Indigenous Knowledge of Climatic Conditions for Sustainable Crop Production under Resource-Poor Farming Conditions Using Participatory Techniques

L. O. Nethononda[1, 2], J. J. O. Odhiambo[1] & D. G. Paterson[3]

[1] Department of Soil Science, University of Venda , Thohoyandou, South Africa

[2] Madzivhandila College of Agriculture, Thohoyandou, South Africa

[3] Agricultural Research Council-Institute for Soil Climate and Water, Pretoria, South Africa

Correspondence: L. O. Nethononda, Madzivhandila College of Agriculture, Thohoyandou, South Africa. E-mail: nethonondao@gmail.com

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Abstract

Rambuda irrigation scheme is situated in Vhembe District of Limpopo Province in South Africa. It was established in 1952 and farmers do not have access to recorded climatic information. Farmers are growing crops on a trial and error basis, hence low yields and crop loses. The objective of the study was to investigate indigenous knowledge of climatic conditions relevant for crop production using participatory techniques. Situation analysis was conducted to gain information on factors influencing crop choice. Participatory exercise was conducted with 33 of 104 of plot-holders. Farmers could identify climatic factors important for crop production and those limiting to crop performance. Hot, dry conditions during August to October and January months were limiting to crops, particularly sweet potato production. The results showed that indigenous knowledge of climate needs to be considered during agricultural development planning and scientists need to investigate linkages between modern agro-meteorology and indigenous knowledge.

Keywords: indigenous climate knowledge, crop production, sweet potato

1. Introduction

Rambuda Irrigation Scheme was established in 1952 to improve rural household livelihood and rural economic development through agriculture. The main crops grown are sweet potatoes and maize while cabbage, African shade-bush, Chinese cabbage, dry beans and ground nuts are grown as minor crops. There are no yield data, but plot-holders indicated that the yields are low. External consultants were contracted for the planning and construction of the irrigation scheme. A biophysical resource survey was conducted in 1987 (Personal communication, T.P. Mukhanu, 2009), but there was no report both in the irrigation scheme and the district office. There is no land suitability plan or basis for crop choices. Therefore, plot-holders have been growing crops on a trial and error basis using indigenous local knowledge of climatic conditions. Such information may be limiting to seasonal and crop growth stages requirements and consequently there is a low increase in yields for the crops that are grown in the area.

Sound planning of changes in land use requires a thorough knowledge of the natural resources, and a reliable estimate of their agricultural potential, so that reliable land use predictions and recommendations can be made (Aubert, 1981). Information on climate is necessary for choice of suitable crops for sustainable crop production. There is increasing consensus on the invaluable contribution of local knowledge systems of traditional plot holders in ethno-meteorology (Magistro & Roncoli, 2001; Carmen et al., 2002; Sadras et al., 2003; Stiger et al., 2005) and soil surveys (Siltoe, 1998; Oudewater & Martin, 2003; Ryder, 2003). Understanding of local farming systems is indispensible in land suitability evaluations for sustainable development (FAO, 1976; Laker, 1982).

Most people in developing countries live in rural areas, and have developed complex pastoral and cropping systems to cope with the unpredictable and harsh climatic conditions (Bonkoungou & Niamir-Fuller, 2001). These cropping systems or strategies for risk management were in response to inter alia, the varying limiting climatic conditions (Stiger et al., 2005). Indigenous knowledge has the potential of providing information for addressing current and future climatic events and building on indigenous knowledge system offer great prospect for effective integration strategies to small-scale farmers (Nyong et al., 2007)

The aim of this study was to investigate indigenous knowledge of climatic conditions relevant to sustainable crop production of resource poor farmers using participatory techniques at Rambuda irrigation scheme in Limpopo Province, South Africa.

2. Research Procedures

2.1 Site Description

Rambuda Irrigation Scheme is situated north of Thohoyandou (22°59'30"S latitude and 30°25'30"E longitude) in the Mutale Municipality, Vhembe District of Limpopo Province, South Africa (Figure 1). The total area of the scheme is 120 ha demarcated into 104 terraced plots of 1.28 ha (1.5 morgen) each. The plots are subdivided into subplots with sizes ranging between 300 m^2 and 900 m^2. The main crops grown in this irrigation scheme are sweet potato and maize with vegetables grown as minor winter crops. In general, soils can be described as deep and well drained with small portions of moderately drained soils in some places. The soils were classified according to the South African Taxonomic system as belonging to Oakleaf form (Neocutanic, *chromic*, *haplic and chromic rhodic, luvic*) and Hutton form (Rhodic, eutrophic; m*esotrophic, haplic and luvic*) (Nethononda & Odhiambo, 2011).

The main source of water is the Tshala River. Water is supplied from a weir into the main concrete canal that supplies water by gravity into the four balancing dams on the irrigation scheme. Water is distributed from the balancing earth dams to specific plots by secondary canals. Short earth furrows are used to irrigate the crops planted on ridges. An irrigation programme/schedule is used to allocate irrigation times. The irrigation scheme is divided into six (6) management blocks and each block is allocated a full day of irrigation per week.

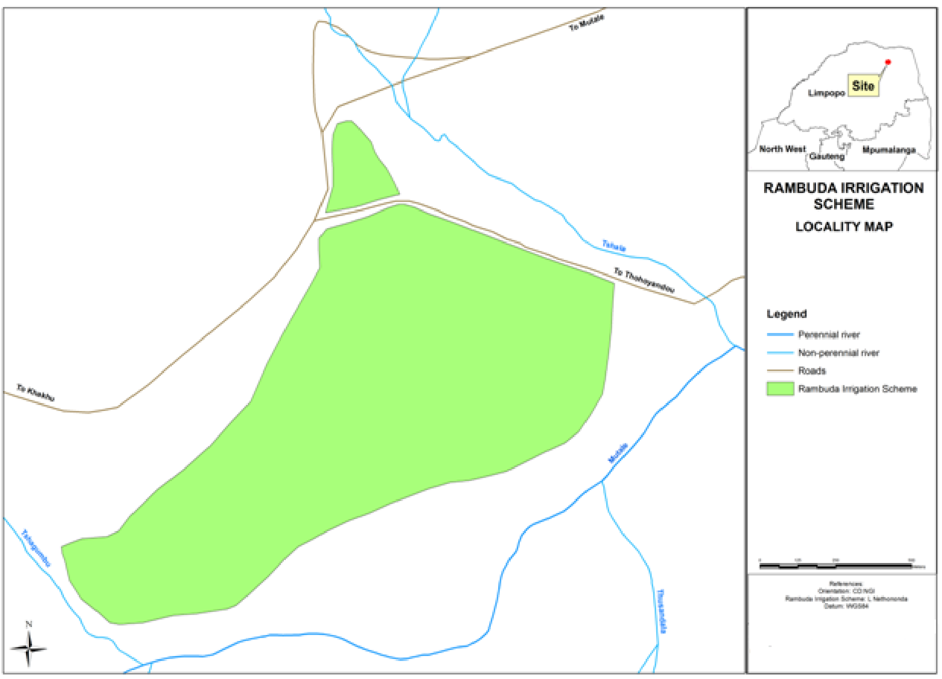

Figure 1. Locality map of Rambuda irrigation scheme

2.2 Situation Analysis

The study involved preliminary situation analysis of the irrigation scheme with the full participation of the responsible extension officer. Information collected during situation analysis was used to develop a theoretical framework that consisted of the full set of climatic factors known to influence crop production. The framework was used to compile a logically arranged checklist of issues explored during interviews with participants according to the principles described in the triple-A framework (Van Averbeke & Khosa, 2004).

2.3 Participatory Climate Description

Climate description was conducted with plot-holders to identify and describe climatic conditions and their implications on crop production. Thirty-four (34) farmers of 76 were present on the day of participatory exercise and all plot-holders who were present participated in the survey. Participants were divided into three groups. Members were randomly allocated to each group and each group chose a group leader. Plot-holders were asked to list climatic factors important for crop production based on their observations, understanding and experience. Each group was given an aerial photograph of the irrigation scheme at a scale of 1:3 000. Plot-holders were also requested to indicate areas which are prone to frost incidences on the aerial photograph.

Rating of severity of each climatic parameter and period of the year was conducted at a scale of 0-5. Participants were asked to indicate when rains fall, as well as cold, hot and dry months during the year. Rating for cold, hot and dry was achieved by marking stars as follows: 0 = no problem, 1 = slight, 2 = moderate, 3 = problem, 4 = severe and 5 = very severe. Rainfall was rated as follows: 0 = no rain, 1 = one day drizzle, 2 = two days good rain, 3 = 5 days good rain, 4 = a week of good rain, 5 more than two weeks of good rains. Groups were then combined to integrate and resolve anomalies in climatic knowledge.

The observations listed by plot-holders were collated to the recorded climatic data of Tshiombo Weather Station situated (22°80'147" E and 30°48'145" S) ± 8 kilometres south east of the study area at 650 m above sea level to validate responses of plot-holders (Figure 2 and Table 1). Data from participatory ranking and rating was subjected to matrix scoring to assess the severity of each climatic variable in relation to recorded climatic data. This information was used to describe the implications of climate on crop production at the irrigation scheme.

3. Results and Discussion

3.1 Empirical Climatic Knowledge of Plot-Holders

The results of participatory exercise showed that plot-holders consider the area to be characterized by warm to hot summers with mild to cold winters. This observation was confirmed by long-term recorded climatic data (Table 1). Plot holders indicated that the area receives summer rainfall. The wettest months were stated by plot-holders as February, March, April, November and December with most rain falling during February and March (Figure 2). Recorded climatic data indicated that February (208.3 mm) was the wettest month confirming the observations made by the plot-holders.

Table 1. Average climatic summary for Rambuda irrigation scheme

Month	Min Temp (˚C)	Max Temp (˚C)	Rainfall (mm)	Relative Humidity (%)		Class-A Pan evaporation (mm)	Wind speed (km/h)
				08h00	14h00		
Jan	19.60	30.00	178.40	84.70	40.50	197.80	108.30
Feb	19.60	29.10	208.30	84.00	41.40	160.80	104.10
March	18.50	28.50	154.70	87.20	42.80	163.10	90.80
April	15.80	27.20	39.90	86.50	38.50	131.10	78.10
May	12.00	25.60	15.70	87.80	35.00	122.60	75.00
June	9.40	23.50	20.70	87.00	32.40	100.40	79.50
July	9.20	23.10	17.20	86.50	32.10	111.40	88.90
Aug	10.90	25.00	8.90	84.20	30.10	143.20	100.20
Sep	13.70	27.40	21.30	84.10	32.70	175.10	115.80
Oct	16.00	28.00	61.60	81.30	35.70	191.20	121.60
Nov	17.80	29.20	103.40	83.30	38.90	203.50	113.10
Dec	19.00	29.70	126.00	84.00	39.20	195.80	105.00

December (126 mm) and March (154.7 mm) were both higher than November (103.4 mm) and April (39.9 mm) (Table 1). However, plot-holders gave contrasting impressions in comparison to the recorded data for January. According to the data, 178 mm rainfall was received during January. This is higher than rainfall received in

March, April, November and December months (Table 1). Plot-holders reported January as one of the driest months. This response could be attributed to rainfall distribution or heavy rains falling for a short period during very hot period.

3.2 Climatic Conditions Limiting to Crop Production

According to plot holders January, September, October, November and December are the hottest months with January and September being the hottest months. Data in Table 1 showed that September (29.0 °C) was not as hot as January (30.0 °C) though plot-holders rated them as equal. Temperatures are likely to rise above 30 °C value during most days of January. Recorded climatic data showed that September is not as hot as October, November and December. According to the recorded climatic data August and September have the lowest relative humidity at 14h00 (30% and 32% respectively). High temperatures experienced during January overshadow the gains from rains falling during this period. This could be the reason that caused plot-holders to rate September equally as hot as January.

According to plot-holders, light frost was experienced during the months of June and July (Figure 2), but it is more prevalent in July. Plot-holders rated April, May, June and July as the coldest months. This observation is reflective of the climatic data as June and July are the coldest months. According to the climatic data, the coldest months are April (15.8 °C), May (12.0 °C) and June (9.4 °C). Recorded climatic data show little differences in temperatures between June (9.4 °C) and July (9.2 °C). It is possible that the temperature during July will on occasion drop below the freezing point, mainly because the irrigation scheme lies in the valley. Poor growth and yield is attributed to low soil and ambient temperatures which drop below the minimum root and shoot growth temperature of 10 °C (Niederwieser, 2004). The implications are that crops that are susceptible to frost cannot be planted during the above-mentioned months or that only crops that are frost tolerant can be planted.

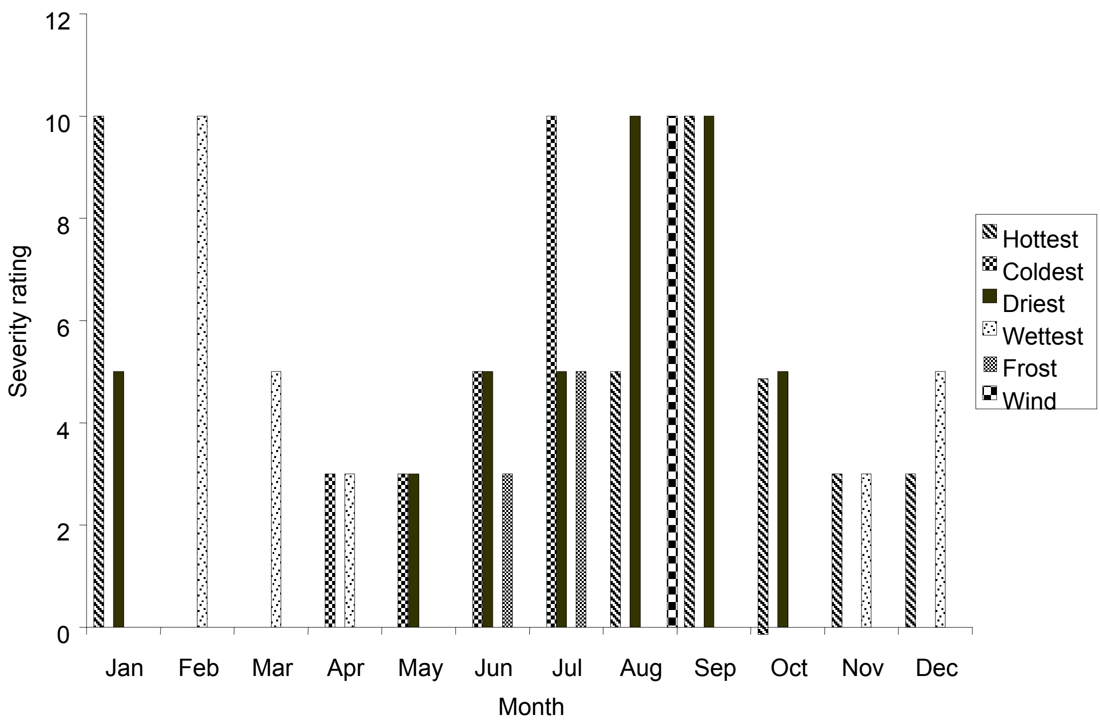

Figure 2. Participatory rating of the severity of climatic variables

According to plot-holders, August was the windiest month compared to the other months of the year. Climatic data shows that the wind speed was highest during October followed by September and November, respectively (Table 1). Other months with high wind speed were December, January, February and August. August has the least wind speed compared to December, September, October, November, December, January and February. Any observations made by plot-holders on wind were different and certainly not reflective of measured data.

In general, hot, dry conditions were a major limiting factor to crops at Rambuda irrigation scheme. Hot, dry conditions were more severe during August to October according to the plot-holders. The monthly rainfall during September to October was just above 20 mm, coupled with low afternoon (14h00) relative humidities of around 30% and maximum temperatures sometimes exceeding 30°C (Table 1). This is a critical period for sweet potatoes because they have just produced early young spring sprouts of growth.

The tender sprouts are sensitive to high temperatures and low humidity experienced during August, September and October. This is because they have not yet developed a strong resistance mechanism in the form of a thick cuticle to counteract the loss of water through transpiration (Niederwieser, 2004). The implications are that such conditions are extremely unfavourable for sweet potato planted in early June that has young tender sprouts in August and September. This suggests that sweet potato and maize planted in August and September will show the symptoms of atmospheric evaporative demand and high temperature stress even when the soil is irrigated to field capacity, i.e. irrigation that is applied during September and October cannot make up for the water that is lost through transpiration. Plot holders reported that the river flow level is very low, making irrigation water scarce during this critical period of the year. The potential effects of the high temperatures and low relative humidities are deleterious to the growth and development of young sweet potato plants. Irrigation during such hot and dry months may not be able to overcome the potential negative effects of the atmospheric evaporative demand together with high temperature stress on crops grown during this period.

4. Conclusions

This study found that plot-holders could identify climatic conditions that are important for crop production and their relative effects on crop performance. They also knew critical conditions that are limiting to crop production at Rambuda irrigation scheme. Empirical knowledge of climatic conditions using indigenous knowledge is an important factor used by plot-holders in deciding cropping seasons and crop choices. This knowledge can be used in land suitability evaluation, particularly in areas where there is no recorded climatic data. There was slight difference between recorded climatic data and plot holders observations of climatic conditions at certain months. More research is needed to document climatic criteria used by indigenous farmers under indigenous knowledge system to decide on crops to be grown in their locations. Findings from such studies can be used to record indigenous knowledge and integrate it into modern land suitability assessment guidelines. In general, indigenous knowledge of climate could be used to describe climatic conditions in areas without modern weather stations.

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