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Influence of smallholder farmers' perceptions on adaptation strategies to climate change and policy implications in Zimbabwe

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Abstract: Smallholder agricultural production is largely affected by climate change and variability. Despite the negative effects brought by climate variability, smallholder farmers are still able to derive livelihoods. An understanding of factors that influence farmers' responses and adaptation to climate variability can improve decision making for governments and development partners. This study investigated farmers' perceptions and adaptation strategies to climate change and how these influence adaptation policies at local level. A survey was conducted with 100 households randomly selected from Chiredzi district. Data collected was used to derive farmer perceptions to climate change as well as the influence of their perceptions and subsequent adaptation methods to ensuing local agricultural adaptation measures and policies. The results indicated that smallholder farmers perceived general reduction in long-term annual rainfall and rising local average temperatures. Adverse trends in rainfall and average temperature perceived by farmers were consistent with empirical data. These perceptions and other socio-economic factors helped to shape smallholder farmer agricultural adaptation strategies. Policy implications are that the government and development partners should seek ways to assist autonomous adaptations by farmers through investments in planned adaptation initiatives.

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1 Introduction

Agriculture remains a significant contributor to the gross domestic product in developing country economies. About 60% of Sub-Saharan African are employed in the agricultural industries and more than 80% of the region's poorest households depend directly or indirectly on farming for their livelihoods [1]. In Zimbabwe, the agricultural sector has been a significant contributor to the country's economy and the welfare of its people through its direct impact on economic growth, household income and food security [2]. It provides employment and valuable livelihoods to about 70% of the country's population and accounts for about 40-50% of the country's total export revenues [2]. However, the agricultural sector is currently affected by climate change and variability, among other things. Climate change is expected to have serious environmental, economic and social impacts in the smallholder farming sector of Zimbabwe. In particular, smallholder rural farmers, whose livelihoods depend on the use of natural resources, are likely and already bearing the brunt of adverse impacts. The extent to which these impacts are felt depends largely on the degree of adaptation in response to climate change.

Adaptation is widely recognized as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced [3]. The degree to which an agricultural system is affected by climate change depends on its adaptive capacity. Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes to moderate potential damage), to take advantage of opportunities, or to cope with the consequences [4]. Thus, the adaptive capacity of a system or society describes its ability to modify its characteristics or behaviour so as to cope better with changes in external conditions. For the smallholder rural farmers, adaptation to climate change requires the farmers to first notice that the climate has changed, and then identify useful adaptation strategies and implement them [5]. Many agricultural adaptation options have been suggested in literature. They encompass a wide range of scales (local, regional, global), actors (farmers, firms, government), and types: (a) micro-level options, such as crop diversification and altering the timing of operations; (b) market responses, such as income diversification and credit schemes; (c) institutional changes, mainly government responses, such as removal-preserve subsidies and improvement in agricultural markets; and (d) technological developments — the development and promotion of new crop varieties and advances in water management techniques [6,7]. Most of these represent possible or potential adaptation measures rather than the ones actually adopted. However, there is no evidence that these adaptation options are feasible, realistic, or even likely to occur. Furthermore, the adaptation strategies would only be possible with complete and accurate knowledge of future climatic conditions, which is why these were aptly named 'clairvoyant farmer' scenarios [8]. Thus, climate change impact studies often assume certain adaptations and little explicit examination of how, when, why, and under what conditions adaptation actually occurs in economic and social systems. This study, as part of a more recent strand of adaptation research, seeks to investigate actual adaptations at the farm level, as well as the factors that appear to be driving them.

The primary hypothesis is that farmers adapt to perceived and repeatedly observed climate change and variability. The analysis is conducted in two stages. First, it is determined whether the climate has changed, whether the farmers perceive climate change and variability, and what characteristics differentiate farmers who perceived changes from those who did not. Second, the determinants of adaptation are examined. Not all of the farmers who perceived climate change will respond by taking adaptation measures. Here it is argued that farmers who perceived climate changes and responded share some common characteristics. Therefore, there is a need to understand the reasons underlying their response (or failure to respond for those who did not adapt). Furthermore, adaptation to climate change requires farmers to choose from among a set of adaptation options (practices and technologies) available in their region. By identifying the important determinants of choosing any of the adaptation options, this paper provides important policy information on how to promote various adaptations to climate change in rural Zimbabwe.

2 Materials and methods

2.1 Study area

The study was carried out in Chiredzi District which lies between 18°55' S and 29°49' E covering a significant part of Masvingo Province (Fig 1). Chiredzi District was especially chosen because it falls within the semi-arid areas, lying mostly under agro-ecological region V of Zimbabwe's farming regions which receives mean annual rainfall of less than 450 mm. However the climate of Chiredzi District is also modified by the altitude of the area and rainfall pattern in the district is also influenced by relief. The mean annual rainfall ranges from 450 mm in the southern parts of the district to 750 mm in the North Eastern sections.

Four wards were selected, two on either side of the Runde river, namely, ward 2, 4, 6 and 8. A ward is an administrative area which covers an average of 200 ha and, in this case, consisted of an average of 15 villages of about 40 households each. Although a better part of the district is endowed with very fertile black soils which do not require any meaningful fertility treatments, crop production is mainly constrained by dry conditions and short growing season. This region is recommended for extensive livestock production, however, smallholder farmers in these areas practice mixed crop and livestock farming systems despite acute weather conditions. Common crops grown include maize, sorghum, millet, cowpeas, sunflower and cotton. Maize is grown despite its high chances of crop failure due to erratic rainfall in any particular season. The communal areas of the district also have a widespread shortage of grazing pastures for livestock which also constrains livestock production.

2.2 Data collection

Data was collected using a structured questionnaire, focus group discussions and key informants interviews. 100 households practicing dryland farming, 25 from each of the four wards were interviewed. Five villages were then randomly chosen from each ward. Within the randomly selected villages, five farmers were also randomly selected using the farmer lists from agricultural extensions officers in each village to give 25 respondents per ward. Key informant interviews were done with

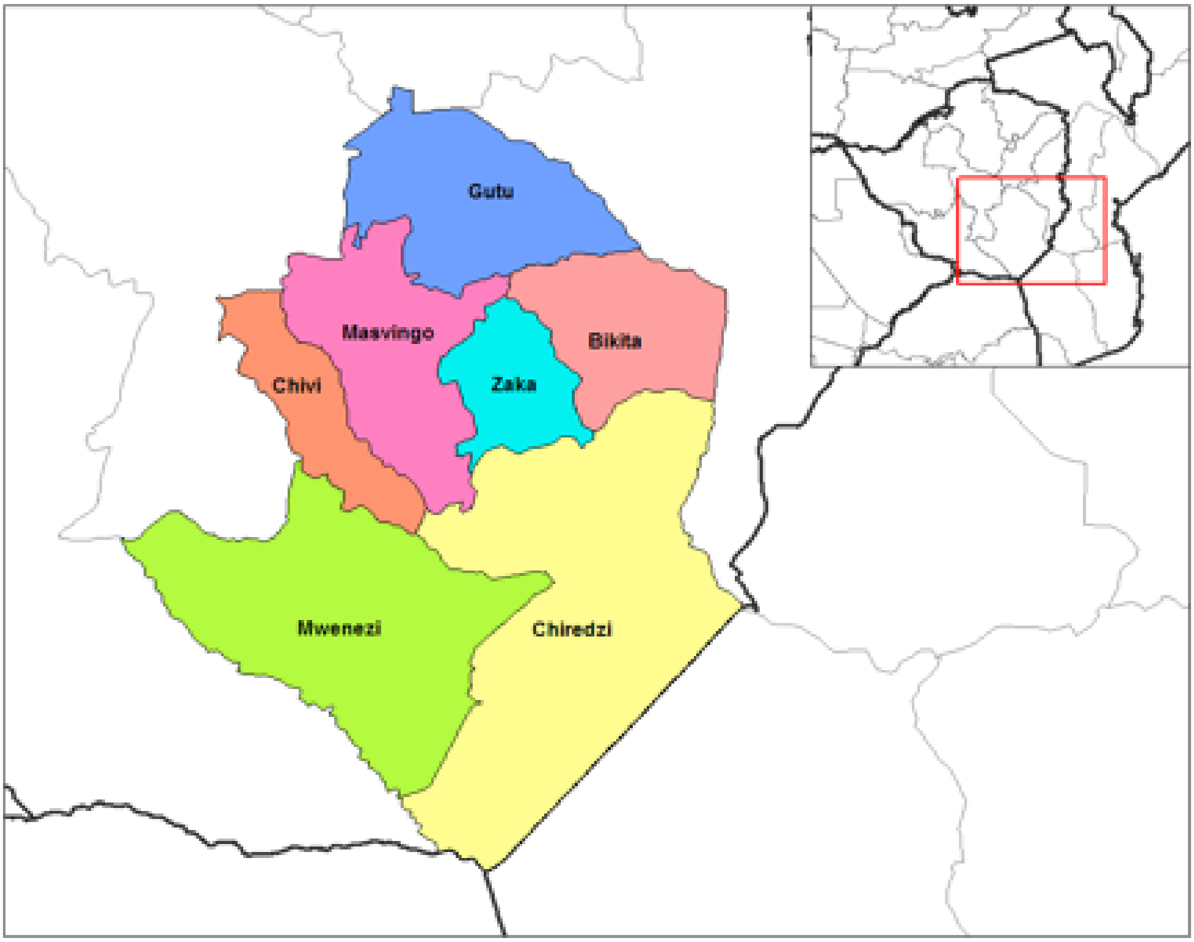

Figure 1: Location map for Chiredzi district in Masvingo Province, Zimbabwe

local authorities, community leaders and government agricultural extension officials. Key informant interviews were also done with key people from the local government, government agricultural extension officials, non-governmental organisations and the community leadership to gain a general idea about the policy issues concerning climate adaptation in the district. Five focus group discussions were conducted, one in each ward using semi-structured questionnaires so as to gain more insight on the adaptation strategies and constraints of the farmers.

Secondary data on climate (rainfall and temperature data) was collected from the Meteorological Services Department in 2013 while data on various economic indicators was obtained from the Zimbabwe Statistical Agency in the same year. The data from meteorological stations was compared to information provided by smallholder farmers on the traditional and indigenous indicators that they use to predict weather patterns.

2.3 Data analysis

The Statistical Package for Social Sciences was used for simple descriptive analyses of household demographic and other socio-economic variables using frequencies and means, and for linear trend analyses of time series data on climate variables and households. The multinomial logit regression was used for analysis of determinants of adaptation. A standard regression model was used to describe the relationship between the rainfall and temperature, and the time obtained for time series data of rainfall and temperature for the study area. The multinomial logit model was used to analyze determinants of smallholder farmers' choice of agricultural adaptation strategy in coping with climate change and variability.

3 Results

3.1 Perceptions on long term rainfall and temperature changes

Farmers perceived changes in both rainfall and temperature in the past 10 – 20 years. An average of 91% perceived an increase in temperature and 90% perceived a decrease in annual precipitation. Farmers highlighted that there was increase in incidences of droughts and heatwaves. Data provided by Chiredzi research station showed a negative trend in total rainfall in the district from 1980 to 2013 (Fig 2). The decrease in rainfall was at the rate of 2.58 mm/year. The trend in mean annual average temperatures was shown to be positive. The trend increase in average temperatures was 0.04ºC/year (Fig 3).

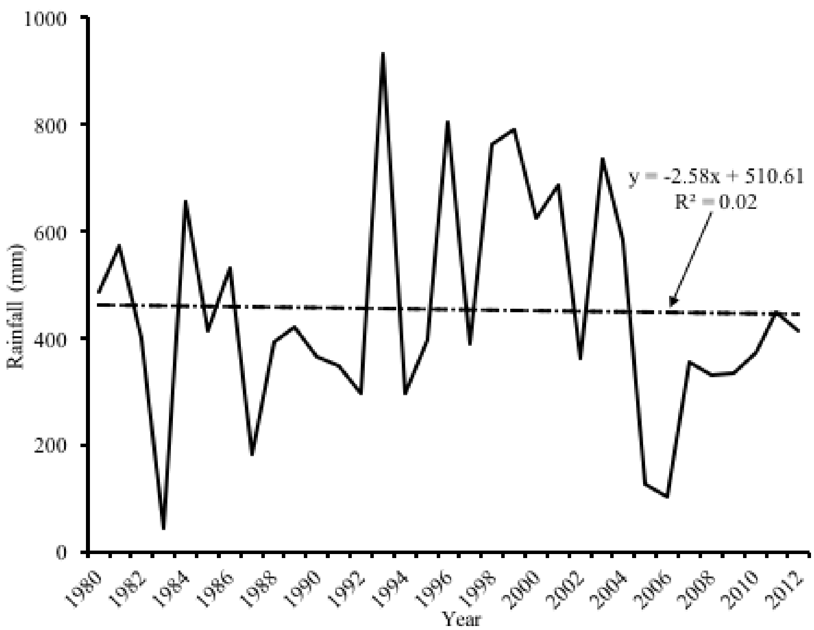

Figure 2: Rainfall trend for Chiredzi district from 1980-2012

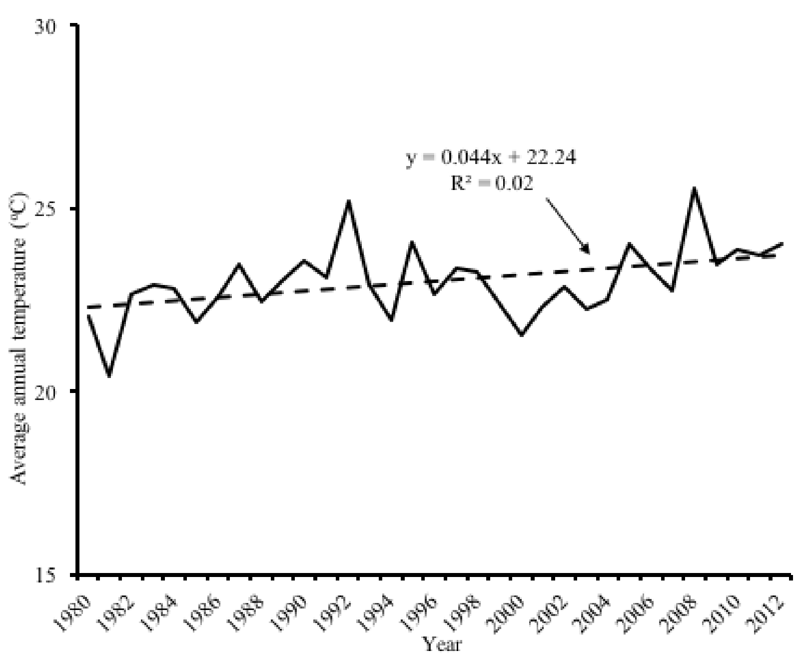

Figure 3: Temperature trend for Chiredzi district from 1980-2012

3.2 Smallholder farmer perceptions on long-term changes in plant cover, crops and livestock dynamics

Most farmers perceived a decline in bush encroachment and decline in herbaceous cover (Figure 4) and a decline in vegetation heights (Figure 5). Majority of the farmers perceived increases in incidences of agricultural pests, diseases and weeds (Table 1). However, there were also relatively high numbers of farmers who perceived no changes in pests and diseases.

3.3 Smallholder farmer adaptation strategies to climate change

Farmers were observed to have different strategies in response to changes in rainfall, temperature, crop and livestock phenology and other environmental changes. These strategies were variable and mainly focused on improving crop production (Table 2).

Farmers confirmed that they do not use one strategy singly, so the strategies were grouped into 8 categories (Table 3). Crop adaptations through use of agronomic

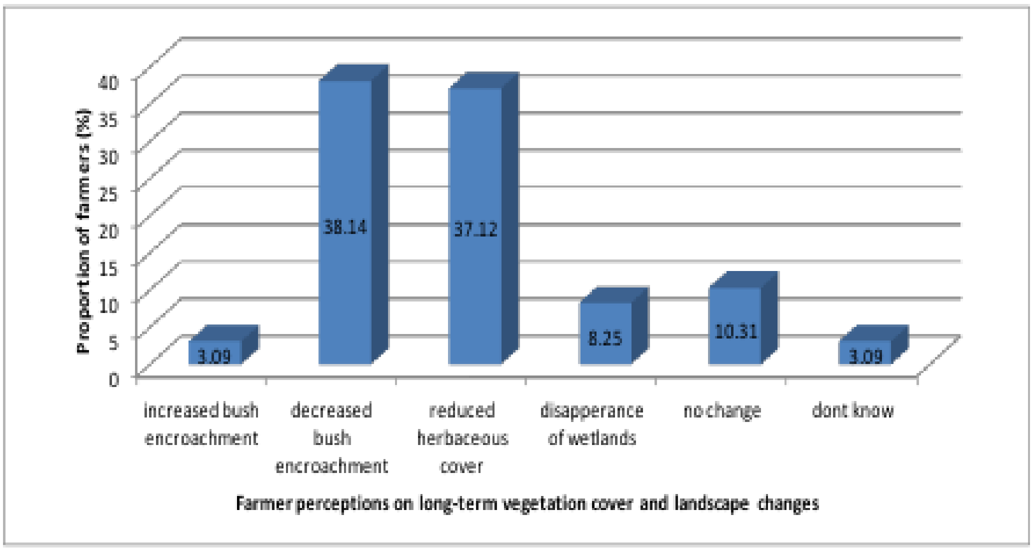

Figure 4: Farmer perceptions on long-term vegetation and landscape changes in Chiredzi district, Zimbabwe

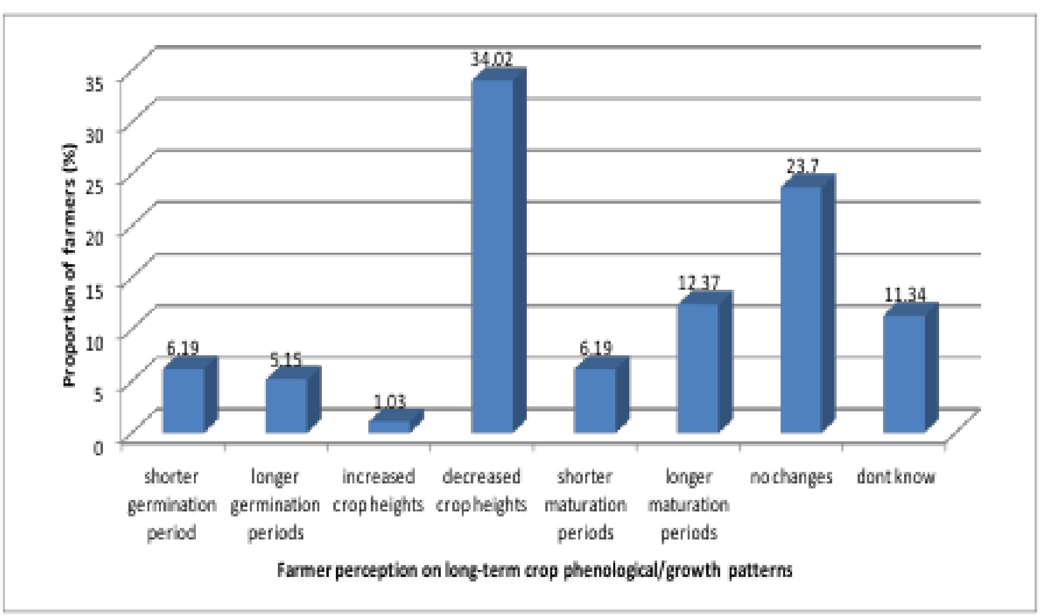

Figure 5: Farmer perceptions on long-term crop phenological changes in Chiredzi district, Zimbabwe

Table 1: Perceptions of farmers on different crop and livestock pests and diseases

	% frequency				
Attribute	**Increase**	**Decrease**	**Change in seasonality or species**	**No change**	**Don't know**
Crop pest abundance	62	5	7	21	4
Crop diseases	47	4	5	35	9
Weed abundance	31	10	15	42	2
Livestock pest	50	5	7	30	9
Livestock diseases	43	5	3	36	12

Table 2: Adaptation measures by smallholder farmers in Chiredzi district

Adaptation measure	Percentage of adopters
Different crop varieties	52
Crop diversification (Different crops)	64
New planting dates	68
Shortening the length of growing period	70
Mixing dry land and home gardens	84
Mixing farming and non-farming activities	84
Use of irrigation (home gardens)	80
Use of chemicals, fertilisers, manure and pesticides	77
Increasing water conservation on farms	61
Increasing soil conservation on farms	66
Shading and sheltering young plants	74
Mixing crops and livestock (diversification)	74
Livestock diversification (different animals)	83
Adjusting livestock management practises	83
Insurance	0
Use of prayer and socio-cultural adaptations	84

Table 3: Categorised adaptation measures used by farmers

Adaptation measure	% of respondents
No adaptation	14
Agronomic practices only (crop and/or soil modifications)	55
Livestock practices only (management and/or modifications)	2
Socio-cultural practices and beliefs only (prayers and cultural festivals)	0
Agronomic and livestock practices (combined)	27
Livestock and socio-cultural practices (combined)	0
Agronomic and socio-cultural beliefs/practices (combined)	2
Agronomic, livestock and socio-cultural beliefs/practices (combined)	0

practices under dry land conditions is the dominant system followed by combination of agronomic and livestock practices under dry land conditions. Livestock adaptations only without crops was carried out by the minority, which showed that this adaptation strategy is less popular among smallholder farmers in the district despite suitability of livestock in the region. Mixing agronomic practices (crop adaptations) and socio-cultural beliefs and practices were shown to be the least common strategy of adaptation.

3.4 Smallholder farmers' choice of adaptation strategy

An estimation of the multinomial logit model for the determinants of the type of agricultural adaptation strategy to climate change in Table 4 showed that age of the household head, gender, members fit for work in the household, draught cattle ownership and average crop yields were important in the choice of an adaptation strategy.

4 Discussion

Farmers in the district perceive declining annual rainfall while they perceive annual average temperature to be increasing which is in line with the actual trends from the trend analyses. Analysis of temperature data from 1980 to 2012 in Chiredzi district shows a trend of increasing temperature. Rainfall also shows a declining trend, although very marginal. It has been reported that rainfall in southern Africa would be characterized by large inter-annual variability due to climate change [9] and there has been noticeable, long-running trend of decreasing rainfall. Farmers' perceptions of climatic variability are in line with climatic data records. Thus, the consistency between farmer perceptions on climate change and the actual trends in climate may imply that farmers are in a better position to implement measures and agricultural practices which can help them cope with the negative impacts of climate change [10]. Other than farmers' perception on changes in climate, majority of the farmers also perceived changes in crops and livestock dynamics. This confirms findings by [11] that phenology of plant and animal species are changing as a result of changes in climate.

Having established that farmers' perceptions are in line with actual trends in the climate, and that farmers perceive changes in crop and livestock dynamics, the next focus was on the actual agricultural adaptations being implemented by farmers to cope with the changing climate and factors affecting adaptations by farmers to climate. It was observed that farmers used diverse strategies which ranged from practices that are agronomic based, practices that are based on livestock improvement

Table 4: Influence of household endowments on adaptation strategies

Explanatory variables	Agronomic practices only		Livestock practices only		Agronomic and livestock practices		Agronomic and socio-cultural beliefs/practices	
	Coeff.	P-level	Coeff.	P-level	Coeff.	P-level	Coeff.	P-level
Intercept	-2.01	0.02**	-2.65	0.09*	-5.00	0.02**	-4.23	0.99
Gender	0.54	0.05*	-2.91	0.09*	3.16	0.01**	-5.02	0.99
Age	0.66	0.06*	2.50	0.10*	0.05	0.02**	1.63	0.10*
Members fit for agriculture	0.16	0.00***	0.12	0.02**	0.22	0.00***	0.22	0.01**
Cattle owned	0.04	0.08**	7.43	0.07*	0.08	0.06*	-5.47	0.99
Maize yield	0.07	0.00***	5.27	0.92	0.03	0.08*	2.04	0.08*
Cotton yield	14.19	0.05**	3.66	0.85	13.78	0.00***	3.58	0.01*
Perception on climate	0.87	0.01***	1.03	0.60	0.17	0.04**	0.84	0.08*
Base category		No adaptation						
Likelihood Ratio Chi²		61.97						
Pseudo R^2		0.62						
Log likelihood		-110.82						

Note: ***, **, * = significant at 1%, 5%, and 10% probability level, respectively.

and practices based on socio-cultural beliefs. Of these strategies, agronomic practices such as using different crop varieties and new planting dates were the dominant adaptation strategy followed by combination of agronomic practise with livestock practices. Use of livestock practices strategies alone and socio-cultural practices and beliefs were not highly ranked as common adaptation strategies. This concurs with results from other studies in southern Africa [11,12].

Factors that determine adoption of the different adaptation strategies by farmer were mainly based on resource endowment of the farmer, characteristics of the farmer, farmer yields and farmer's perception on environmental changes. This was also reported by [13] in his studies on climate change adaptation using the multicriteria adaptation analysis. The results from the multinomial logit models highlight that household size, wealth, farm size, farming experience, perception to climate change and crop yields were the factors that enhance adaptive capacity to climate change. This agreed with studies carried out elsewhere which showed that these determinants are critical in defining adaptation [14,3,7].

Knowledge about perceptions and adaptation may be used to compliment specific policies to address problems within a vulnerability sector, such as the rural farming community of Chiredzi district. Long term planning for climate-sensitive resources should incorporate changes in conditions that would affect services provided by those resources. Including climate change in long term plans could result in changes that will enable future generations to cope better with climate vagaries in vulnerable communities. An inventory of existing practices and decisions used for climate change adaptation could be used in areas that become drier, like Chiredzi, due to climate change. Such adaptation planning would be critical as southern Africa, a known climate 'hot spot', rattles with negative impacts of climate change [15]. Disaster risk programs would be better implemented when there are existing policies driven by local area knowledge of vulnerabilities and adaptation options. In fact, disaster relief could be tied to hazard reduction programs. Such policies would benefit local communities as current climate risk would be reduced. Climate variability and the climate risks are often not well understood by decision makers. Because climate adaptation will affect the individual, organisational and policy level, communication about the human significance of climate variability would be important at all levels of the community. Increasing sensitivity to climate issues would facilitate adoption of measures to prepare for future climate variability and change [16]. The implications of these policy considerations are that policy makers should evaluate these options based on the degree to which they may address known climate variability concerns as well as the degree to which they will ease potential burden for future generations to cope with climate change. The easiest political course for decision makers may be to ignore climate change until its impacts are felt. This, however, will leave it entirely upon the future generations to bear the full costs of adaptation to our legacy of increase greenhouse gas concentrations. This is why countries such as Malawi are beginning to address climate change in their long-term planning [17]. Making incremental changes now will make it easier for future generations to cope with climate change [18].

5 Conclusion and policy implications

Majority of the farmers were able to give correction perceptions on climate change as indicated by their perceptions which were in line with metrological data. The farmers, being well aware of climatic changes, seem to take steps to adjust their farming activities. The majority of the farmers have adjusted their farming practices to account for the impacts of climate change. The main adaptation strategies of farmers in Chiredzi district are switching crops, changing crop varieties, changing planting dates. Factors influencing adaptation measures taken by farmers varied from household socioeconomic attributes and crop yields. This study demonstrates the importance of government policies and strategic investment plans that support improved access to climate forecasting, research into the development of, and information about, appropriate farm-level climate adaptation technologies, farmer education and awareness, especially in areas where dryland farming currently predominates. There is need to educate farmers to improve their responsiveness to climate change and to enhance adoption of suitable adaptation techniques. The government should also create an enabling environment that improves accessibility to new crop diversities and livestock species that are appropriate to drier environments and access to production information like water and soil conservation techniques as well as the other adaptation options that can be identified s essential in promoting farmer adaptation to changes in climate. This study also concludes that it is important for governments to consider smallholder farmers' perceptions to climate change in adaptation policy formulating as adaptation strategies adopted by smallholder farmers depend on their local understanding of climate risks and shocks.

Conflict of interest statement: The authors declare no conflict of interest.

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