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Perceptions of Climate Change and the Potential for Adaptation in a Rural Community in Limpopo Province, South Africa

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Abstract: Perceptions of climate change by rural communities are centered on observations of variations in temperature and rainfall patterns supported by observations and projections on climate alterations in the form of increased temperatures and scarce rainfall by scientists worldwide. The present study documented perceptions of climate variation and the community's ability to adapt to climate change hazards threatening the production of subsistence crops. Data were collected through interactions with 100 participants. In the study, climate change is explained as variations in temperature and rainfall patterns which resulted in excessive heat, erratic rainfall patterns and drought negatively impacting on subsistence crop production. Community members have the potential to limit the impacts of climate hazards on subsistence crop production. The negative impacts of climate hazards are limited by community members' indigenous knowledge of rainfall prediction, the seasons, crop diversification and mixed cropping. Mulching and the application of kraal manure improve the soil structure and fertility to reduce crop failure. These adaptation measures are resilient to the negative impact of climate hazards and may be helpful in the development of adaptation policies to assist rural communities vulnerable to climate change hazards.

Keywords: climate change; climate hazards; rural community; adaptation; subsistence crops

1. Introduction

Perceptions of climate change and its threats to rural communities are among the major challenges faced by scientists. A few studies prove that these communities are aware of change in climatic conditions and their impacts on people's livelihoods [1,2]. However, it is reported that rural communities' perceptions of climate change are centered on variations in temperature and rainfall patterns [3] manifested as rising temperature trends and scarce rainfall [1]. Rural communities are aware that devastating changes in their living conditions such as malnutrition, poverty, water and air contamination, increased risks of disease, floods, soil erosion and depletion of biodiversity are as a result of climate and environmental variability [3,4]. Observed change in rainfall and temperature patterns are supported by annotations of a drastic increase in temperatures with negative impacts on the livelihood patterns of rural communities [5]. This type of understanding of climate change is crucial in planning the adaptation and mitigation measures to address the effects of increased temperature and scarce rainfall for sustainable livelihood [3].

Observed effects of climate change on rural communities are: drought, depletion of water resources and biodiversity, soil erosion, decreased subsistence economies and cessation of cultural activities which are likely to impact negatively on human health conditions and livelihoods [6]. About 70% of people in developing countries living in the rural areas depend on subsistence crop production [7,8] which is recently characterized by low productivity and instability [9] as a result of

marginal and erratic rainfall, low soil and ambient temperatures below the minimum temperature of 10 °C. Subsistence farmers are vulnerable to the impacts of increased temperature [10] and drought [11,12] which are among the recent pervasive stressors rural communities have to cope with [13,14].

It is becoming clear that realization of development goals would be seriously hampered by a decrease of suitable areas for maize, cotton and sorghum suitable by 2080 [4]. Drought is also expected to exacerbate declining agricultural outputs, further compromising economic growth and stability, employment levels, food security, demand for other goods and poverty reduction [15,16]. Major climate hazards; excessive heat, disease, depletion of biodiversity and water scarcity threaten the livelihoods of communities that depend on subsistence crop production for survival. Furthermore, there is a remarkable ecological variability as a result of persistent drought which resulted in decreased water resources and biodiversity [4] threatening the livelihoods of rural communities [17,18].

However, rural communities have developed culture-based mechanisms of adaptation to the harsh weather conditions threatening their subsistence agricultural production [19]. Adaptation to drought, scarcity of rain, decreased production of crops is accomplished through community-based measures to sustain human livelihoods [20]. These mechanisms are complex, developed and used within cultures [11] and imply greater dependability on the use of indigenous knowledge to carry on production of subsistence crops [21]. Production of subsistence crops in the era of climate change is planned in terms of the people's knowledge of the seasons, soil fertility and texture, and crop variations which enhance sustainable production of crops [21]. Small-scale farmers sustain the production of crops [1,22,23] through knowledge of environmental conditions and seasonal change without access to modern scientific knowledge. These community-based adaptation methods are grounded on the communities' priorities, needs, knowledge and capacities [3] which empower people to plan and cope with the impacts of climate change [4]. Studies on rural communities' perceptions of climate change and their potential for adaptation to climate change hazards are limited. The present study examined rural community members' perceptions of climate variation and their capability to adapt to the impacts of climate change hazards on the production of subsistence crops on which they depend for livelihood.

2. Methods

2.1. Study Area

The study is based on fieldwork conducted between February 2014 and October 2015 in Mogalakwena community in Limpopo Province, South Africa. The community falls within Rebone which has a total area of 20 km^2 with a population of about 10,579 (991.83 per km^2). The households are distributed in the area between Steilloop and Neandertal along Seepabana River (Figure 1). The community falls within the summer rainfall region of Limpopo Province. The average rainfall is 600–650 mm with the highest measurements in January and December. Thunderstorms are recorded fairly often. The climate is renowned for its pleasant summer and mild sunny winter. Summer temperatures are from October to March ranging between 27 °C and 30 °C [24].

Topography of the area is characterized by irregular undulating lowlands with hills and low-lying mountains. Environmental challenges are inadequate sanitation systems, erratic rainfall, drought and inconsistent water supply while the mines and industrial activities negatively affected underground water quality. The local municipality is the largest contributor to domestic fuel burning emissions in the district, contributing to approximately 52% of emissions [24]. Land use ranges from residential, subsistence farming and livestock holdings. Deforestation, degradation of the natural vegetation caused by overgrazing and poor cultivation methods are held responsible for land deprivation. Inadequate land cover as a result of depletion of biodiversity exacerbates soil erosion and the development of dongas. Alien plant invasion poses threats to the indigenous flora. Extensive cattle and

goat farming is for domestic usage. There is an observable gradual movement away from subsistence economy towards wage labour in the local shops, towns and mines within the local municipality [25].

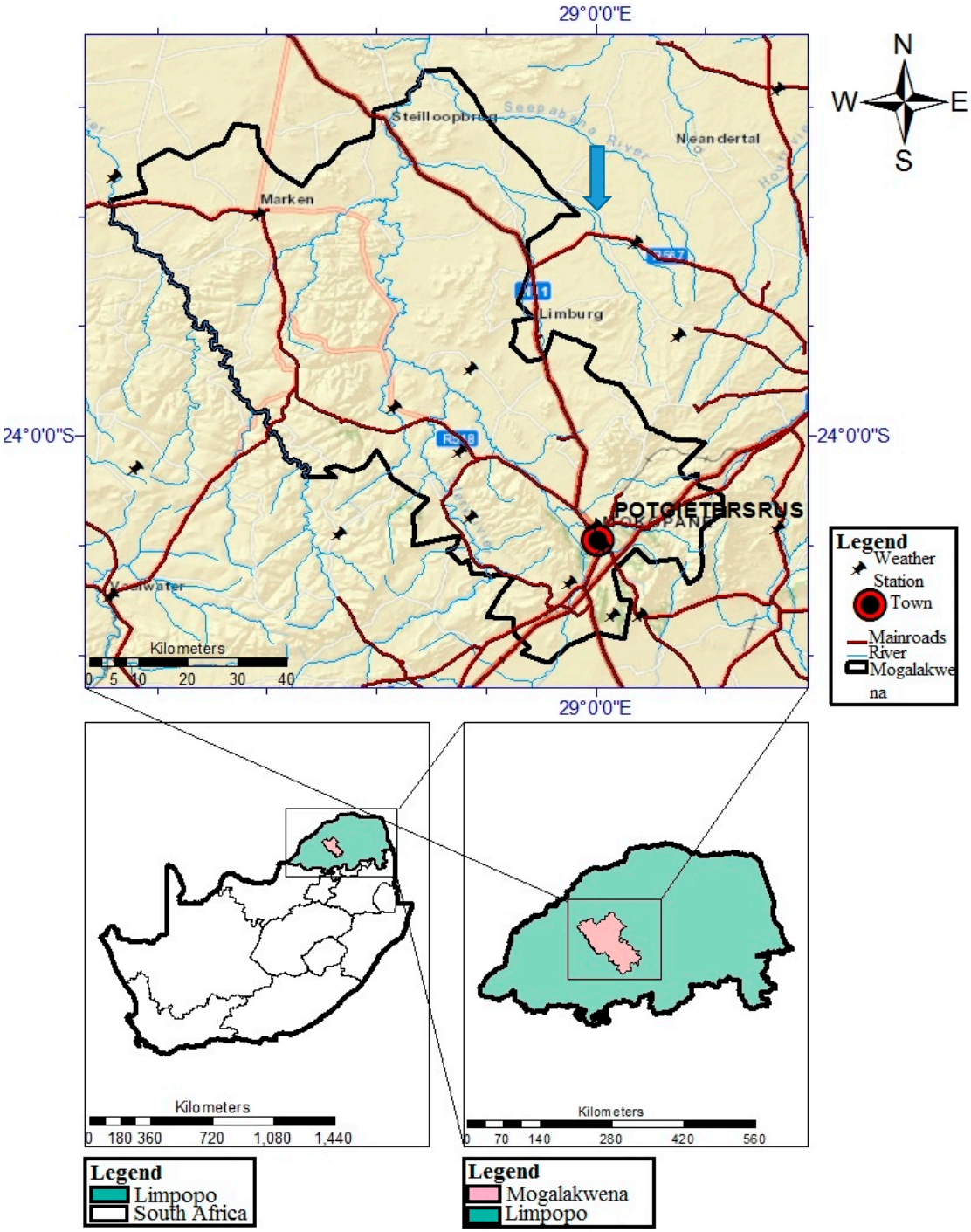

Figure 1. Study Location.

Mogalakwena community is a rural settlement where the dwelling units consist of a mixture of huts and modern brick houses. Settlement in the community takes place in blocks of houses with a proper planning and the provision of basic household infrastructure. The residential area is made up of demarcated housing stands with a block of demarcated ploughing fields in a flatter and red-sandy area [25].

2.2. Study Design

A qualitative study was conducted to examine the rural community's perceptions of climate change and adaptation methods developed to adjust to the climate hazards threatening the production of subsistence crops. Data were collected through direct interactions with participants. An open-ended questionnaire was used to collect data. The research questions were developed, revised and adopted through several encounters with the participants. The questions began with collection of biographical information of the participants, followed by the participants' perceptions of climate change, the types of subsistence crops grown by the participants, how climate change impacts on subsistence crop production and the participants' capability to take measures to adapt to these impacts for continued production of crops.

2.3. Participants

Structured interviews were conducted with a sample of 100 participants purposely selected in Mogalakwena community over a period of 22 months. This extended period of data collection allowed the researcher to interact with the participants. A larger sample was used to obtain a diversity of responses about perceptions of climate change. Perceptions of climate change within rural communities in Limpopo Province are not yet fully explored; as a result, the researcher used a larger sample to obtain evidence of knowledge of changing climatic conditions within a single community.

The sample had diverse ranges of participants in terms of age, gender and socio-economic group. They were household heads (52 male, 48 female) whose age ranged from 25 to 86 years. The recent economy of the community is varied and as result fewer participants depend fully on subsistence farming for their livelihoods. Subsistence farming recently supplements the food stuffs bought from the retail stores. Despite observable scarcity of rain and its impacts on the livelihoods of community members, 64 participants are engaged in subsistence crop production in the home-gardens surrounding the compounds and in the ploughing fields, whereas 36 participants are planting the crops only in their home-gardens. The fields are arranged in a rectangular pattern within a walking distance from the households. An average land holding is two hectares per household. Lack of fences around the field perimeters prevents members of the community to plant earlier than their neighbours. The field are ploughed simultaneously for concurrent protection of the crops from damage by stray wild animals and livestock. *Citrullus vulgaris* (melon), *Zea mays* (maize), *Vigna sinensis* (beans) and *Voandzeia subterranean* (nuts) are the most common subsistence crops recently planted.

Food is processed from the fresh and dried crops. The crops are harvested, washed, boiled and consumed. The fruits of *Citrullus vulgaris* and *sorghum vulgare* (sweet-reed) are taken fresh as fruits. The fresh and tender leaves of *cucurbita pepo* (pumpkin plant), *vigna sinensis* and *citrullus vulgaris* are collected, washed and boiled to make side-dish to relish porridge. The fresh fruit of *lagenaria vulgaris* (gourd) is boiled and taken with milk. The fresh fruits of c*itrullus vulgaris* and *cucurbita pepo* are peeled, boiled and mixed with maize-meal to make a vegetable porridge. Dried beans collected from *vigna sinensis* and nuts from *voandzeia subterranean* are boiled to make whole-grain stew and side-dish to relish porridge. Side-dish is also made from roasted melon seeds. The beans, nuts and melon seeds are preserved by sun-drying for future use. The sun-dried materials are mixed with the ash of *Aloe ferrox* (aloe) to prevent the seeds from attack by weevils, and stored in plastic bags and buckets which may last up to three years. Dried maize is pounded with a mortar and pestle to make maize-meal and samp [26].

2.4. Data Collection and Analysis

All the participants were speaking *Sepedi*, as a result the interviews were conducted in *Sepedi* and translated into English. The interviews were conducted in the households of the participants where they were mostly relaxed and freely responded to the questions. The open-ended questionnaire was used to document the participants' perceptions of climate change and the adaptation measures used

to adjust to the impacts of climate hazards on subsistence crop production. The questionnaire was administered by the researcher. The responses were captured for each of the questions. Explanations for the responses provided were captured in a note book. Data were transcribed to facilitate qualitative analysis. A thematic analysis of data was done by identifying common issues that recurred in the responses. These were developed into themes and sub-themes. The main sub-themes emerged from data about perceptions of climate change were increase temperature and rainfall scarcity. The types of subsistence crops grown in the community were cited as maize, melons, nuts, beans and sweet-reed. The potential for adaptation was reflected by measures such as indigenous knowledge of rainfall prediction, the seasons, change of crops, mixed cropping, use of fertilizer and mulching.

2.5. Trustworthiness

Completeness and reliability of collected data were obtained through quick reviews of data with the participants. The participants were able to provide corrections to the inconsistencies, contradictions and data gaps. Follow-ups and informal discussions were conducted for validation and clarification of data.

2.6. Ethical Considerations

Ethical approval was obtained from the host institution. The local authorities allowed the researcher to conduct the interviews in the community. The participants consented to participate in the study by signing the consent form, and their names and identities remained anonymous throughout the study.

3. Results and Discussion

3.1. Perceptions of Climate Change

Climate change in the study is perceived as changes in temperature and rainfall patterns. There are observations of drastic increase in temperature traced back to the year 1970 which are responsible for excessively hot and dry summer and wet winter. The last period of good rain in Mogalakwena community is the past 50 years ago and since that time rain is unpredictable. In the past fifty years, the first rainfall was received in September, but recently the first rain falls between October and December with the ploughing season coming later in the year to the beginning of the next year. Further explanations of climate change are persistent rainfall hazards such as drought which resulted in loss of livestock, fallow fields and deteriorating water levels in the rivers and boreholes; soil erosion, dust and depletion of biodiversity. These perceptions are corroborated by observation and projections on climate alterations in the form of increased temperature and erratic rainfall patterns by scientists worldwide [4,27,28]. Remarkable changes in temperature patterns were reported between the years 1960 and 2009 where the mean annual temperature increased by at least 1.5 times the global average of 0.5 °C over the past five decades [11].

Additionally, climate change is explained in terms of cessation of cultural activities and important livelihood patterns. These include consumption of traditional fruits and vegetables, brewing of traditional beer, production of traditional crops and livestock, celebration of the first-fruit rituals, communal labour, hunting and fishing. It was mentioned that rain-induced diseases such as cholera, bilharzia and dysentery are becoming common in the community as a result of use of contaminated water, drought and excessive heat. Perceptions of climate change as variations in temperature and rainfall patterns in the study are supported by projections on climate alterations reported [11] to have increased over the past five decades [9,29]. These climate alterations resulted in frequent windy weathers, increased heat and drought [11,27,30]. Observations of change in rainfall and temperature patterns in the study are supported by justifications of drastic increase in temperatures with perceived impacts on agricultural production [15], ecological variability [4] and road infrastructure in the local communities [28,31,32].

3.2. Subsistence Crops of Mogalakwena Community

Table 1 presents the scientific and local names of subsistence crops produced in Mogalakwena community. The Table also presents the names of the products produced out of the cops.

Table 1. Subsistence crops.

Scientific Names	Local Name	Product
Zea mays L.	Lefela	Maize
Vigna sinensis End b.	Monawa	Beans
Voandzeia subterranean Thou.	Tloo-marapo	Beans
Sorghum vulgare Pers.	Nyoba	Sweet-reed
Citrullus vulgaria Schrad vars.	Morotse/Mogapu/	Melon
Cucurbita pepo L.	Mofodi	Melon
Lagenaria vulgaris Ser.	Moraka	Gourd

3.3. Climate Change Impacts on Subsistence Crop Production

Subsistence crop production in Mogalakwena community is negatively impacted by drought, scarce rain, excessive heat, soil erosion and barrenness. However, community members are grappling with these hazards to lessen their impacts on their crop yields for a sustainable livelihood. This is in line with the IPCC [4] observation that agricultural production in the rural areas is negatively impacted by changing climatic conditions.

Table 2 presents the participants' perceptions of climate hazards which threaten the production of subsistence crops. Several threats to crop production are presented with the frequency number of identification.

Table 2. Participants' perceptions of climate threats to crop production.

Climate Hazard	Consequences and Threats to Crop Production	No. Participants Reported
Drought	Planting of crops is inconsistent In some years there is no planting at all	79
Scarce rain	Planting commences late December to early January the following year Low crop yields	83
Excessive heat	Withering of immature crops Increased crop failure Barren soil	76
Heavy rain and strong winds	Soil washed away by wind and rain Shallow soils Loss of soil fertility Crops damaged by strong wind	89

3.4. Adaptation to the Impacts of Climate Change

Community-based measures were identified as methods used to adjust to the impacts of climate change on the production of subsistence crops. The measures are based on local experiences developed to limit the impacts of drought, erratic rainfall and changing soil structures on crop production.

Table 3 presents six adaptation measures and their value towards sustainable crop production. The measures were identified by more than 80% of the participants.

Table 3. Participants' perceptions of adaptation measures.

Adaptation Measure	Sustainable Crop Production	No. Participants Reported
Rainfall prediction	Plan planting according to predicted rainfall	98
Knowledge of seasons	Planting soon after the first rain during the rainy season	65
Change of crops	Planting short-season crops instead of late maturing ones	93
Mixed cropping	Maximizes simultaneous growth of several crops in the same field	94
Use of kraal manure	Improves soil structure and fertility to increase crop yields	99
Turning the soil with the crop residues	Prevents soil erosion Improves soil structure and fertility to enhance crop yields	91

3.4.1. Adaptation to Drought and Rain Scarcity

(1) Rainfall Prediction

Indigenous knowledge of rainfall forecast is used as an adaptation method to climate hazards. Community members are able to predict rain availability and scarcity through observance of the behaviour of the animal and plant species and the position and appearance of the sun. It is reported that at the beginning of September month, the *Senegali* plant species produce yellow flowers which denote the beginning of a good season with forthcoming rainfall if the flowers are deep-yellow whereas pale flowers signify limited rainfall. The appearance of *tsie* (edible insects) in greater numbers in spring signifies shortage of rain in the next season. These observations are supported by the IPCC [4] and Ziervogel et al. [11] that increased pest and crop disease are the signs that climate change is happening and represents one of the greatest environmental, social and economic threats.

The participants observed that in summer the sun is situated in the south and in the north in winter. Change in these positions envisages bad omen in the form of infrequent rain. Community members strictly observe these changes to plan the planting process. When limited rain is predicted, cultivation of crops is restricted to short-season crops such as maize, nuts, beans and melons. These observations are consistent with the Malunga farmers' explanations of the position of the sun in Tanzania. When the sun is positioned in the northwest during the rainfall season, it signifies imminent rainfall [17]. Furthermore, it is observed that the blowing of wind from east to west direction in August predicts a bad season; season without rain.

Moreover, it is observed that a good season with plenty rain is marked by wind blowing from south to north direction in August. Higher temperatures at the beginning of spring also symbolize a good season with plenty rain. Climate prediction methods observed in the study are cultural and religious dimensions because they are based on the community's cosmological views [32]. The predictions are further reinforced by the weather and rain predictions in Malunga and Chibelela communities in Tanzania in which community members use plant phenology, birds, insects, wind direction and solar system to predict the weather [5]. Local farmers use these indigenous forecasts to predict weather patterns because it enables them make the necessary farming adjustments to adapt to climate change and variability [33].

(2) Knowledge of the Seasons

Indigenous knowledge of seasonal change is the additional adaptation method. There are observations that winter starts at the end of March and ends in July and August is dusty. Rain begins to fall in September. The months of November and December have plenty rain and planting starts any time before the end of December. Recent scarcity of rain and patterns of increased temperature have led to the shifting seasons. Lately the planting season is shifted to late December and early January due to late rainfall. The recent winter precipitation is tempting the farmers to plant in this season because of the many months it takes to have rain in the community. Gandure et al. [3] support these observations by showing that due to the late onset of rain in Gladstone; the farmers had shifted their planting dates. Hachileka and Vaatainen [33] observe that the local farmers in Zambia adjust to

seasonal change in the onset and cessation of rainfall by changing their planting dates to coincide with new rainfall regimes [34].

(3) Change of Crops

The most common crops produced are short-season crops such as maize, melons, gourd, sweet-reed, nuts and beans. Traditional sources of staple food in the community; millet and sorghum are no longer grown because their production requires plenty rain and are susceptible to damage by birds. The farmers plant early-maturing and drought-tolerant crop varieties to reduce crop failure. Frequent drought and late onset of rain make the farmers opt for short-season crops and low water demand crops to coincide with intermittent rain patterns [35,36].

(4) Mixed Cropping

The traditional method of multi-cropping is practiced. The seeds of maize, melons, sweet-reed, nuts and beans are mixed and sown simultaneously on the same field to maximize the chances of concurrent growth of the crops. This type of mixed planting in Ghana is referred to as crop diversification [32,33,37].

3.4.2. Adaptation to Changing Soils Structure

Kraal manure is applied to fertilize the soil and improve its moisture capacity to maximize crop productivity. Additionally, subsequent to harvesting, the soil is tilled with the crop residues to improve its texture and fertility. To this practice, Kato et al. [38] say it is an adaptation option with significant impacts on reducing crop production risk in Ethiopia. For Traerup and Mertz [39] the most effective adaptation strategy to changing climatic conditions is the use of fertilizers to sustain crop production.

4. Conclusions

Climate change is described as variations in temperature and rainfall patterns. There are observations of change in summer and winter temperature. At present, summer is hotter and winter is warmer than they were the past 45 years. This community perception of changing temperature patterns corroborates recent observations of excessively hot summer and warmer winter across the globe. Good rain in the study area was last experienced half a decade ago. Rainfall is described as unpredictable as it rains during unexpected periods in the year. Climate change is further explained in terms of changes in cultural activities and livelihood patterns which are climate dependent. Incidences of water-borne diseases are perceived as the result of variations in water scarcity and drought. Change in temperature and rainfall patterns is responsible for persistent drought, excessive heat, unpredictable rainfall and heavy rain and strong wind, which are major threats to the production of subsistence crops. Sometimes planting is not done at all, but if it is done the farmers obtain low yields as a result of drought, erratic rainfall, excessive heat, heavy rain and wind. However, community members have the potential to adapt to these climate hazards in order to improve subsistence crop production. Adaptation methods used to continue subsistence crop production are informed by the community's worldview in which indigenous knowledge of the seasons, rain forecast, crop diversification and improvement of soil structure is used to plan the planting season to sustain the crop yields.

Perceptions of climate change by a rural community make a contribution to the need to understand the local community's knowledge of climate change, mitigation and adaptation measures. Adaptation measures adopted in the study are resilient to climate variations and they sustain subsistence crop production and human livelihoods. They may be helpful in the development of sustainable adaptation policies to assist rural communities vulnerable to climate change hazards. However, these community initiatives may be used to inform policy on adaptation and coping with climate change.

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