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Analyse the Coping Mechanisms Employed by Farmers for Effective Canal Irrigation Management in Krishna Command Area (KCA) in Karnataka

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ABSTRACT

Background: Rainfall is considered as one of the most supreme sources of water, especially when it is timely and adequately received. However, in India, the rainfall pattern is erratic, varying significantly across regions and is characterized by uncertainty, irregularity and depends seasonality. These extremes variation in rainfall adversely affect agriculture. Due to uncertainty of rainfall necessitates providing insurance against crop failure through assured irrigation facilities. Thus, irrigation is crucial for maintaining food security in India.

Methods: The study was carried out in Krishna Command Area of Karnataka, encompassing the districts of Vijayapura, Kalaburagi and Yadgiri in Karnataka, during the years 2017-2019. Its main objective was to analyze the coping mechanisms of farmers located at the head reach and tail end of the irrigation system. Data was collected from a sample of 100 head reach farmers and 100 tail-end farmers, thus a total of 200 farmers across the districts of Vijayapura, Kalaburagi and Yadgiri.

Result: The results indicated that farmers in the Krishna Command Area had adopted various coping mechanisms due to the scarcity of irrigation water. Among head-reach farmers, the most common practice was frequently cleaning field irrigation channels (44%), followed by strictly adhering to the warabandi schedule (42%) and adopting drip or sprinkler irrigation methods (40%). In contrast, at the tail-end locations, 67 per cent of farmers primarily cultivated drought-tolerant crops, followed by participating in meetings on selecting less water-consuming crops (60%) and changing cropping patterns (59%).

Key words: Coping mechanism, Head reach farmers, Irrigation water, Tail end farmers, Warabandi schedule.

INTRODUCTION

The impacts of climate change-such as rising temperatures, prolonged droughts, intensified storms, warming oceans and frequent floods and landslides-are reducing agricultural productivity worldwide and endangering global food security (IPCC 2022). Hence, Rainfall is regarded as one of the best sources of water, when it falls in the right place and at the right time, However, India's rainfall pattern is unpredictable and uneven (Sandhu *et al.,* 2016). Agriculture operation primarily depends on seasonal and it changes depending on the region (Gupta *et al.,* 2014). India's rainfall fluctuation has a negative impact on agriculture.

In arid and semi-arid climates, unpredictable rainfall has made irrigated agriculture essential for optimizing crop production (Champaneri *et al.,* 2026). Therefore, effective irrigation management fulfilling the crops' water requirement by timely and controlling water application to avoid waste of water, soil, nutrients and energy (Neeru *et al.,* 2022). In response to reduce agricultural yields, farmers are using a variety of coping mechanism strategies (Adimassu *et al.,* 2014; Kattumuri *et al.,* 2015).

Individuals employ coping mechanism strategy as a means of managing stressors and related issues (Wuryaningsih *et al.,* 2019). Coping mechanisms in the context of farmers might be useful tactics like coming up with alternate solutions, working with other farmers, or adjusting to shifting circumstances. Furthermore, social support from family or affiliated institutions can be a coping method (Fitria and Riyadi, 2022). The results examined in present study would provide practical steps or coping mechanism employed by the head reach and tail end farmers for effective management of canal irrigation water.

The head reach farmers of KCA had implemented several coping mechanisms, such as frequently cleaning field irrigation channels and adhering rigidly to the warabandi schedule. Similarly coping mechanisms

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adopted by the tail-end farmers of KCA are cultivation of drought-tolerant crop, followed by meetings on selection of less water consuming crops. These all strategies are crucial to cope with the excess or shortage of irrigation water among the head reach and tail end farmers. Farmers' coping strategies for effective canal irrigation management are influenced by several socio-economic factors (Adimassu *et al.,* 2015; De Jalon *et al.,* 2014; Kassie *et al.,* 2013; Adimassu *et al.,* 2012; Deressa *et al*., 2009; Seo and Mendelsohn 2008) in head reach farmers, factors like, occupation, livestock possession, extension contact, mass media exposure, social participation, achievement motivation and risk orientation had positive and significant relationship with coping mechanism at five per cent level and Similarly, in tail-end farmers, factors such as farming experience, family size, annual income, extension contact, mass media exposure, social participation, achievement motivation, innovativeness and management orientation had positive and significant relationship with coping mechanism at five per cent level were found to influence farmers' coping strategies among head reach and tail end farmers for effective management of canal irrigation water in KCA.

Policies and initiatives that seek to advance sustainable agriculture must have a deeper comprehension of the factors that lead farmers to choose specific coping mechanisms (Hoe *et al.,* 2014). However, there is a dearth of such data, especially in KCA. Thus, the purpose of this study is to identify the key factors that influence farmers' choices about how to cope with excess or shortage of irrigation water.

MATERIALS AND METHODS

The KCA of Karnataka's three districts-Vijayapura, Kalaburagi and Yadgiri were purposefully selected for the investigation. Since these three districts have maximum net irrigated area and irrigated by Narayanpur left bank canal (NLBC) in Krishna command area. Table 1 and Fig 1 depicts the picture of preliminary information collection and district-wise area under irrigation in Upper Krishna Project. Based on the longest length, two distributories *viz*., Shahapur Branch Canal (SBC D-6, 36 km) and another one from Indi Branch Canal (IBC D-11, 39.38 km) (Fig 2 and Fig 3) were purposively selected (*Distributory refers to the channel taking off from a distributory, allocating water to watercourses and field channels).

Therefore, 50 farmers from the head reach and an additional 50 farmers from the tail end were chosen from each distributory, or from IBC D-11. Similarly, 50 head reach and 50 tail-end farmers were chosen for the investigation from SBC D-6. Consequently, 200 farmers make up the entire sample *i.e.,* 100 head reach and 100 tail-end farmers.

Selection of dependent and independent variables

Farmers' participation in effective canal irrigation management was selected as a dependent variable for the study and twenty independent variables that were supposed to influence the dependent variable were identified based on review of literature and also in consultation with the social scientists.

Analysis of data

Using SPSS, the collected data were scored, analyzed and tabulated using mean, standard deviation, frequency, percentage, correlation tests and stepwise regression test. The correlation test was employed to calculate the r-value, which helped to identify the relationship between the dependent and independent variables. Stepwise regression analysis was also used to select the best subset of variables for predicting the dependent variable.

RESULTS AND DISCUSSION

Coping mechanism adopted by the head reach farmers in KCA

Table 2 depicts the various coping strategies used by KCA's head reach farmers. The following are some of these coping mechanisms: frequent cleaning of field irrigation channels, which comes first, followed closely by the strictly adhere to warabandi schedule (Rank II); drip irrigation/sprinkler irrigation method (Rank III); growing short-duration crops (Rank IV); levelling and bunding the land and cultivating less water-required crops (Mandal *et al.,* 2019) stands fifth rank; avoiding crop stress at critical periods and adhering to the irrigation schedule (When, How and What quantity) (Lalichett *et al.,* 2025 and Ahmad and Kumar, 2015) which stands sixth rank; cultivating drought-tolerant crops (Patel *et al.,* 2022; Amarapalli, 2022 and Fisher *et al.,* 2015) which stands seventh rank; *in-situ* moisture conservation (Rank VIII); covering crops/green manures (Kumar *et al.,* 2015) to minimize leaching and erosion and using compost or decomposed organic matter (Rank IX); increased seed rate during sowing (Rank X); re-excavation of pond (Rank XI); building open ditch drains to remove excess water (Rank XII); crop diversification/IFS (Rank XIII); changing cropping pattern (Chowhan, *et al.,* 2021) and meetings on selection of less water consuming crops (XIV) and adopt best farming practices (Rank XV).

Table 1: District-wise area under irrigation in upper krishna project.

Districts	Gross irrigated area (ha)	Net irrigated area (ha)
Viijayapur	136414	118173
Kalaburagi	40279	38158
Yadgiri	140848	129354

(Source: DES report on annual season and crop Statistics, 2015).
*Gross irrigated area: It is the total area under crops, irrigated once and/or more than once in a year. It is counted as many times as the number of times the areas are cropped and irrigated in a year.
*Net irrigated area: It is the area irrigated through any source once in a year for a particular crop.

Most of head reach farmers adopted effective coping mechanisms like strictly following the warabandi schedule, using drip or sprinkler irrigation, frequently cleaning field irrigation channels and growing short-duration crops. Although farmers often have timely information, experience and sufficient income from farming, many do not adopt practices like crop diversification, updated cropping patterns, improved farming techniques, or compost use. This reluctance might be due to receiving enough water, reducing the perceived need for change and lack of targeted training on integrated farming systems and water management practices. The results were supported by the findings of Dhaka *et al.* (2010).

Coping mechanism adopted by the tail-end farmers in KCA

Table 3 list out the various coping strategies used by KCA's tail-end farmers. These coping mechanisms include cultivation of drought-tolerant crop, which come first, holding meetings to discuss choosing less water-consuming crops (Rank II), altering cropping patterns which stands third rank (Sah, 2024), levelling and bunding the land (Rank IV), increasing the seed rate when sowing (Rank V), cleaning field irrigation channels frequently, adopting best farming practices (Rank VI), cultivating crops that require less water and using drip irrigation or sprinkler irrigation



Fig 1: Gathered preliminary information from command area development authority.

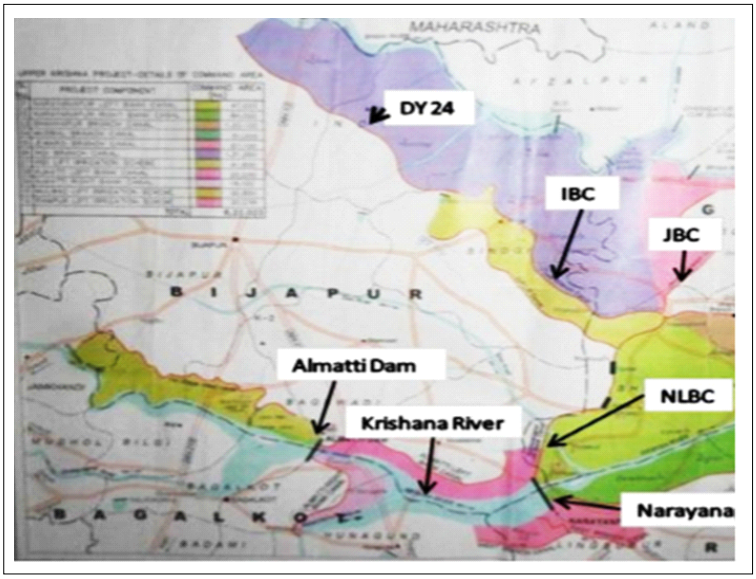


Fig 2: Schematic representation of UKP map.

(Rank VII), adhering strictly to the warabandi schedule (Rank IX), adhering to the irrigation schedule (When, How and What quantity) and using compost, or decomposed organic matter (Rank X), to conserve moisture in-situ (Rank XI), construction of open ditch drains to remove surplus water (Rank XII), crop diversification/IFS (XIII), cover crops/green manures to minimize leaching and erosion and avoid crop stress at critical periods (Rank XIV) and re-excavation of pond (Rank XV).

Majority of tail-end farmers adopted coping mechanisms such as cultivating drought-tolerant crops (Kachiguma *et al.,* 2023), land levelling, bunding, selecting less water-consuming crops, increasing seed rates, changing cropping patterns and frequently cleaning

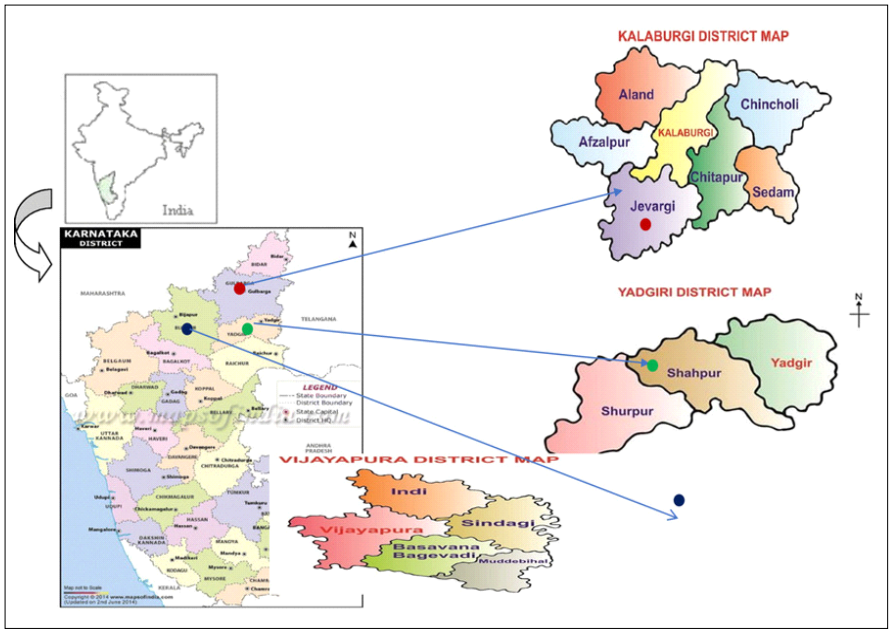


Fig 3: Map of districts selected for the study.

Table 2: Coping mechanisms adopted by the head reach farmers due to scarcity of irrigation water in krishna command area (n_1=100).

Coping mechanism	Always	Somewhat	Never	Rank
	f (%)	f (%)	f (%)	
Cultivation of drought-tolerant crop	31	35	34	VII
Avoid crop stress at critical periods	33	36	31	VI
In-situ moisture conservation	29	32	39	VIII
Re-excavation of pond	25	36	39	XI
Changing cropping pattern	15	26	59	XIV
Drip irrigation/sprinkler irrigation method	40	36	24	III
Adopt best farming practices	12	35	53	XV
Cultivation of less water required crop	35	37	28	V
Cover crops/green manures to minimize leaching and erosion	28	32	40	IX
Growing short duration crops	38	31	31	IV
Construction of open ditch drains to remove surplus water	24	43	33	XII
Crop diversification/IFS	20	22	58	XIII
Follow irrigation schedule (When, How and What quantity)	33	50	17	VI
Use compost, or decomposed organic matter	28	31	41	IX
Increased seed rate during sowing	27	37	36	X
Land leveling and bunding	35	51	14	V
Frequent cleaning of field irrigation channels	44	31	25	I
Strictly follow warabandi schedule	42	33	25	II
Meetings on selection of less water consuming crops	15	38	47	XIV

*f = Frequency; % = Percentage.

Table 3: Coping mechanisms adopted by the tail-end farmers due to scarcity of irrigation water in krishna command area (n_2=100).

Coping mechanism	Always	Somewhat	Never	Rank
	f (%)	f (%)	f (%)	
Cultivation of drought-tolerant crop	67	30	4	I
Avoid crop stress at critical periods	10	48	43	XIV
In-situ moisture conservation	20	63	18	XI
Re-excavation of pond	3	53	45	XV
Changing cropping pattern	59	23	19	III
Drip irrigation/sprinkler irrigation method	29	40	32	VII
Adopt best farming practices	31	45	25	VI
Cultivation of less water required crop	25	59	17	VIII
Cover crops/green manures to minimize leaching and erosion	10	44	47	XIV
Growing short duration crops	29	52	20	VII
Construction of open ditch drains to remove surplus water	17	26	58	XII
Crop diversification/IFS	14	20	67	XIII
Follow irrigation schedule (When, How and What quantity)	21	63	17	X
Use compost, or decomposed organic matter	21	30	50	X
Increased seed rate during sowing	50	43	8	V
Land leveling and bunding	55	30	26	IV
Frequent cleaning of field irrigation channels	31	62	8	VI
Strictly follow warabandi schedule	23	25	53	IX
Meetings on selection of less water consuming crops	60	31	10	II

*f = Frequency; % = Percentage.

Table 4: Relationship between profile characteristics of head reach and tail-end farmers and their coping mechanism adopted due to scarcity of irrigation water. (n=200)

Characteristics	Correlation Co-efficient (r)	
	Head reach (n_1=100)	Tail-end (n_2=100)
Age	0.02^{NS}	0.07^{NS}
Education	0.03^{NS}	0.04^{NS}
Farming experience	0.04^{NS}	0.24*
Family size	0.07^{NS}	0.27*
Land holding	0.08^{NS}	0.02^{NS}
Annual income	0.02^{NS}	-0.26*
Occupation	0.22*	0.02^{NS}
Livestock possession	0.24*	0.03^{NS}
Material possession	0.03N^{S}	0.12^{NS}
Extension contact	0.27*	0.32*
Mass media exposure	0.26*	0.21*
Cosmopoliteness	0.14^{NS}	0.14^{NS}
Social participation	0.21*	0.32*
Economic motivation	0.02^{NS}	0.17^{NS}
Achievement motivation	0.22*	0.28*
Innovativeness	0.02^{NS}	0.23*
Risk orientation	0.31*	0.11^{NS}
Decision making ability	0.06^{NS}	0.02^{NS}
Management orientation	0.06^{NS}	0.34**
Scientific orientation	0.17^{NS}	0.02N^{S}

*Significant at 5 per cent level; **Significant at 1 per cent level; ^{NS}Non-significant.

irrigation channels. This was followed primarily due to irrigation water scarcity, which discourages the cultivation of high water-consuming crops. Additionally, lack of appropriate training programs, small land holdings, medium annual incomes, lack of timely information, limited access to resources and technical guidance and insufficient government funding, all of which influence their adoption of these coping mechanisms.

Association between socio-economic factors and coping mechanism of head reach and tail-end farmers in KCA

Association between various socio-economic factors and coping mechanisms was analyzed and the results are presented in Table 4.

In head reach farmers

Various factors such as occupation, livestock possession (Kumar *et al.,* 2021), extension contact, mass media exposure, social participation, achievement motivation and risk orientation had positive and significant relationship at five per cent level with coping mechanism of the farmers in KCA.

In tail-end farmers

The independent variables such as farming experience, family size, annual income, extension contact, mass media exposure, social participation, achievement motivation, innovativeness and management orientation had positive and significant relationship at five per cent level with coping mechanism of the farmers in KCA.

The possible reasons for the significant relationship of socio-economic factors with coping mechanism are:

Table 5: Stepwise regression analysis showing the significant steps included in coping mechanism of head reach farmers. (n_1=100)

Factors	df	F value	R^2
X8	1, 98	30.72	37.64
X8, X6	2, 97	28.31	42.15
X8, X6, X7	3, 96	25.31	46.56
X8, X6, X7, X10	4, 95	22.17	48.15
X8, X6, X7, X10, X17	5, 94	19.26	49.76

R^2=0.497

*X8= Livestock possession; X6= Annual income; X7= Occupation; X10= Extension contact; X17= Risk orientation.

Table 6: Stepwise regression analysis showing the significant steps included in coping mechanism of tail-end farmers due to scarcity of irrigation water. (n_2=100)

Factors	df	F value	R^2
X3	1, 98	28.12	24.43
X3, X13	2, 97	25.43	35.64
X3, X13, X4	3, 96	22.82	41.35
X3, X13, X4, X10	4, 95	19.87	47.36
X3, X13, X4, X10, X16	5, 94	18.32	51.23
X3, X13, X4, X10, X16, X19	6, 93	16.23	52.34
X3, X13, X4, X10, X16, X19, X15	7, 92	14.45	54.67

R^2=0.546

*X3= Farming experience; X13= Social participation; X4= Family size; X10= Extension contact; X16= Innovativeness; X19= Management orientation; X15= Achievement motivation.

Highly experienced tail-end farmers were more likely to adopt new farming practices due to their farming information on crop management practices, showing a positive relationship between farming experience and coping mechanisms under water scarcity. Family size also positively influences tail-end farmers at a 5% level of significance, as more family members help save labor costs. However, there was a negative association between annual income and coping mechanisms, as poorer socio-economic status drives farmers to adopt better coping mechanism for better returns.

For head reach farmers, occupation positively correlates with coping mechanisms, as regular irrigation water supply allows farmers to engage in subsidiary activities like dairy farming. Livestock possession was also positively related, as medium-income farmers might afford and maintain animals, benefiting from farmyard manure.

Both head reach and tail-end farmers in KCA shows significant positive correlations with extension contacts, mass media exposure, social participation and achievement motivation, as these factors help them to gain knowledge and improve their self-confidence and they seek more information and become more aware. Tail-end farmers demonstrate a positive relationship between innovativeness and coping mechanisms, driven by their willingness to adopt new ideas. Risk orientation was significantly related to coping mechanisms for head reach farmers, as sufficient water supply allows them to take risks with new technologies and management orientation positively associates with coping mechanisms for tail-end farmers, for effective planning and market orientation boost income and coping ability under water scarcity of tail end farmers.

Extent of contribution of socio-economic factors on coping mechanism of head reach farmers in KCA

Table 5 explain the stepwise regression analysis that the step number one, which includes livestock possession (X8) as the only factor, might account for almost 37 per cent of the variation in coping mechanisms. Until the point at which the R values began to decrease, the predictive power increased when each element was added to the subsequent steps. The last phase in which all of the included factors were determined to be significant was the one that yielded the greatest R value. The fifth and last step was chosen for the study. 50 per cent of the variation was found in the head reach farmers' coping technique in KCA was explained by the five parameters included in the final stage. The stepwise regression analysis results, considering the final step with all significant factors, identified the key factors as livestock possession (X8), annual income (X6), occupation (X7), extension contact (X10) and risk orientation (X17).

Extent of contribution of socio-economic factors on coping mechanism of tail-end farmers in KCA

The stepwise regression analysis for tail-end farmers Table 6 revealed that farming experience (X3) alone explained about 25 per cent of the variation and the final step accounted for around 54 per cent of the variation in coping mechanisms. Significant factors included in the final step were farming experience (X3), social participation (X13), family size (X4), extension contact (X10), innovativeness (X16), management orientation (X19) and achievement motivation (X15).

CONCLUSION

Substantial water loss occurs in canals and field channels due to percolation, leakages and seepages. Additionally, unequal water distribution between head reach and tail-end farmers remains a persistent issue in irrigation. The primary coping mechanisms for head reach farmers of KCA are frequent cleaning of field irrigation channels (Rank I) and strictly following the warabandi schedule (Rank II). For tail-end farmers, the main strategies are cultivating drought-tolerant crops (Rank I) and attending meetings on selecting less water-consuming crops (Rank II). Therefore, attaining irrigation efficiency aims to increase crop yield. Effective operation and maintenance of irrigation structures and irrigation channels are crucial for realizing benefits. Irrigation management involves efficient use and equitable distribution of water among the both side of farmers.

Conflict of interest

All authors do not have any conflict of interest.

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