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Perception of climate change and coping strategies among smallholder irrigators in Zimbabwe

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Introduction: Across sub-Sahara Africa, governments and international aid agencies are making huge investments in smallholder irrigation schemes to enhance food security, climate resilience and economic transformation in rain-fed farming systems. Unfortunately, a majority of the smallholder irrigation schemes have performed dismally on these fronts. Climate change is a major exacerbating factor to existing challenges resulting in the poor performance of the schemes. Hence, it is crucial to understand smallholder irrigators' perceptions of climate change and current adaptation strategies to co-design appropriate and acceptable adaptation strategies to address water stress in the schemes. This area had received less significant research attention. This study aims to determine the perception of climate change and coping strategies in smallholder schemes.

Methods: A mixed-method research strategy was used to collect data from 317 irrigation scheme farmers in three schemes (Exchange, Insukamini, and Ruchanyu) in Midlands Province. A binary logistic regression (BLR) method was used for data analysis.

Results: The results suggest that scheme farmers have noticed changes in temperature and rainfall patterns. Results obtained from the model show that climate change perception was mainly influenced by age, gender, location, irrigation experience, and plot size. Farmers perceived that climatic change has resulted in decreased irrigation water availability, thus leading to poor yields. This study also shows that the main adaptation strategies to water stress include improving soil moisture conservation, construction of small-scale reservoirs, water charging and trade, setting clear water use priorities, and adoption of climate-resilient and short-season crop varieties. Perception of high temperatures, long dry periods, late rainfall, increase in the frequency of drought, shortening of cold season, and shortening of rain season influence adaptation strategies adopted by scheme farmers.

Conclusion: This study offered useful data for policymakers and irrigation developers to develop appropriate policies and programs to improve the sustainability of schemes given current and projected water stress in Zimbabwe and sub-Sahara Africa in general.

KEYWORDS

food security, weather events, adaptation, livelihoods, sustainability

1. Introduction

Globally, smallholder irrigation schemes were developed to enhance the livelihoods of rural households (Mdemu et al., 2020), improve food security (Masasi and Ng'ombe, 2019), raise farm household income (Masasi and Ng'ombe, 2019), alleviate poverty (Phakathi, 2022), and agricultural transformation (Masasi and Ng'ombe, 2019). This development was predicted to be stimulated by high-impact pathways including higher crop yield, higher food production, and higher income (Hanjra and Williams, 2020). Nonetheless, there is abundant literature (Burney and Naylor, 2012; Fanadzo and Ncube, 2018; Hanjra and Williams, 2020; Mdemu et al., 2020) indicating that a majority of the smallholder irrigation schemes in SSA and especially in Zimbabwe have not performed according to the expectations as they are characterized by poor maintenance and dilapidated infrastructure. According to Harrison (2018), farmer-led, externally engineered, and induced schemes models are more complex, costly, outdated, mismanaged, and have high failure rates. Local, national, and international political economies, lack of funding, limited technological and engineering expertise, regulation and control, profitability, and technical efficiency are some of the factors contributing to malfunctions of century-old traditional irrigation scheme models which are exacerbated by climate change in the region (Harrison, 2018; Veldwisch et al., 2019). The failure of smallholder irrigation schemes in SSA reflects the interaction between this complex range of factors. In Zimbabwe, ∼30% of the existing schemes in Zimbabwe are not functional and are characterized by low performance (IFAD, 2016). The initial stages of irrigation development consisted of huge state-managed projects for food and income security. However, these schemes had appalling results mainly due to poor management (Samakande et al., 2004; Dube, 2016), lack of profitability (Moyo et al., 2020), limited access to supply and product markets (Dube, 2016), and dependency on government assistance (Muhoyi and Mbonigaba, 2022). According to Moyo et al. (2017), crop yields in smallholder irrigation schemes in Zimbabwe were reported to range between 5% and 15% of irrigation potential which is ∼80% of yield potential, resulting in a proportional decrease in profitability.

Furthermore, there is overwhelming scientific evidence showing that climate change exacerbates many, historic reasons for the non-performance of smallholder irrigation schemes in SSA posing threats to food security through increased water scarcity, increased flooding, excessive heating, and an increase in pests and disease occurrences (Harrison, 2018; Higginbottom et al., 2021). Higginbottom et al. (2021) state that climate change and variability are exacerbating the failure of poorly planned schemes in SSA.

While rural communities in SSA have adopted diverse coping strategies to respond to the challenges compounded by climate change and variability (Berman et al., 2015; Kumasi et al., 2019), there is little empirical evidence on the response to climate change in smallholder irrigation schemes (Chipfupa et al., 2021). There is a growing need for scheme farmers to improve their coping with an uncertain future and make the appropriate adjustments to minimize the impacts of climate change. The ability of farmers to engage in coping mechanisms in irrigation schemes relies on economic resources, information access, and satisfaction with tenure security among other factors (Villamayor-Tomas and García-López, 2017). Policies that support the diversification of household income sources while supporting and fostering social capital should be promoted to cope with climate change (Berman et al., 2015).

A Smallholder irrigation scheme is an operational unit with a wide array of a complex combination of stakeholders and processes including input suppliers, engineers, scientists, output buyers, processors, decision-makers, international funding institutions, water users associations (WAU), and government institutions (Harrison, 2018; Lefore et al., 2019; Higginbottom et al., 2021). With climate change exacerbating the historic factors resulting in the malfunctioning of schemes, there is a need to involve scheme farmers and local players in all facets of irrigation development to ensure that promised benefits are delivered. According to Berman et al. (2015), understanding how wider processes, power relations, socio-economic characteristics, the value of social and behavioral factors including risk perception shapes vulnerability, and the success of climate change coping strategies is of paramount importance. Therefore, this study specifically seeks to examine scheme farmers' perception of climate change and to identify the responsive strategies that farmers are willing to adopt to cope with the effects of changing climate in smallholder irrigation schemes. In the context of the existing sphere of influence of different actors involved in irrigation scheme development, improved empirical evidence on farmer perception will provide valuable guidelines to improve the capacity of the farmers to implement on development of schemes in face of climate change.

2. Methodology

2.1. Study area

The study was carried out in Insukamini, Exchange and Ruchanyu irrigation schemes of Gweru, Kwekwe and Shurugwi districts, respectively. Administratively, the three districts are under Midlands province, Zimbabwe. Exchange is situated 60 km and 80 km North-West of the Kwekwe and Gweru towns, respectively. Also, Insukamini is situated 46 km Northwest of Gweru, while Ruchanyu is situated 49 km South-West of Shurugwi town. The Exchange, Insukamini and Ruchanyu irrigation schemes have a total population of 982, 125 and 85 scheme farmers, respectively. Ruchanyu irrigation scheme is under agroecological zone (AEZ) 3, while Exchange and Insukamini are both in AEZ 4. Their rainfall falls between 450 mm and 850 mm and the average temperature for Insukamini and Ruchanyu is 16°C, while that of Exchange is 26°C. In addition, irrigation water is delivered by concrete-lined canals in Exchange and Insukamini, while a sprinkler irrigation system is used in Ruchanyu. Soils in Exchange are mainly high-fertile clay soils, in Insukamini, they range from sandy loam to clay loam, while in Ruchanyu they are dominantly sandy loam.

2.2. Sample selection

Multi-stage sampling was used to select the three schemes. Midlands province was purposively selected given that it is among the top three provinces with the most irrigation schemes, among which a higher proportion of them are operating below average or have collapsed (IFAD, 2016). This was followed by the random selection of Gweru, Kwekwe and Shurugwi districts, in which the three schemes which were considered for this study were similarly randomly selected. Further, the participants were randomly selected for individual questionnaires and key informant interviews. A sample of 317 participants was selected using the probabilistic proportional sampling technique based on sample size. Male and female participants were proportionally selected to ensure gender balance. To ensure this, a total of 200 males and 117 females took part in the questionnaire-based study. We also conducted six focus group discussions (FGDs) involving 29 female and 32 male participants. During focus group discussions, males and females participate in different groups to ensure the full participation of females in the interviews. Consequently, 192, 88, and 37 were selected from Exchange, Insukamini, and Ruchanyu irrigation schemes, respectively.

2.3. Data collection

The questionnaire with both quantitative and qualitative responses was the dominant tool used for data collection. The questionnaires used for this study consist of both closed- and open-ended questions in order to capture the opinions of the farmers in detail. Data was also obtained from focus group discussions and key informant interviews for triangulation and standardization of questionnaire-based data. Key informant interviews for this study includes provincial and district AGRITEX officers, officers from the Department of Irrigation (DIRR), extension officers, irrigation committee members and traditional leaders. Two Focus Group Discussions (FGDs), each with 10 to 15 participants were contacted in each of the three schemes studied. Data was collected on participants' perceptions of climate change and their preference for adapting to climate change. Climate trends from Thornhill Meteorological l Station were obtained from the Department of Meteorological l Services of Zimbabwe for 20 years (1990 to 2019). Thornhill Meteorological l Station was selected because it is the nearest meteorological l station to the study areas. Climate change factors and coping strategies were predefined by the researchers based on the existing literature on climate change adaptation and coping. Given that this study mainly focuses on smallholder irrigation schemes, farmers define drought as a lack of sufficient water to irrigate their crops in the dam.

2.4. Data analysis

Mann-Kendell (MK) test, a rank non-parametric test, was used to test the significance of trends of temperature and rainfall based on data obtained from Thornhill Meteorological l Station. The Mann-Kendell test was developed by Mann and Kendell and is fundamental for detecting the linearity of the trends. In this test, the existence (H_1) and non-existence (H_0) of trends were tested. Mann-Kendell test was run on XLSTAT.

The multinomial logistic (MNL) model is widely used for the analysis of studies that focuses on perception. To avoid misinterpretation, MNL may not be applicable to this study considering that farmers selected several climate change perceptions and coping strategies at the same time. In addition, a combination of factors affecting perceptions and adaptation strategies to climate change is not homogeneous. Hence, a binary logistic regression (BLR) method was used for the analysis of farmers' perceptions of climate change and the suggested coping strategies among smallholder irrigators. Several publications such as Alemayehu and Bewket (2017), Khan et al. (2020), and Ali et al. (2021) have used the BLR to analyse coping strategies in farming systems. This analysis helps to understand smallholder irrigators' perception of climate change and the benefits to adapt to climate change in the schemes.

The perception of climate change and potential alternatives for adaptation put forth by the farmers in the chosen smallholder irrigation projects in three areas of the Midlands province were estimated using a binary logistic model. This help to understand how farmers identify variation in temperature and rainfall patterns due to changing climate conditions and provide alternative response option through innovation and policy response. This study assumes that farmers' adaptation to climate change is based on their perception of climate change. A latent variable (Y^*_{ef}) represents perceived climate change perception and suggested adaptation options.

$$Y^*_{ef} = \alpha + \sum \beta_g X_g + \varepsilon Y^*_{ef} \tag{1}$$

A binary equation Y^*_{ef} have subscripts e representing farmers who perceived a change in climate variable and f representing farmers who perceive no change in climate variable.

Where: (X_g)—a vector of variables that affect farmers' perception of climate change for g explanatory variables, β_g–vector of coefficients of binary regression, and εY^*_{ef}–error term.

The latent variable Y^*_{ef} was not directly noticed in this study. Observations were:

$$Y_{ef} = \begin{cases} 1 \ \ if \ Y_{ef} > 0 \\ 0 \ if \ Y_{ef} \leq 0 \end{cases} \tag{2}$$

Where: Y_{ef} is a perception variable where farmer e perceives a change in climate variable f ($Y_{ef} = 1$) if the perceived changes were greater than zero ($Y_{ef} > 0$), and alternatively, e has not perceived a change in climate variable f if perceived changes were less than or equal to zero ($Y_{ef} \leq 0$).

Therefore, for perceived binary variable (Y_{ef}) for Equation (2) is written as follows:

$$P\left(Y_{ef} = 1\right) = Y_{ef} = G(\beta_g X_g) \tag{3}$$

Where: $G(.)$ – binomial distribution.

The variation between schemes in terms of age of household heads, education level, household size farming experience, years

TABLE 1 Mann-Kendall trend test for rainfall and temperature for the study area.

Variables		Temperature		
	Rainfall	Mean	Maximum	Min
Kendall's tau	−0.305	0.457	0.456	0.103
S	−58.000	84.000	85.000	19.000
Var (S)	950.000	934.667	942.333	937.667
p-value (Two-tailed)	0.064	**0.007**	**0.006**	0.557
Alpha	0.050	0.050	0.050	0.050

The bold values indicate statistically significant values at 5% or below.

in irrigation, and plot size which are continuous variables were tested using ANOVA, while categorical variables including gender, marital status, access to credit and livestock ownership were tested using Chi-squared.

3. Results

As shown in Table 1, the mean temperature and maximum temperature were significantly increasing. Therefore, the H_1, which suggests that there is a trend was accepted for maximum and mean temperature, while H_0 which states that there is no trend was accepted for rainfall and minimum temperature.

However, although during the Mann-Kendell test, H_0 was accepted for minimum temperature (Table 1), the sen's slope generally shows increasing temperature trends (minimum, maximum and mean) (Figure 1).

Similarly, despite the H_0 being accepted during the Mann-Kendell test of rainfall (Table 1), the sen's slope generally shows a decreasing trend of rainfall with the negative coefficient of the slope on the equation of the trend (Figure 2).

Table 2 shows the socio-economic characteristics of smallholder irrigators who participate in this study. The results in Table 2 show a significant variation in the age of the household head of the three schemes. The three schemes were composed of aging irrigators. The plot ownership was dominantly dominated by male farmers. Farmers in Insukamini irrigation scheme significantly attained a higher level of education followed by those in Exchange. Similarly, the study shows that irrigators in Ruchanyu had significantly higher household sizes compared to those in the other two schemes. Results in Table 2 show that farmers in Ruchanyu were dominantly married compared to the other schemes of this study. Farmers in Exchange irrigation scheme have significantly higher farming experience compared to those in Insukamini and Ruchanyu irrigation schemes. Also, farmers in Exchange irrigation scheme significantly have more years in irrigation farming compared to those in Insukamini and Ruchanyu irrigation schemes. As shown by the results in Table 2, there is no variation in access to credit among the three schemes. While livestock ownership was high across all schemes, the ownership was significantly higher in Exchange irrigation scheme (97.4%) compared to Insukamini (87.5%) and Ruchanyu (89.2%) irrigation schemes.

Figure 3 illustrates the percentage of farmers who perceive a change in climate variables. Fewer farmers perceived a shortening of the farming season and temperature increase. Results show that the majority of the irrigators in Insukamini scheme perceive longer dry spells, followed by those in Exchange irrigation scheme. Furthermore, farmers in the three schemes similarly perceive that rainfall was erratic. Farmers in Exchange perceive that there is a late onset of rainfall season compared to the other schemes. Meanwhile, an increase in drought frequency was highly perceived in Insukamini and Exchange irrigation schemes.

Figure 4 shows adaptation strategies suggested by irrigators in this study. The results show that irrigators in Exchange dominantly suggest improving soil moisture retention through practices like mulching and crop residue retention compared to other schemes. In addition, the adoption of small-scale reservoirs was relatively higher in Insukamini irrigation scheme compared to the other two schemes. Further, farmers in this study highly consider the setting of clear water use priorities, improve monitoring and early warning and change in crops and cropping patterns. Improved monitoring of climatic events and timely dissemination of early warning information *via* accessible channels was considered as the best practice to adapt to the negative impacts of climate change among the three schemes. Moreover, crop diversification and in particular, growing climate-resilient crops and changing cropping pattern, is among the suggested strategies to build climate resilience across all the three schemes.

Table 3 shows parameter estimates of the logistic regression model on the perception of irrigators on climate change adaptation. As shown in Table 3, the perception of an increase in drought was significantly varying across schemes and irrigators, that's farmers with small plots were more likely to significantly perceive an increase in droughts ($P \leq 0.05$). Youth were more likely to perceive an increase in future droughts compared to aging farmers in this study ($P \leq 0.05$). Also, there was a variation in perception across schemes ($P \leq 0.01$). Further, irrigators with larger plot sizes were more likely to perceive the rise in future droughts ($P \leq 0.05$). In addition to this, variation was significantly observed in the perception of the occurrence of short rain seasons across schemes ($P \leq 0.01$). Farmers who have been into irrigation farming for more years significantly perceive short rainfall seasons ($P \leq 0.05$) and farmers who access credit significantly perceived a shortening of the rain season ($P \leq 0.01$). On another note, the perception of the occurrence of long dry spells was significantly higher for male farmers than female farmers at ($P \leq 0.01$). Just like all the previous variables, there was significant variation among schemes on the perception of the occurrence of long dry spells ($P \leq 0.01$). Similarly, an increase in years of plot ownership significantly decreases the perception of the occurrence of perceived long dry spells ($P \leq 0.01$). Perception of erratic rainfall was positively affected by gender ($P \leq 0.05$) and negatively affected by household size ($P \leq 0.05$) and years in irrigation farming ($P \leq 0.01$). Perception of late occurrence of rainfall was significantly influenced by age ($P \leq 0.01$), gender ($P \leq 0.01$), schemes ($P \leq 0.01$), access to credit ($P \leq 0.01$), and plot size ($P \leq 0.05$). Perception of the rising frequency of droughts significantly varies across schemes ($P \leq 0.05$), is negatively influenced by years of irrigation farming ($P \leq 0.01$) and increases as plot size increases ($P \leq 0.05$). In addition, the perception of a decrease in the cold season was significantly higher

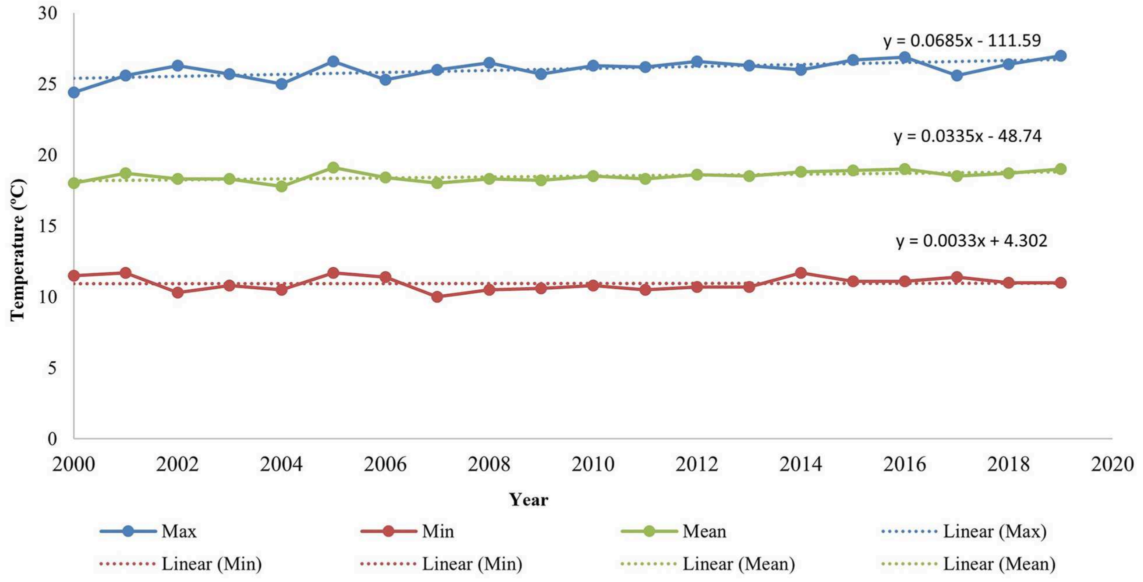

FIGURE 1
Temperature trends (Maximum, Minimum, and Mean).

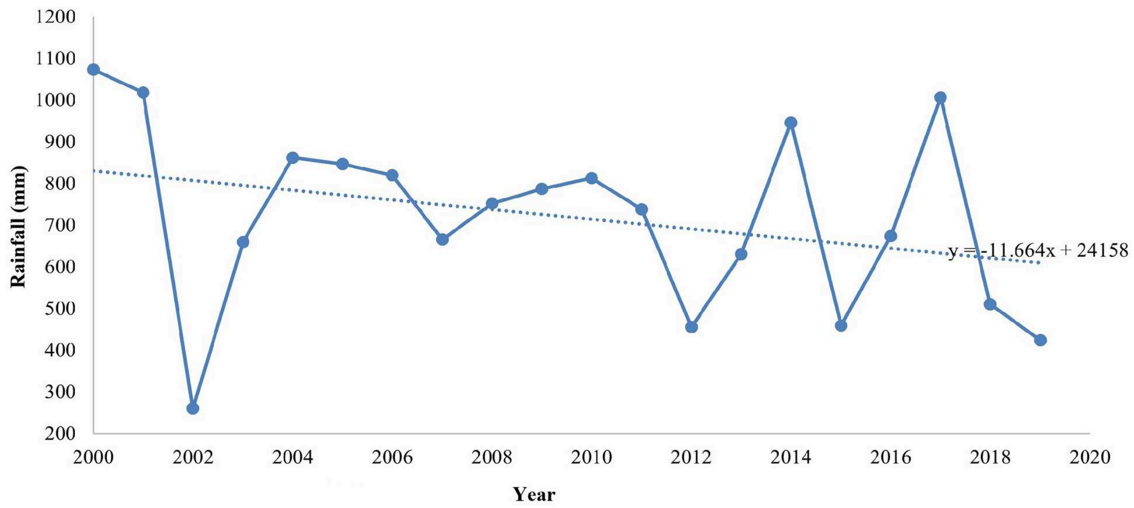

FIGURE 2
Rainfall trends.

for male farmers ($P \leq 0.05$), increase with rising education level ($P \leq 0.05$), and increase with livestock ownership ($P \leq 0.05$), while it decreased with years in irrigation farming ($P \leq 0.05$).

Surprisingly, farmers with high irrigation experience have a positive correlation with short rain seasons ($P \leq 0.05$) while having a negative correlation with long dry spells ($P \leq 0.01$), erratic rainfall ($P \leq 0.01$), increase in future droughts ($P \leq 0.01$) and decrease in clod season ($P \leq 0.05$). On a similar note, there was a negative correlation between age of farmers and the rise in drought ($P \leq 0.05$), while it positively correlates with long dry spells ($P \leq 0.01$) and late rainfall ($P \leq 0.01$). Although access to credit positively correlates with short rain season ($P \leq 0.01$), it negatively correlates with late rainfall ($P \leq 0.01$).

Table 4 shows the relationship between the perception of climate change and adaptation strategies as suggested by smallholder irrigators in the study. Perception of long dry spells ($P \leq 0.01$) and an increase in the frequency of droughts ($P \leq 0.05$) positively influence farmers to suggest improvement of soil moisture retention. Further, the adoption of small-scale reservoirs was suggested as an adaptation mechanism by farmers who perceive long dry spells ($P \leq 0.05$). Water charging and trade were significantly not considered by farmers who perceive high temperatures and short cold seasons. Although setting clear water use priorities was significantly and positively related to the perception of shortening the cold season ($P \leq 0.01$), it was significantly and negatively related to the perception of the late occurrence of rainfall and shortening of the rainy season ($P \leq 0.05$).

TABLE 2 Socio-economic characteristics of farmers in exchange, Insukamini, and Ruchanyu irrigation schemes.

Variable	Exchange		Insukamini		Ruchanyu		X^2 value	F-value
	Freq (SD)	%	Freq (SD)	%	Freq (SD)	%		
Age of HH	56 (12)		52 (13)		53 (12)			3.349*
Gender		63.5		59.1		70.3	1.440	
Education	9 (3)		10 (3)		8 (3)			6.661**
HH size	5 (2)		6 (2)		7 (3)			38.223**
Marital status		70.3		71.6		94.6	9.620**	
Farming experience	31 (1)		20 (1)		20 (2)			24.326**
Years irrigating	24 (13)		11 (7)		9 (3)			51.382**
Access to credit		30.2		40.9		40.5	3.766	
Plot size	0.20 (0.14)		0.39 (0.35)		0.34 (0.22)			23.607**
Livestock		97.4		87.5		89.2	11.433**	

**, *indicates statically significant at 1% and 5%, respectively.

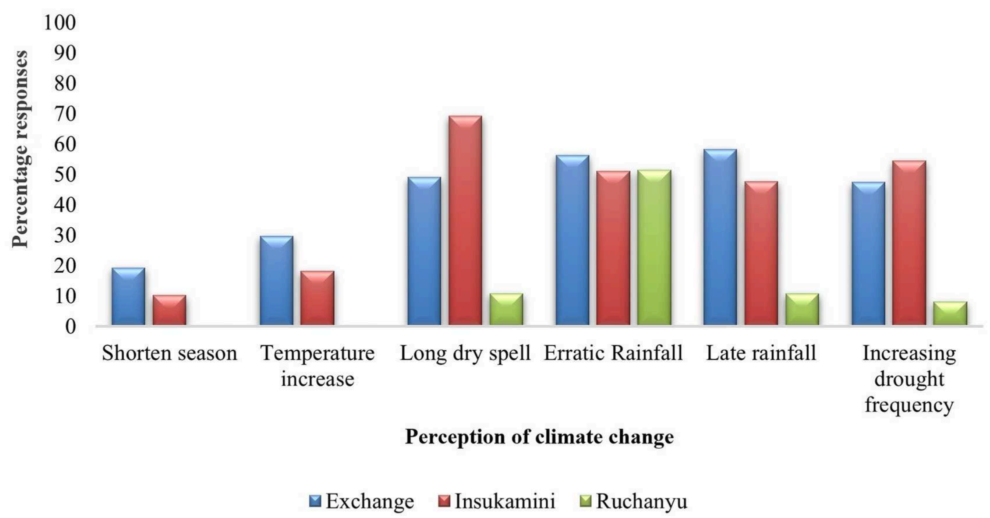

FIGURE 3
Perception of climate change.

As shown in Table 4, Adopting climate-resilient and short-season crop varieties was an adaptation option significantly suggested by irrigators who perceive long dry spells ($P \leq 0.01$).

Discussion

Irrigation development is a key strategy for eradicating poverty, improving agricultural productivity, raising income, and sustainability of ecosystems, particularly among rural communities (Asrat and Simane, 2018). Sadly, irrigation schemes are also becoming vulnerable to climate change, particularly increased water stress, hence, smallholder irrigators need to adapt to such changes. Climate change adaptation initially requires farmers to perceive climate change prior to identifying adaptation strategies. However, a wide range of socio-economic factors affects farmers' perception on climate change.

3.1. Farmers' perception on climate change

Smallholder irrigators were aware of climate variability and change as shown by their perceptions of climate change. This is likely to be associated with the rising trend of seasonal irrigation water shortages as catchment refill decreases gradually. Based on the findings of this study, the perception of climate change among smallholder irrigators was influenced by several socio-economic factors. The effects of several factors on climate change are discussed below.

The coefficient of age was significantly and positively related to the perception of long dry spells and late rainfall, while significantly and negatively related to the perception of the rise in droughts incidences. Previous studies reveal that the impacts of climate change vary with age (Zamasiya et al., 2017). A study by Dhaka et al. (2010) and Rapholo and Makia (2020) reveal that the age of household head positively and significantly related with the correct

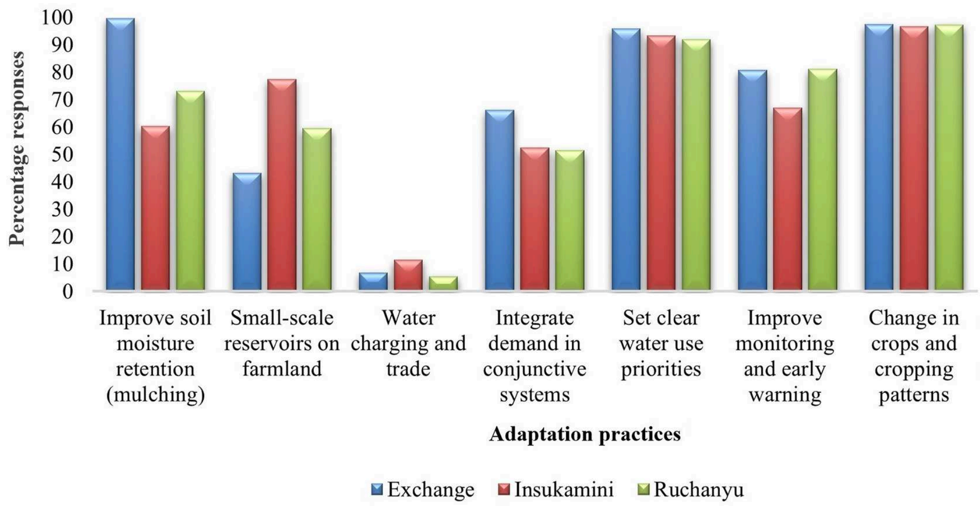

FIGURE 4
Coping strategies used by farmers in the three schemes.

TABLE 3 Parameter estimates of the binary logistic model for perception on climate change.

Variables	Rise in temperature	Rise in drought	Short rain season	Long dry spell	Erratic rainfall	Late rainfall	Increase in future drought	Decrease in cold season
Age	0.002	**−0.044***	0.033	**0.072****	0.017	**0.065****	0.030	0.029
Gender	0.910	0.187	0.637	**0.938****	**0.680***	**1.701****	1.009**	**1.119***
Level of education	0.040	0.061	−0.013	−0.034	−0.019	−0.006	0.024	**0.148***
HH size	−0.121	−0.066	−0.122	−0.122	**−0.150***	−0.044	−0.058	−0.022
Location	**1.805***	**−3.901****	**3.757****	**2.853****	0.129	**4.362****	**2.541****	20.162
Marital status	0.593	0.377	0.788	−0.760	−0.457	−0.682	−0.687	−0.475
Years in farming	0.054	0.037	0.008	−0.014	0.036	0.036	0.031	0.049*
Years in irrigation farming	−0.033	−0.027	**0.044***	**−0.088****	**−0.083****	−0.009	**−0.068****	**−0.050***
Access to credit	0.023	0.006	**1.200****	0.422	0.180	**−0.084****	0.390	−0.511
Plot size	−1.134	**2.657***	0.525	0.146	1.200	**2.024***	**1.844***	−2.264
Livestock	0.165	−0.203	0.650	−0.176	−0.292	−0.785	−0.613	**1.387***

**, *indicates statically significant at 1% and 5% respectively. The bold values indicate statistically significant values at 5% or below.

perception of climate change variability. According to Rapholo and Makia (2020), farmers that are younger than the age of 30 do not have extensive farming experience. Farming experience can be inferred from the household head's age (Zamasiya et al., 2017). Perception of climate change will positively relate to aging, as previous studies reveal that age positively influences adaptation to climate change due to skills development over the years (Zamasiya et al., 2017; Ford et al., 2020). The effects of age on climate change perception have been found to be consistent across many countries (Poortinga et al., 2019). According to Poortinga et al. (2019), age effects are explained by differences in motivations to maintain the prevailing social structure, with older people integrated into existing social orders having more to lose due to environmental change. Further, changes in value orientation over the course of life have implications on how one feels about climate change (Poortinga et al., 2019). That's people become more conservative with age, hence strongly determining climate change perception.

In contrast, it is no longer relevant or obvious that earlier generations knew their natural surroundings better than newer generations that are adjusting to changing environmental conditions (Aswani et al., 2018). While older people may have more skills, money, or willingness to adapt to climate change, that does not automatically mean they know more about it than younger people. While older people have a greater amount of time to accumulate knowledge, emerging knowledge shows that the present pattern of intellectual variability and connection closely relates to access to information among the youth (Mathez-Stiefel et al., 2012; Busch et al., 2019).

Gender (male and female farmers) is extremely important to the perception of climate change. Gender has a significant and positive

TABLE 4 Parameter estimates of the binary regression model of coping strategies.

Variables	Improve soil water conservation (mulching)	Small-scale reservoirs on farmland	Water charging and trade	Set clear water use priorities	Integrate demand in conjunctive systems	Improve monitoring and early warning	Change in crops and cropping patterns
High temp	−0.635	−0.530	**−2.336****	−0.375	0.608	0.066	0.702
Long dry spells	**1.412****	**0.891***	0.404	0.713	−2.294	−0.412	**1.648****
Erratic rainfall	−0.506	−0.002	0.700	−0.264	1.235	−0.279	0.274
Late rainfall	0.397	−0.538	1.105	**−0.871***	0.344	−0.724	−0.352
Increase in frequency of droughts	**1.144***	−0.547	−1.385	−0.553	−2.297	0.640	−0.059
Shorten cold season	−0.953	0.287	**−1.593***	**1.966****	1.131	0.204	−0.074
Shorten rain season	−0.993	0.079	0.814	**−1.136***	0.701	0.777	−0.033

**, *indicates statically significant at 1% and 5%, respectively. The bold values indicate statistically significant values at 5% or below.

coefficient with the perception of long dry spells, erratic rainfall, late rainfall, rising frequency of droughts, and a decrease in the cold season. This may reflect that male farmers in the study were better observers of climate change compared to their female counterparts. Previous studies (Gender and Alliance, 2016; Buckingham and Le Masson, 2017; Pearse, 2017) revealed that gender is positively related to climate change. Women, particularly those who are poor and are in rural areas have been found to be disproportionately and adversely impacted by climate change compared to males (Tanny and Rahman, 2016; Patel et al., 2019). Our findings concur with the findings by Selm et al. (2019) where women were found to have a negative self-perception of climate change knowledge. According to Selm et al. (2019), negative self-perception of climate change knowledge among female farmers is attributed to low confidence due to the high attrition rate of women in science, technology, engineering, and math (STEM) fields and negative cultural stereotyping. However, a recent study by Assan et al. (2020) shows the absence of variation in the perception of climate change variables, particularly rising temperatures, shortened cropping season, and increasingly erratic rainfall between men and women.

A significant and positive coefficient of education on the perception of a decrease in the cold season has been shown in Table 3. Such a relationship shows a remarkable contribution of education toward climate change perception. The finding from our study concurs with the findings by Ali et al. (2021) that people with higher education significantly predict a greater perception of climate change-related risks. Assan et al. (2020) suggest that education contributes to perceptions that will help to improve food security, wellbeing and resilience to climate stressors. Education is fundamental to accessing innovative information and new enhanced agricultural technology which helps to improve the perception of climate change (Ali et al., 2021). According to previous research, education is an important factor in climate change perception (Poortinga et al., 2019) and adaptation (Ali et al., 2021).

Results from this study show that household size is negative and significantly (at the 5% level) associated with the perception of erratic rainfall. Our results support the findings by Ndambiri et al. (2013), Oluwatusin (2014), Sanogo et al. (2017), and Uddin et al. (2017) showing a higher probability of a decrease in the perception of climate change with increasing family size. Before this study, we expect that perception of climate change increases with family size, as they are most likely to increase consumption expenditure as production reduces, hence reducing available capital for climate change adaptation. According to Uddin et al. (2017), household size is among the influential factors in the perception of climate change. Uddin et al. (2017) suggest that large families interact less and have limited access to extension contact than small families. In smallholder agriculture, farm families are a crucial source of labor for any farm operations. Several studies (Asrat and Simane, 2018; Ali et al., 2021) have found that household size influences perception and adaptation to climate change. However, our study findings differ from the previous studies (Asrat and Simane, 2018; Ali et al., 2021), whose findings show a positive relationship between household size and perception of climate change. Several studies including Ojo and Baiyegunhi (2020) and Ali et al. (2021) postulate that a positive relationship between household size and adaptation to climate change result from the ability of the household to supply family labor toward diverse livelihood options.

There was a significant and strong variation in the perception of the majority of climate change variables across different locations. Huang et al. (2018) also find variation in perception of climate change across geographical scales. Climate change perception and response are shaped by spatial variation in climate change and variability (Gaynor et al., 2019; Howe et al., 2019). Farmers' perceptions of climate change are centered on rainfall intensity, distribution and frequency, and severe event magnitudes of limited geographical scales (Habte et al., 2021). Further elements that affect farmers' perceptions of climate change include social, economic, demographic, and institutional aspects which can vary across spatial scales. A study was done in Africa by Ayanlade et al. (2018) and Gaynor et al. (2019) revealed that climate change risks, risk perception, and response have high spatial variability. According to Huang et al. (2018), spatial variation of the average knowledge of respondents influences their perception of climate change. Also, variation in objective vulnerabilities across spatial scales led to a geographical variation of perception of environmental risks (Huang et al., 2018). Exploring farmers' views in relation to local climate data analysis is crucial for improved planning and implementation of region-specific solutions to combat the effects of climate change.

Farming experience is an important factor in climate change perception and adaptation among smallholder farming sectors. The coefficient of the length of farming experience and perception of a decrease in the cold season was significantly and positively related. Farming experience can improve climate change perception and response. Length of farming experience brings together past and present knowledge to detect, understand and respond to climate change risks (Ford et al., 2020). According to Ayanlade et al. (2017) and Asrat and Simane (2018), the length of farming experience influences climate change perception and adaptation strategies adopted. Asrat and Simane (2018) suggest that the length of farming experience improves perception and response practices to climate change.

Length of experience in irrigation farming has a significant and positive coefficient with the perception of a shortening of the rainy season while having significant and positive coefficients with the perception of long dry spells, erratic rainfall, a rise in drought frequency, and a decrease in the cold season. Farmers experienced in irrigation farming have greater experience in farming and climate events (Parajuli et al., 2021). According to Abid et al. (2019), irrigation and farming experience indicates the probability of adapting to climate change increases with growing farming experience. This suggests that experienced farmers are more adaptable than less experienced farmers since they are more knowledgeable of various farm management strategies. That is, compared to farmers with less expertise, experienced farmers have more confidence to make courageous judgments.

In this study, access to credit has a significant and positive coefficient with the perception of a shortening of the rain season and a significant and negative coefficient with the perception of late occurrence of rainfall. Access to credit significantly affects adaptation to climate change (Ali et al., 2021). This study's finding on the relationship between access to credit and the perception of the shortening of the rainy season was in support of the findings by Ali et al. (2021). However, the relationship between access to credit and perception of late occurrence of rainfall was contrary to their findings. This reveals the implication of credit on climate change variables varies across climate change variables. While livelihood capital is an important fulcrum for sustainable livelihoods, farmers with more capital may be less interested in irrigation as they may have other (primary) sources of income and are therefore less concerned about irrigation and less interested in adoption of adaptation measures (Guo et al., 2022). This will contribute to their negative perception of climate change as they become latent observers of climate change. Farmer's livelihood capital determines their vulnerability to climate change and their adaptation strategies (Guo et al., 2022). Livelihood capital lead to a complex feedback relationship between farmers' cognition of the ecological-economic-social value (Guo et al., 2022). Access to credit is an essential climate change adaptation measure among the existing adaptation measures within smallholder irrigation systems (Asrat and Simane, 2018; Ali et al., 2021).

A positive relationship was found between the size of irrigation plots owned by irrigators and the perception of rising incidences of future droughts, the late occurrence of rainfall, and the rising frequency of droughts, while it was found to be negative for the relationship between plot size and perception on the decrease in the cold season. Results from these studies support findings by Asrat and Simane (2018) that land size affects climate change adaptation decisions and hence climate change perception. Small plot sizes constrain climate change adaptation decisions (Asrat and Simane, 2018).

Livestock ownership [size of livestock in Livestock Units (LUs)] significantly and positively relates to the perception of the shortening of the cold season. The findings of the study relate to the findings by Opiyo et al. (2016) whose findings suggest that livestock ownership significantly and positively affects perception and adaptation to climate change among households.

3.2. Perception and adaptation

The study shows a significant contribution of perception on adaptation to climate change among smallholder irrigation schemes. From the study, farmers have witnessed incidences of climate change through a broad range of variables. Therefore, there is a need to understand their adaptation options to cope with climate change variability and change. Adoption of agronomic practices such as the growing of early maturing crops as adaptation measures to the growing challenge of climate change is becoming more relevant in irrigated agriculture. Growing early maturing crop varieties was adopted as a management practice to increase yields in some SISs in South Africa (Fanadzo and Dube, 2019). Further, growing of early maturing varieties is one of the strategies used to reduce vulnerability to climate change in numerous farming systems (Fraga et al., 2020; He et al., 2020; Singh, 2020). According to Singh (2020), early cropping is one of the most the profitable climate change adaptation strategies because of its potential to reduce water consumption under irrigation.

Based on the study, irrigators are more likely to use soil water conservation measures to cope with the rising challenges of climate-induced water stress. Farmers who perceive an increasing frequency of droughts and long drought spells are likely to opt to improve soil moisture retention through practices such as increasing water holding of the growing media. The findings from this study corroborates those by Riaz et al. (2020), who indicated that adopting soil management techniques including stable-mulching and minimum tillage enhances soil water conservation. The adoption of soil water conservation is crucial to improve soil water balance under irrigated farming in dry climates (Zhou and Zhi Zhao, 2019). Improving soil water retention is a proven way of climate change mitigation and adaptation (Alemaw and Simalenga, 2015). A study by Tavares Ordones Lemos et al. (2021)

shows that soil water retention techniques reduce water and electric energy consumption in irrigated agriculture. Miller and Smucker (2015) postulate that soil water retention improves nutrient use efficiency. Further, the construction of small-scale reservoir ponds on farmland was significantly related to the perception of long dry spells. The construction of small-scale reservoirs is a climate change adaptation technique. However, irrigators did not take part in the construction of small-scale reservoirs among the schemes considered for this study. A study in Ghana by Balana et al. (2020) shows that small-scale reservoirs have the to improve groundwater availability and accessibility. Further, small-scale reservoirs can supporting multiple livelihood strategies, including irrigation, livestock production, fisheries and brick fabrication (Balana et al., 2020). Given that irrigation schemes are common pool resources, some of the adaptation strategies were implemented at the community level. Water charging and trade were significantly and negatively associated with the perception of rising temperatures and the shortening of the cold season. Water charging and trade is a climate change adaptation mechanism that decreases inefficient water management (Iglesias and Garrote, 2015) and enable healthy operation of an irrigation area (Tan et al., 2021). While cost recovery could improve efficiency and equity in SISs (Bell et al., 2016), several studies have shown that the cost of irrigation water is not sufficient to cover the operation and maintenance cost (Giannakis et al., 2016; Mutambara et al., 2016; Berbel et al., 2019; Tan et al., 2021). Therefore, this compromises efficiency and equity in schemes, hence negatively affecting perception toward water pricing. Although the setting of clear water use priorities was positively related to the perception of the shortening of the cold season, it was negatively related to the perception of late rainfall and the shortening of the rainy season. Shortening of the rainy season and late rainfall is the least considered in irrigation systems since they primarily rely on irrigation water and are less worried about rainfall. Setting clear water use priorities improves water use efficiency (Iglesias and Garrote, 2015).

Farmers who perceive long dry spells opted to adopt climate-resilient and short-season crop varieties. Long dry spells affect catchment refill, which further reduces the availability of water for irrigation. Surprisingly, farmers who perceive long dry spells show a positive correlation with adopting climate-resilient and short-season varieties, while those that perceive a shortening of the rainy season did not. However, findings from this study show us that farmers who shortening of the rainy season were convinced with setting up clear water use priorities as an alternative option to the adoption of climate resilient and short-season crop varieties especially considering that they are operating in the irrigated system. A review work by Acevedo et al. (2020) concluded that socio-economic factors such as age, education, access to inputs, marital status, ethnicity and quality of extension affect the adoption of climate-resilient crops. However, our results show that only age, gender, household size, access to credit and farming experience affect the perception of farmers toward a drying climate. Operating in the irrigated system offers diverse coping strategies that can be adopted alone or in combination with other options (Thapa and Scott, 2019; Azadi et al., 2021). Climate-resilient and short-season varieties have been recommended as a way to cope with climate change with a highly variable adoption rate (Acevedo et al., 2020). Therefore, its high variability in adaption rate referred to by Acevedo et al. (2020) gives equal opportunities for preferences on either to adopt it or not adopting.

4. Conclusion

This study's findings show incidences of climate change through rising temperatures and a decrease in average rainfall based on readings from the local Meteorological l station. This study reveals that smallholder irrigators perceive a changing climatic condition. Perceptions of climate change were influenced by socio-economic factors. Key factors which affect the perception of climate change as revealed by the binary logistic model include age, gender, location, irrigation experience, and plot size. Socio-economic factors need to be considered in climate change adaptation and development policies to ensure that relevant adaptation interventions are provided to the relevant scheme, farmers' irrigation experience, age group and gender. Based on the perception of climate change, irrigators suggested adaptation strategies to climate change in irrigated systems. Adaptation strategies that are related to the perception of climate change include improving soil water conservation, construction of small-scale reservoirs, water charging and trade, setting clear water use priorities, and adoption of climate resilient and short-season crop varieties. Smallholder irrigation farmers faced value chain constraints and technical efficiency challenges in coping with climate change. Understanding irrigators' perception of climate change and the corresponding adaptation strategies is crucial to promoting context-specific strategies for sustainable development.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Review Board of the University of KwaZulu-Natal (HSSREC/00003196/2021). The patients/participants provided their written informed consent to participate in this study.

Author contributions

LM: conceptualization, data curation, formal analysis, investigation, methodology, software, visualization, writing—original draft, and writing—review and editing. RM: project administration, supervision, validation, visualization, and writing—review and editing. PM: funding acquisition, project administration, resources, supervision, validation, and visualization. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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