With rising temperatures, semi-arid regions of western India are expected to receive higher rainfall, while central regions are likely to experience a 10 to 20 percent decrease in winter rainfall by 2050 ( Ranuzzi and Srivastava, 2012). Furthermore, these semi arid agro ecological regions are affected by water shortages, which impact agriculture (Gajbhiye and Mandal, 2012).

Karnataka is one of the major agrarian states in India, which is often affected by natural calamities and it ranks second after Rajasthan in terms of drought prone. It has 50 percent of the area as semi arid with frequent unequal distribution of rainfall for every 5 years and severe drought conditions for once in every 8-9 years (KNDMS, 2016). It is located between 11° 40' N and 18° 27' N latitudes and between 74° 5' E and 78° 33' E longitudes covering an area of 19.1 million hectares. It totally accounts 5.8 percent of the country's total geographical area. The spatial and temporal feature of rainfall necessitates the need to examine its changing pattern in response to changing temperature as rainfall is one of the most important weather parameters that influence the agriculture of a region and food production. According to simulation studies, if proper mitigation measures are not taken, there would be can be agricultural productivity losses from 5 to 18percent from 2030 to 2080 in the semi arid tropic region (Singh and Bantilan, 2011).Local community's understanding of climate change must consider because even though climate change is a global phenomenon, adaptation is largely site specific (Lema, 2009). Hence, a better understanding of farmer's perceptions of climate change, its impacts on agriculture, ongoing adaptation measures and the factors influencing adopting them is needed to craft policies and programmes aimed at promoting successful adaptation of the agriculture sector (Chaudharya et al., 2011).

**Comment [U2]:** Correct the grammar.

**Data Sources and Methodology**

North Eastern Transition Zoneconsists of Bidar and Gulbarga districts with 7 talukas. The total geographical area of the region is about 8 lakh ha. The annual rainfall in this region varies from 700 to 890 mm. A sample size of 240 semi arid farmers from a cluster of 14 vulnerable villages from both districts of Bidar & Gulbarga based on top climate vulnerable villages report given by KSNDMC, 2020. The talukas are Bhalki&Bidar from Bidardistrict and Afzalpur&Jewaritalukas from Gulbarga district with 60 farmers were chosen from each taluka. Hence, 240 sample farmers from four talukas of two districts formed the total sample size for the purpose of primary survey and data was collected using a structured schedule from these sample farmer drawn from North Eastern Transition Zone. The information regarding the perception of sample farmers about climate change and its impact on their socio economic condition and agriculture were compiled. Further the adaptation measures practiced by them to overcome its adverse impacts were recorded.

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**Data collection**

The daily observed data for maximum temperature (Max Temp), minimum temperature (Min Temp) and Rainfall (R) of study area for a period of 1979 to 2019 were collected from the AICRPAM, CRIDA, Hyderabad. To validate the farmers perception about climate change, the long term data (1979-2019) on temperature and rainfall pertaining to the study districts were analyzed. The long term average temperature and rainfall of South West Monsoon (June-September) and North East Monsoon (October-December) of Bidar and Gulbarga districts were analyzed. The average rainfall during SWM, NEM and annual were compiled and analyzed. The deviation of annual rainfall from long run averages in the region were also analysed in order to assess the possible impact on agricultural system.

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**Garrett Ranking Technique**

The adaptation strategies practiced by farmer were analyzed using Garrett ranking technique which identifies and ranks various strategies based on the calculated mean score. Garrtett's formula for converting normal rank into percent was given by :

$$\text{Position} = 100*(R_{ij}-0.5)/N_j$$

Where,

$R_{ij}$= rank given for $i^{th}$ factor by $j^{th}$ individual

$N_j$ = number of factors ranked by $j^{th}$ individual

The percent position of each rank was converted into scores referring to the table given by Garrett and Woodworth (1969).For each strategy, the scores of individuals respondents are added together and divided by the total number of the respondents for whom scores are added. These mean sores for all the factors are arranged in descending order, ranks are given and most important factors are identified.

**Binary Logit Model**

Binary logit model has been used to analyze the factors influencing the farmers to adopt various farm pond technology to overcome the adverse impacts of climate change. In order to determine whether adaptation had undertaken in response to observation to climate change, a probability model is used where the binary dependent variable is a dummy for undertaking any adaptation at all (i.e. $Y_i$ has only two possible values 1 or 0, for either adapting or not adapting to climate change).

Thus,

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \sum_{i=1}^{k} \beta_k X_{ki}$$

$P_x$ is the probability of an event occurring for an observed set of variables Xi, (1-Px) is the probability of non-adoption. Independent variables includes age, education, farming experience, family size, farm holding size, access to irrigation, livestock, ownership, off farm occupation and access to credit.

**Result and Discussion**

Bidar and Gulbarga have highest maximum temperature with 33°C (Table 1). The mean minimum and maximum temperature was highest in month of May with 25.60°C and 40.13°C, respectively (Table 2). Bidar receives maximum rainfall with 847 mm. The minimum temperature recorded in Gulbarga is 16.36°C.

**Table 1: District wise variation of climatic variables of North Eastern Transition Zone, 1979-2019**

| Districts | Maximum Temperature (°C) | | | Minimum Temperature (°C) | | | Rainfall (mm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | CV | Mean | SD | CV | Mean | SD | CV |
| Bidar | 33.41 | 4.06 | 12.16 | 20.46 | 3.77 | 18.44 | 847.41 | 209.75 | 24.75 |
| Gulbarga | 33.44 | 3.89 | 11.64 | 20.88 | 3.41 | 16.36 | 724.56 | 153.76 | 21.22 |

**Table 2: Monthly mean maximum and minimum temperature of North Eastern Transition Zone, 1979-2019**

| | Minimum Temperature (°C) | | | | Maximum Temperature (°C) | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Min T | Max T | Mean | SD | Min T | Max T | Mean | SD |
| Jan | 12.82 | 17.34 | 15.57 | 1.03 | 27.76 | 32.17 | 30.50 | 0.89 |
| Feb | 15.62 | 19.90 | 17.76 | 0.99 | 31.66 | 35.79 | 33.43 | 0.94 |
| Mar | 19.79 | 23.09 | 21.15 | 0.68 | 34.74 | 38.69 | 36.93 | 1.07 |
| April | 22.27 | 26.50 | 24.24 | 0.72 | 37.20 | 41.87 | 39.46 | 0.96 |
| May | 23.50 | 26.92 | 25.60 | 0.77 | 35.70 | 41.93 | 40.13 | 1.28 |
| June | 22.39 | 24.91 | 23.68 | 0.63 | 31.33 | 37.65 | 35.05 | 1.46 |
| July | 21.74 | 23.78 | 22.53 | 0.41 | 29.19 | 34.65 | 31.59 | 0.99 |
| Aug | 21.30 | 23.05 | 22.00 | 0.32 | 29.44 | 32.52 | 30.61 | 0.67 |
| Sep | 21.41 | 22.77 | 21.89 | 0.31 | 29.55 | 33.04 | 31.35 | 0.85 |
| Oct | 19.39 | 21.65 | 20.55 | 0.57 | 29.96 | 34.22 | 31.89 | 1.05 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nov | 14.99 | 20.34 | 17.70 | 1.25 | 28.98 | 32.63 | 30.72 | 0.87 |
| Dec | 13.39 | 18.64 | 15.33 | 1.12 | 28.00 | 32.69 | 29.79 | 1.02 |

**Socio economic characteristics of sample farmers of North eastern transition Zone**

Farmers' perception towards climate change and ability to adapt varies with socio economic characteristics of farm household (Table 3)

**Table 3: Socio economic characteristics of sample farmers in North eastern transition Zone**

| S. No | Particulars | Bidar N=120 | Gulbarga N=120 | Total Farmers N=240 | Percentage (%) |
|---|---|---|---|---|---|
| 1 | Sample size | 120 | 120 | 240 | |
| 2 | Average age of farmers (Years) | 56 | 56 | | |
| 3 | Average experience of farmers (Years) | 37 | 35 | | |
| 4 | Family size | 4.05 | 4.09 | | |
| 5 | Institutional credit | 45 | 52 | 97 | 40 |
| 6 | Climate information | 52 | 61 | 113 | 47 |
| 7 | Social participation | 47 | 49 | 96 | 40 |
| 8 | Irrigation sources | | | | |
| | i) Dug wells | 97 | 92 | 189 | 79 |
| | ii) Tube wells /bore wells | 73 | 68 | 141 | 59 |
| | iii)Tanks/ Farm ponds | 32 | 21 | 53 | 22 |
| | iv) Drip irrigation | 18 | 22 | 40 | 17 |
| | v) Sprinkler irrigation | 10 | 7 | 17 | 7 |
| | vi) Rain water harvesting | 4 | 7 | 11 | 5 |
| | vii) Lift pumps | - | - | - | |
| | viii) Project Canals | - | - | - | |
| 9 | Off farm occupation | | | | |
| | i) MGNERGA Wages | 51 | 47 | 98 | 41 |
| | ii) Sericulture | 33 | 24 | 57 | 24 |
| | iii) Vermi composting | 27 | 35 | 62 | 26 |
| | iv) Migration | 43 | 45 | 88 | 37 |
| | v) Live stock and poultry | 80 | 72 | 152 | 63 |
| 10 | Land Holding type | | | | |
| | i) Marginal farmer | 44 | 26 | 70 | 7 |
| | ii) Small farmer | 46 | 62 | 108 | 45 |
| | iii) Large farmer | 30 | 32 | 62 | 26 |
| 11 | Education | | | | |
| | i) Uneducated | 35 | 39 | 74 | 31 |
| | ii) Primary | 48 | 42 | 90 | 38 |
| | iii) Higher education | 25 | 23 | 48 | 20 |
| | iv) Graduation | 12 | 16 | 28 | 12 |
| 12 | Income per annum | | | | |
| | i) Below one lakh | 43 | 34 | 77 | 32 |
| | ii) 1 lakh -3 lakh | 69 | 75 | 144 | 60 |
| | iii) 3 lahk to 5 lakh | 8 | 11 | 19 | 8 |
| | iv) Above 5 lakh | - | - | - | - |

The age of the farmer represents his experience in farming. The more experienced farmers had expected to have higher probability of perceiving climate change as they are exposed to different climatic conditions that existed during past and present situation. On an average, the sample farmers were 56 years of age and 36 years of farming experience. The average size of the sample households is 5 persons. Majority of the sample farmers fall under the category of primary education and illiterates with 38 percent and 31 percent, respectively. During the off season, 41 percent of sample farmers were engaged in MGNREGA employment

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programme. About 40 percent of the sample farmers are members of social groups like farmers club, self help groups and joint liability groups, etc. and seek assistance to obtain their loans from banks. Agriculture is the main activity and farmer were also engaged in other nonfarm activities like sericulture, livestock, dairy, and poultry to earn income during off season.

Livestock is an important source of income for small holders and the landless households. Evidence shows that small holders obtain nearly half of their income from livestock (Birthal et al, 2006). About 63 percent of the sample farmers possess livestock such as bullock, cow, sheep and poultry and market their animal products like eggs, meat and milk in urban areas. Sericulture is one of the major nonfarm activity for farmers of Bidar district as government provides reliable subsidies to farmers for infrastructure development. Dug well and tube wells were predominant source of irrigation in the two study districts of Bidar and Gulbarga. When compared to Bidar, it was found that Gulbarga has suffered with less rainfall and more number of farmers shifting to nonfarm activities. Only 17 percent of the farmers were using drip irrigation and improved irrigation methods. Only 40 percent of the sample farmers were able to access institutional credit in the study area and majority of the farmers borrowed money from land lords, money lenders at high interest rate by hypothecating jewels as security. About 80 percent of farmers believed that, scarcity of water resources is major drawback for farmers of NETZ and for their successful cultivation of crops the government has to create irrigation facilities.



**Perceptions of farmers about climate change and variability**

The information was compiled from 240 sample farmers about their perception on climate change. About 178 of the 240 sample farmers had perceived climate change in terms of various meteorological indicators. It is important to perceive their situation and know how they had exposed to climate change. Farmers' perception on various aspects of climate change was also imperative not only for designing effective adaptation measures but also for preparing mitigation strategies for to combat climate change.

**Perception of farmers about climate change and meteorological indicators**

As shown in (Table 4)about 52.08 percent of sample farmers observed that the quantity of rainfall has been decreasing over the years and about 45 percent of farmers perceived increase in temperature. About 40.88 percent of sample farmers observed about increasing the frequency of droughts, 40.41 percent of farmers could observe delayed onset of monsoon, 34.58 percent of farmers perceived erratic rainfall pattern and 20.83 percent experienced frequent monsoon failures and 6.25 percent of farmers perceived that there is increased occurrence of heat waves due to climate change during the last 40 years in NETZ.

**Table 4: Perception of farmers about climate change and meteorological indicators**

| Indicators | Bidar N=120 | Gulbarga N=120 | Total farmers N=240 | Percentage (%) |
|---|---|---|---|---|
| Decreasing quantity of rainfall | 82 | 96 | 178 | 52.08 |
| Increasing Temperature | 76 | 87 | 163 | 45.00 |
| Frequency occurrence of drought | 78 | 67 | 145 | 40.88 |
| Delayed onset of monsoon | 65 | 62 | 127 | 40.41 |

| | | | | |
|---|---|---|---|---|
| Erratic rainfall pattern | 57 | 52 | 109 | 34.58 |
| Frequent Monsoon failure | 43 | 47 | 90 | 20.83 |
| Increased frequency of heat waves | 39 | 41 | 80 | 6.25 |

**Perception of farmers about impact of climate change on agriculture and natural resources**

As shown in (Table 5) about 73.75 percent of farmers claimed that untimely rainfall coupled with frequent droughts for last 40 years greatly constrained the performance of the crop yield and 67.08 percent of farmers opined about the problem of recurrent crop failure. While, 59.16 percent of farmers experienced declining ground water resources in the study area. About 61.25 percent of farmers reported that they face problem in choosing the crop for different seasons and are not able to follow defined cropping pattern due to climate shocks and variations. While, 36.66 percent of farmers perceived decrease in vegetation cover and 35.41 percent of farmers perceived that there is decrease in availability of fodder for animals in the study area.

**Table 5: Perception of farmers about climate change impact on agriculture and natural Resources**

| Indicators | Bidar N=120 | Gulbarga N=120 | Total farmers N=240 | Percentage (%) |
|---|---|---|---|---|
| Decline in crop yield | 85 | 92 | 177 | 73.75 |
| Crop Failure | 76 | 85 | 161 | 67.08 |
| Reduced ground water and surface water | 69 | 73 | 142 | 59.16 |
| Uncertainty about cropping pattern | 76 | 71 | 147 | 61.25 |
| Decreased Vegetation Cover | 41 | 47 | 88 | 36.66 |
| Decreased Availability of fodder | 42 | 43 | 85 | 35.41 |

**Perception of farmers about impacts of climate change on socio economic conditions**

As shown in Table 6 majority ofhouseholds practice agriculture and consider it the main source of income and livelihood. The impact of increasing temperature, decreasing precipitation, extreme weather events and other pertinent changes have became major constraint for the livelihoods of the small and marginal farmers. Before adopting income diversification options, they tried to compensate for the short term reduction in income by shifting from farming to non-farm activities. About 82.91 percent of farmers perceived that there is increased shifting from farm to non-farm activities like sericulture, dairy, etc., due to increase in uncertainty of returns from farm enterprises. About 78.75 percent of farmers observed that there is increasing migration of small farmers to urban areas to seek more lucrative employment. About 77.08 percent of farmers perceived that there was increased practice of households to mortgage their lands while 75.83 percent of farmers observed that due to decline in crop production the farmers are realizing low remunerative prices and returns which increased their debts from money lenders. The 69.10 percent of farmers opinioned that there is increased dependency of farmers on public distribution system (PDS). About 58.75 percent of farmers perceived that the labour scarcity is increasing in rural areas. Even with minor changes in precipitation poses a serious threat to the food security and sustainability from agricultural practices.

**Table 6: Perception of farmers about impacts of climate change on socio economic conditions**

| Indicators | Bidar N=120 | Gulbarga N=120 | Total farmers N=240 | Percentage Percent |
|---|---|---|---|---|
| Shifting to non farm activities | 98 | 101 | 199 | 82.91 |
| Increased farmers indebtedness | 95 | 87 | 152 | 75.83 |
| Increased land mortgage | 92 | 93 | 185 | 77.08 |
| Increased dependency on PDS | 85 | 81 | 166 | 69.10 |
| Migration of farmers to urban areas | 93 | 96 | 189 | 78.75 |
| Increased labour scarcity | 69 | 72 | 141 | 58.75 |

**Validating the perceptions of semi arid farmers of North Eastern Transition Zone of Karnataka**

**Climate trend of temperature of Bidar and Gulbarga of NETZ during 1979-2019**

It is noticed that, the temperature of summer season in Gulbarga was increased as compared to Bidar (Figure 1). The number of hotter days (>35° C) varies within a range of 95 to 110 days in a year and it changed significantly within the last 39 years as shown in Figure 2. The number of extreme hot days (>40° C) varies between 42 to 45 days in a year. This increase in number of hotter days could be considered as existence of warmer temperature in NETZ**.**

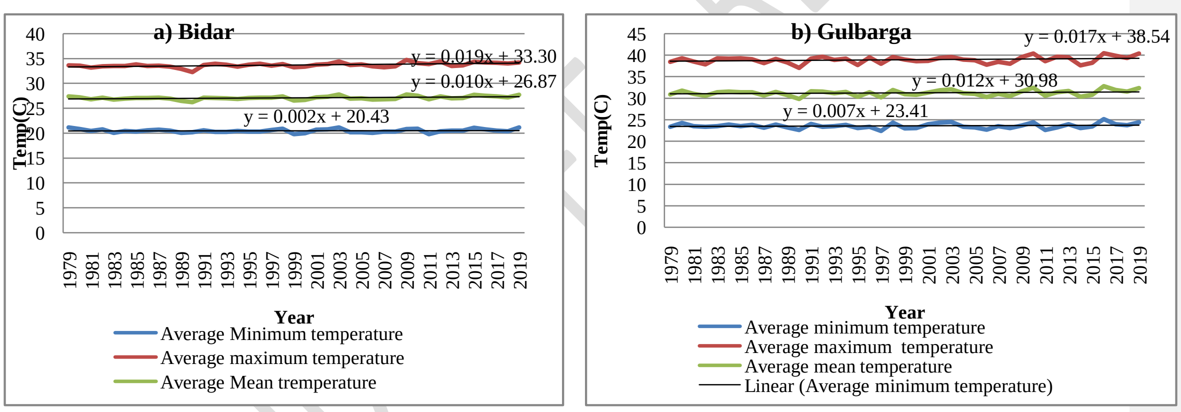


**Fig. 1: Trend of average temperature during summer in Bidar and Gulbarga, 1979-2019**

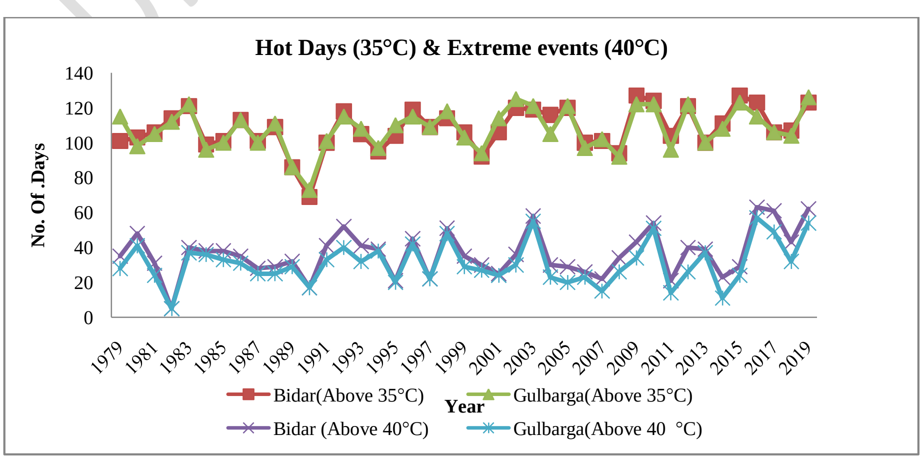


**Fig. 2 : Number of hotter and extreme hot days in Bidar and Gulbarga during 1979-2019**

**Trend of rainfall in Bidar and Gulbarga in NETZ during 1979-2019**

The average rainfall of Bidar is about 860 mm. This district is considered to be a rainfall scarce region. The maximum rainfall of 1344 mm was received in the year 1983 and the minimum rainfall of 549 mm was recorded in the year 1994. The period after 1998 received comparatively lesser rainfall as compared to the previous period. It is observed that the rainfall pattern of south west monsoon is highly erratic during the period 2009-2019 in Gulbarga (Figure 3). The trend line of north east monsoon is showing downward sloping starting from the year 2014-2015. The trend lines reveal that there is decline in rain received from south west monsoon, north east monsoon and annual rainfall from the year 2003-04.

The arrival of monsoon remains nearly at same time but the maximum rainfall is decreasing and the total number of rainfall is also decreasing after 1998. The SWM rainfall of Bidar ranges between 684 to 690 mm for the last 40 years. The lowest rainfall is about 483 mm which was observed in 1993 and the highest rainfall is about 803 mm observed in 1989. The SWM rainfall of Gulbarga ranges between 570 to 600 mm for the last 40 years.

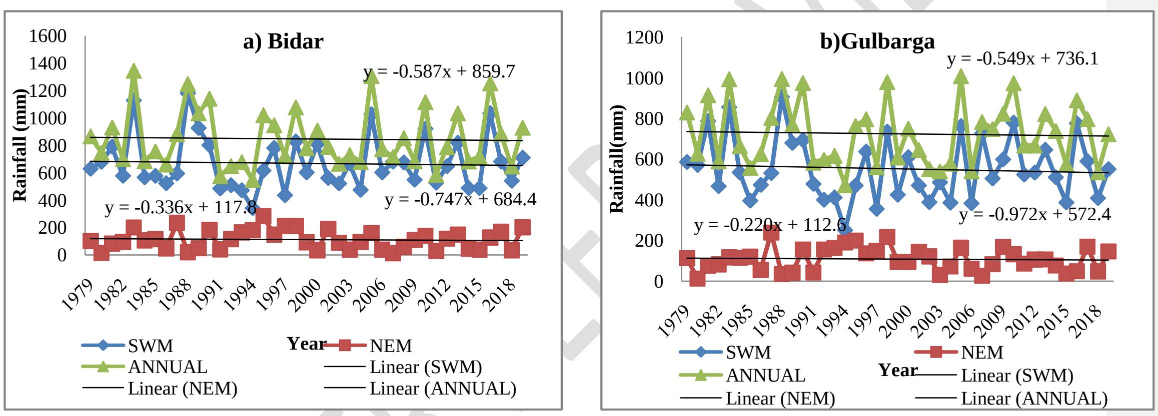


**Fig.3 : Trend of rainfall in Bidar and Gulbarga during 1979-2019**

**Mean deviation and rainy days of Bidar and Gulbarga in NETZ**

To validate the perception of farmers regarding frequency of occurrence of drought in the study area the concepts of mean deviation of annual rainfall and annual rainy days were calculated for 40 years (1979-2019). The deviation from mean rainfall in both Bidar and Gulbarga was observed to be more than (-)20percent and most of such years were experienced after 1984 . A deviation of more than -30percent was observed in 1991, 1994 and 2011 in Bidar (Table 7). Above all, 23 dry years in Bidar and 21 dry years in Gulbarga have experienced drought conditions during 1979-2019. The highest number of rainy days was observed in Bidar (225 days) and Gulbarga (215 days) in the year 1997 and 1989, respectively (Figure 4). Similarly, the lowest number of rainy days was observed in 2011 with 190 days in Bidar and 146 days in year 2012 in Gulbarga. The intensity and number of rainy days has been decreasing during the study period 1979-2019.

**Table 7 : Percent deviation of rainfall from mean in different years 1979-2019**

| Mean Deviation (percent) | Bidar | Gulbarga | Category |
|---|---|---|---|
| <10 percent | 1985,1999,2001, 2006,2012 | 1984, 2011,2012,2019 | Normal Drought |
| 10-25percent | 1980,1982,1984, 1986, 1992, 1993, 1997, 2002,2003, 2004, 2007 , 2009, 2014,2015, 2018 | 1980, 1982,1985,1986, 1991,1992, 1993, 1997, 1999,2001, 2002,2004,2015 | Severe drought |
| 25-30percent | 1991,1994,2011 | 1994, 2003, 2006, 2018 | Extreme Drought |

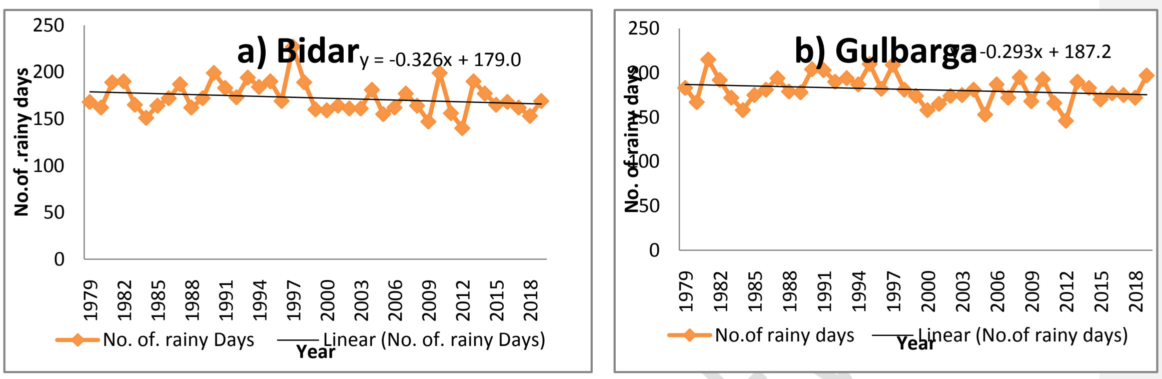


**Fig.4: Number of Rainy days in Bidar and Gulbarga during 1979-2019**



**Adaptation strategies adopted by farmers to climate change in NETZ**

Farmers are practicing various adaptation strategies to overcome the effect of the climate risks in crop production.

**Crop management strategies practiced by farmers**

Generally, the small farmers cultivated sugarcane and soya bean followed by black gram and bengal gram. The large farmers cultivatedbengal gram and soya bean in both seasons in NETZ. Crop management strategies practiced by farmers to mitigate the effect of climate change are shown in (Table 8 ). Majority of the farmers usually alter the sowing dates of crops (rank I) in accordance with the date of onset of monsoon 74.80percent. Using drought tolerant varieties when there was scarcity of water and mixed cropping (Ex; sugarcane +groundnut) to avoid the risk of crop failure receive rank II and rank III, respectively. Farmers also manage climate change through adoption of short duration crops (rank IV), conservation agriculture (rank V) and by changing crop (VI). Very few farmers showed their preferences for planting crops in different geographical area and is ranked VII.

**Table 8: Crop management strategies practiced by farmers in NETZ**

| S. No | Strategies | NETZ | |
|---|---|---|---|
| | | **Garatte mean score** | **Rank** |
| 1 | Alteration of sowing dates | 74.80 | 1 |
| 2 | Drought tolerant varieties | 64.85 | II |
| 3 | Mixed cropping | 57.55 | III |
| 4 | Early maturing crops | 56.10 | IV |
| 5 | Conservation agriculture | 50.79 | V |
| 6 | Change of crop choice | 34.50 | VI |
| 7 | Planting crops in different geographical areas | 30.85 | VII |

**Extent of adoption of crop management adaptation measures**

About 9.17 percent of the farmers did not adopt any farm management strategy while 90.83percent adopted at least one crop management practice as shown in Ffigure 5.. Most of the sample farmers (22.50 percent) adopted four different farm management practices followed by adoption of three different measures (20.00percent). Those who adopted one and two different measures were 12.92percent and 11.67percent, respectively. About 5percent adopted six management measures while 3.33 percent adopted seven management strategies.

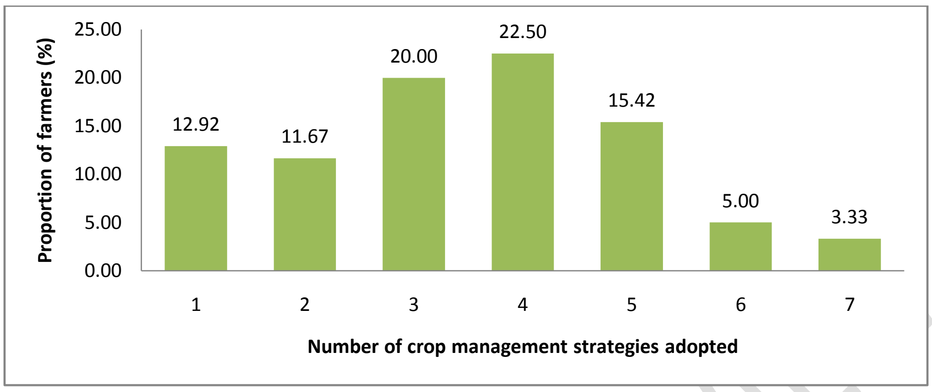


**Fig 5:Extent of adoption of crop management strategies by farmers (n = 240)**

**Income management strategies practiced by Farmers**

Farmers adopted various income management strategies to combat climate adversities. Crop insurance (rank I) was the most preferred strategy for the farmers of both Bidar and Gulbarga as shown in Table 9. During off seasons, farmer earned daily wages by participating in government employment programmes (MGNREGA) such as road and construction works (rank II). Other measures include reducing expenditure on children education (rank III), remittance from children working in cities (rank IV) borrowing from friends, relatives and money lenders (rank V) and mortgage of properties and assets (rank VI). Farmers gave last preference on reducing expenditure on health (rank VII) as income management strategy.



**Table 9: Income management strategies practiced by farmer in NETZ**

| S.No | Strategies | NETZ | |
|---|---|---|---|
| | | Garatte mean score | Rank |
| 1 | Remittance | 69.58 | IV |
| 2 | Borrowing from friends and relatives, money lenders | 68.73 | V |
| 3 | Crop insurance | 73.45 | I |
| 4 | MGNREGA Employment wages | 70.57 | II |
| 5 | Reduced expenditure on children education | 69.76 | III |
| 6 | Reduced expenditure on health care | 64.78 | VII |
| 7 | Land mortgage and jewellery loan | 68.35 | VI |

**Extent of adoption of income management adaptation measures**

Every farmer in the study area practiced one or the other income management strategy (Figure 6). Most of the sample farmers (28.75 %) adopted five different income management practices followed by adoption of four practices (23.75%). The proportion of farmers who adopted one and two different measures were 7.50% and 9.58 %, respectively. About 6.25 % of farmers adopted six management measures while 2.92 % adopted all the seven management strategies.

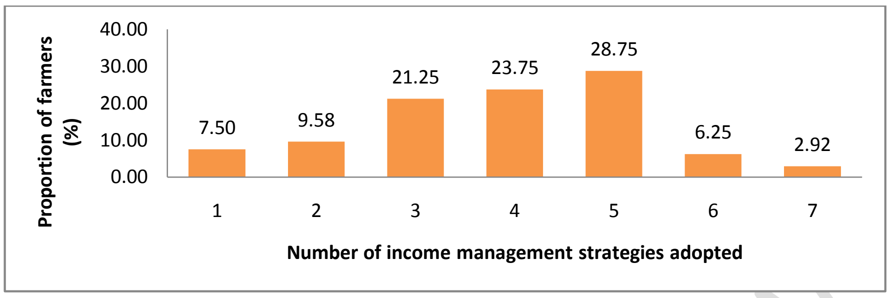


**Fig6: Extent of adoption of income management adaptation measures by farmers**

**Water management strategies practiced by Farmers**

Farmers adopted various water management strategies during rainfall off season and dry spell days. Rain water harvesting (rank I) was practiced by majority of semi arid farmers as shown in (Table 10). Farmers use water source from groundwater through bore well (Rank II) for irrigating crop in the fields. They try to have irrigation through pumps from rivers (rank III). Farmers gave least preference for drip irrigation (IV) due to its high cost of investment.

**Table 10: Water management strategies practiced by farmer in NETZ**

| S.No | Strategies | NETZ | |
|---|---|---|---|
| | | Garatte mean score | Rank |
| 1 | Rainwater harvesting | 67.50 | I |
| 2 | Drip/Sprinkler irrigation | 55.34 | IV |
| 3 | Irrigation from rivers | 59.65 | III |
| 4 | Drilled a bore well (Groundwater) | 62.19 | II |

**Extent of adoption of water management adaptation measures**

Most of the sample farmers (51.67 %) adopted at least one water management strategy (Figure 7) followed by adoption of two practices (27.92%). The proportion of farmers adopting 3 and 4 different water management measures were 14.58 % and 5.83 %, respectively.

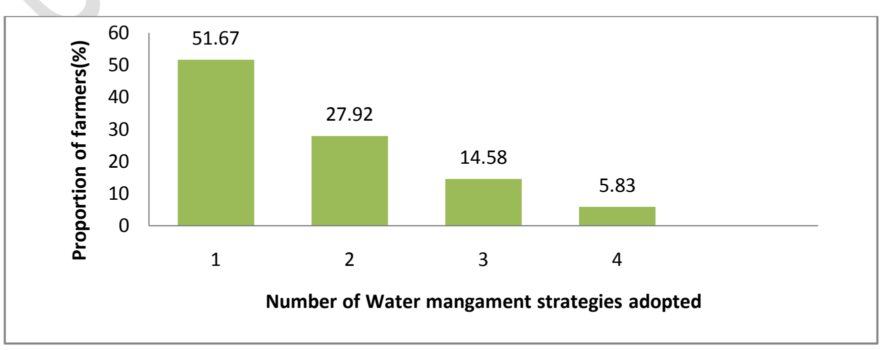


**Fig 7: Extent of adoption of water management adaptation measures**

**Off-farm adaptation strategies practiced by Farmers**

Farmers practice various off farm activities to earn additional income in order to overcome the effect of climate change (Table 11). Migration of farmers to urban cities in search of employment is one of the most important adaptation strategy adopted by 68.28 percent farmers (rank I). Farmers (64.06percent) practice group savings and use the same during difficult time (Rank II). Sericuture is very popular (55.86percent) in north eastern transition zone and is supported by government by way of subsidy and serves as very good source of off farm income (rank III). A good majority of farmers (53.58percent) leased out their land for grazing purpose which generates additional income to the farmer and is ranked IV.

**Table 11: Off-farm adaptation strategies practiced by Farmers**

| S.No | Strategies | NETZ | |
|---|---|---|---|
| | | Garatte mean score | Rank |
| 1 | Members migrate in search of employment | 68.28 | I |
| 2 | Farmer Group saving | 64.06 | II |
| 3 | Business (sericulture) | 55.86 | III |
| 4 | Leasing out grazing land | 53.58 | IV |

**Extent of adoption of Off-farm adaptation strategies practiced by Farmers**

Most of the sample farmers (48.07%) adopted at least two off- farm adaptative strategy (Figure 8) followed by adoption of one practices (31.25%). Those who adopted three and form different measures were 14.26 % and 7.34 %, respectively.

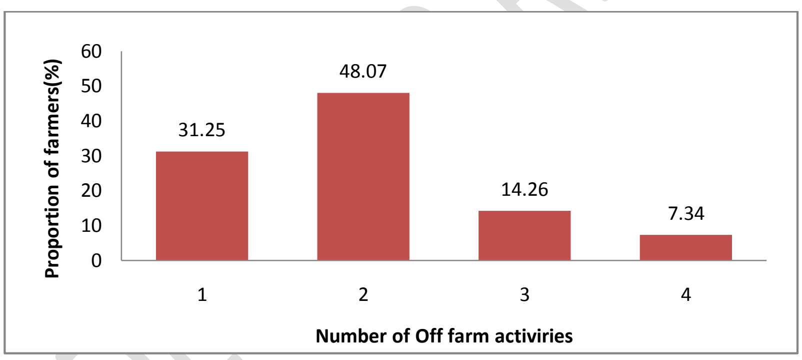


**Fig 8: Extent of adoption of off farm adaptation measures**

**Factors influencing adoption of adaptation strategies**

As mentioned earlier, the socio economic characteristics of the farm household determine the adoption. The results of the logit analysis showed (Table 12) that farm size, access to institutional credit, livestock ownership and climate information are the factors which positively shows significant influence on adoption. An increase in the land holding size contributed to an increased probability of the adoption of adaptation strategy in the study area Farmer always wish to bring more area under cultivation with variety of crop cultivation if their farm size is large. Economic incentives play an important role in the adoption of modern technologies. Access to institutional credit will support the farmers financially in adopting water conservation techniques like farm ponds, micro irrigation products, etc.

**Table 12:Logit model to understand the factors influencing adoption of adaptation strategies by semi arid farmers in NETZ**

| S.No | Factors | Coeff | Std.err | Odds ratio |
|---|---|---|---|---|
| 1 | Age | -.116** | 0.465 | 0.890 |
| 2 | Farm Size | 1.961** | 0.579 | 7.139 |
| 3 | Education | 1.103 | 0.681 | 3.013 |
| 4 | Climate information | 1.740* | 0.269 | 1.077 |
| 5 | Institutional credit | 1.974** | 0.603 | 7.200 |
| 6 | Livestock | 3.057** | 1.210 | 21.274 |
| 7 | Non farm activity | -.367** | 0.089 | 0.692 |
| | _Constant | -17.386 | 6.197 | 2.813 |

*& ** denotes level of significant at 10 and 5 percent respectively

Age of the farmers and non-farm activity negatively influence adoption of adaptation strategies. The likelihood to adopt a modern irrigation technology was negatively correlated with the age of the household. The income from non-farm activity gives the farmer the option to skip farming during distress season. The older farmers are reluctant to prefer modern irrigation techniques. It is observed that education have no significant effect on adoption of any adaptation strategies.

**Conclusion**

Though the farmers are constrained with lack of funds, irrigation facilities and season specificity of crops, they tried to adopt various adaptation strategies against climate change which includes crop management, income management, water management and non-farm activities. Majority of farmers altered the sowing dates, used drought tolerant varieties and practiced mixed cropping. Majority of the farmers prefered crop insurance as income management strategy. The socio economic variables like farm size, climate information, institutional credit and livestock were found to increase the probability of adopting different adaptation strategies by semi-arid farmers in North Eastern Transition zone of farmer belonging to a higher adopter category. During the last one decade, the net irrigated area in Karnataka ranged from 31 to 35 percent and remaining area was under dry land. Therefore, it is imperative to harvest excess rainwater through dugout farm ponds for improving the productivity of rain fed crops. Water conservation techniques like farm ponds, micro irrigation techniques besides providing protective irrigation, could meet multiple needs of the society such as drinking and domestic water requirements, livestock and fish production.

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