Perception on Irrigated Smallholder Agricultural Enterprises led by Women and Youth (ISHAEs W-Y) towards climate extreme events variability for the selected field crop suitability potential at Vhembe District Municipality in Limpopo Province of South Africa

T. J. Mavhungu[1, 2*], A. E. Nesamvuni[2], K. A. Tshikolomo[1, 2], N. S. Mpandeli[3] and J. Van Niekerk[2]
[1] Centre for Sustainable Agriculture, University of the Free State, Bloemfontein, 9300, South Africa
[2] Limpopo Department of Agriculture and Rural Development, Private Bag X9487, Polokwane, 0700, South Africa
[3] Water Research Commission of South Africa, Private Bag X03, Gezina, 0031, South Africa
Correspondence Author: T. J. Mavhungu
Received 23 Jun 2023; Accepted 2 Aug 2023; Published 7 Aug 2023

Abstract
The study was conducted at Madimbo Corridor which is Semi-arid area. This area is characterized by low erratic mean annual rainfall pattern which are main factors that hinder farming in the semi-arid regions. Consequently, the production areas experience extended spells of the dry season and shorter wet periods. The purpose of this study is to examine the perception on irrigated smallholder agricultural enterprises (ISHAEs) towards climate variability for the selected crop suitability potential in the study area. A representative sample was based on the number of irrigated smallholder irrigation entrepreneurs on the identified agro-ecological zone. Primary data were collected using a questionnaire and village transact. At least 294 women and youth smallholder irrigation entrepreneurs were sampled for interviews and prompt responses on the perceptions of ISHAEs towards climate variability for the selected crop suitability potential in their irrigated Smallholder Agricultural Enterprises. The study applied both primary and secondary data collection instruments. The findings show that wise stewardship of temperature resource can ensure reduced diminishing effect on ISHAEs practices on the production areas. Rainfall quantity and its distribution are key factors determining the rainy season characteristics, farming systems, field crop production. Climate variability has direct impact on irrigated smallholder agricultural enterprises and livelihood opportunities in the agriculture sector. In conclusion, the study provides strong motivation towards examining perception of ISHAEs towards climate variability for the selected crop suitability Potential in the study area. The results of this study can assist with the economic production menus and programs for long term sustainability.

Keywords: Agro-ecological zone, climate extreme events variability, madimbo corridor, crop suitability potential

1. Introduction

Vhembe District in South Africa is blessed with diverse agro-climatic zone with distinct seasons due to which one can able to grow wide range of field Crop commodities. The main field crops grown are maize, dry bean and sweet potatoes at irrigated smallholder agricultural enterprises (ISHAEs). Even though, the area is blessed with diverse agro-climatic zone, productive farming is affected directly by increases in mean temperature; changes in rainfall patterns and amounts; decreases in water availability; frequency and intensity of climate variability - notably droughts and floods. These impacts extend beyond food production and can negatively affect the rural economy, if the district's ability to produce irrigated smallholder agricultural field crops and generate income be reduced, while increase food shortages in the household of irrigated smallholder agricultural enterprises led by women and youth (ISHAEs W-Y). Increasing climate variability, resulting in more frequent and more serious extreme meteorological and climatological events, will be a factor with which all farming systems will have to cope (Stiger, Dawei, Onyewotu, and Xurong, 2005) [34]. It is, above all, poorer farming enterprises that will be the most adversely affected by severe conditions since they are mostly directly dependent on the natural environment and ecosystem services for their profit making and livelihoods.

According to Schulze (2016) [30], Climate is vital for the selection of appropriate field Crops for a given locality or site, irrespective of whether farmers are planning for maximum economic returns or for sustaining their immediate family's livelihood. It is therefore possible with detail knowledge to anchored in the principles of sustainable intensification of agricultural production of field crops that is working on landscape level with an ecosystem approach that conserves and enhances natural resources. Climate variability, which includes erratic and unpredictable seasonal rainfall, floods and drought, contributes to the risk of ISHAEs in Vhembe district. The rivers and aquifers depend on rainfall for its recharge, but those production areas are characterized by low and erratic precipitation. ISHAEs W-Y producing in this areas are posed by extreme climatic variations. Most farmers 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 and Naimir-Fuller, 2001) [6]. These cropping systems practices for risk management were in response to the varying limiting climatic conditions. Although farmers have long maintained a suite of indigenous strategies and options to manage risk and to deal with poor overall productivity in spite of low returns, it is generally acknowledged that low-resource agriculture is no longer capable of meeting the livelihood demands. According to Stiger, *et al.*, 2005[34], Climate variability and related disasters can be mitigated by temporary or permanent protective measures or by avoidance strategies that try to escape the peak values or their consequences. The objective of this investigation is to try and explore perception of irrigated smallholder agricultural enterprises towards climate variability for the selected crop suitability Potential for Vhembe District Municipality, Limpopo, South Africa.

2. Research methodology

2.1. Study area

The Madimbo Corridor varies from Arid and Semi-arid. An Arid area is characterized by a severe lack of water resources to the extent of hindering the development of plants and vegetation. Such a lack is brought forth by the predominance of the evapotranspiration to the rate of the precipitation (Derya, Mehmet, Süha, Sermet, and Tomohisa, 2009) [9]. Agricultural production in this category is impossible with the exception where there is irrigation.

Semi-Arid areas are characterized by low erratic mean annual rainfall pattern which are main factors that hinder farming in the semi-arid regions. Griffins (1985) [14], defines the semi-arid regions as an area whose evapotranspiration supersedes the potential precipitation. Consequently, the area experiences extended spells of the dry season and shorter wet periods. However, these areas experience frequent climate variability which is characterized by spells.

2.2. Sample frame and sampling procedure

2.2.1. Sample frame

Welman, Kruger and Mitchell, (2005) [37], define sampling frame as a complete list of units of analysis in which each unit is mentioned only once. The sampling frame for this study was conducted at Vhembe district of Limpopo province, in Musina Local Municipality. The smallholder irrigation scheme identified in this local municipality is Madimbo corridor irrigation scheme. Madimbo Corridor irrigation schemes form part of Ha-Gumbu, Malale, Masea, Ngwele, Tshipise and Nwanedi area. A representative sample was based on total ISHAEs W-Y available in both smallholder irrigation schemes. A total of 294 ISHAEs W-Y after sampled were available for interview.

2.2.2. Sample procedure

In order to ensure proper selection of respondents chosen in such a way that they represent the total population as good as possible, a two-stage simple random sampling process was conducted using *SURVEYSELECT* procedure of SAS. According to Statistical analysis system (SAS), 2009[28], PROC *SUREVEYSELECT* allows selection of probability-based random sampling where sampling in different categories or class depends on the number of units within that class and appropriate for handling selection bias. This includes primary area selection of municipalities (both district and local municipalities), location selection of irrigation schemes and respondents' selection of ISHAEs W-Y.

In simple random sampling, study units are chosen, as the name implies, randomly. A simple random sampling was used to select a respondents and a total unit of 294 was randomly selected for this study. In this total number of 294, adult women were 223 and youth were 71. Out of 294 as total number, 15 were male youth and 279 were females (adult and youth). This means that female youth were 56. The respondents were also selected with an emphasis of gender and age. Youth were considered to be of the age between 18 to 35 years. The numbers were (a) Youth female (age 18 – 35 years) were N=56; youth male (age18 – 35 years) were N=15, Adult-female (age 36 – 59 years) were N= 153 and Pensioner-female (age above 60) were N=68. Sampling was done as a process of selecting units from a population of interest, so that by studying the sample, the results obtained from the sample may be generalized to the population from which the sample had been chosen (Leedy and Ormrod, 2005) [17]. In case of time for sampling, the best time was immediately after harvest when the farmers still remember most of the information that happen during the production period.

2.3. Data collection and analysis

The study applied both primary and secondary data collection instruments. Primary data were collected using a questionnaire and transact walk (observation). The questionnaire was developed to collect both qualitative and quantitative data. A semi-structured questionnaire was used to collect ISHAEs W-Y primary data at these two smallholder irrigation schemes. The questionnaires were administered on face-to-face interviews which embrace both open- and close-ended questions. As revealed by Leedy and Ormrod (2010) [18], the closed-ended questions collected quantitative data while the open-ended questions recorded qualitative data. The questionnaire was developed based on the social, economic and Bio-physical characteristics as the other assets of the livelihoods framework and household food security.

The village and smallholder irrigation scheme transact is a primary data collecting instrument through carrying out physical observation of points of interest related to social, economic and Bio-physical characteristics. The transact walk carried out with a group of representatives from the Madimbo corridor irrigation scheme who explained relevant social, economic and Bio-physical aspects of their irrigation schemes. During the village transact, the physical observations regarding social, economic and Bio-physical characteristics were noted. Some of noted physical observations regarding social and economic characteristics verified the information furnished on the questionnaire. Informal interviews with people encountered on the way also form part of primary data collected. In many cases, it was useful to have informal talks with ISHAEs W-Y who visit, or persons accompanying the walk to further probe into examples of how ISHAEs W-Y survived through smallholder irrigation scheme.

For Secondary data collection, existing related documents was collected from some NGOs offices, government departments and ministries, academic or research institutions, journals and use of personal advantage to contact the scholars, researchers, and friends who have done their researches concerning these issues in order to get in-depth understanding about this study. The above related documents and information collected also served as guarding the information furnished by ISHAEs W-Y. Quantitative data was transcribed into MS Excel Package and analyzed statistically using the Statistical analysis system (SAS) Package. The Procedure FREQ of SAS was used to generate simple frequency tables for variables of interest. Selected data was summarized in Excel Spread-sheet. Descriptive analysis techniques were used in the study to capture the perceptions of respondents mainly the qualitative data.

3. Results and discussion

Agriculture is deeply interconnected with weather and climate, the main drivers of agricultural production, but also the dominant factors in the overall variability of food production (Selvaraju, Gommes, and Bernardi, 2011) [31]. It is important to understand the perception of climate variability principles in the context of future growth and sustainability of ISHAEs in Vhembe district. Climate of an area influence almost every aspect of production in the irrigated smallholder agricultural areas. Many farmers in our country do not understand how to adapt and manage their farms in challenging conditions, particularly the ISHAEs W-Y who are most vulnerable to climate impacts. ISHAEs W-Y need to be encouraged to become strongly commit themselves to conserve the natural environment by farming in a way that is profitable for business, society and nature. This section outlines the perception of climate variability in the ISHAEs, their impacts to sustainability in irrigated smallholder agricultural production. and how this has progressed over the past years. The focus will be on the (a) Perception of ISHAEs W-Y on climate variability on the irrigated smallholder agricultural production area, (b) Perception on the impacts of climate variability on the field crop production, (c) Perception of ISHAEs W-Y on the mitigation of climate variability in the irrigated smallholder agricultural area, and (d) Climate conditions at the study area.

3.1. Climate variability on the irrigated smallholder agricultural production area experienced in the past years of production

3.1.1. Perception of ISHAEs W-Y on temperature vary over the past years

Wise stewardship of temperature resource can ensure reduced diminishing effect on ISHAEs W-Y practices on the production areas.

Table 1: Perception of ISHAEs W-Y on temperature vary over the past years

Variables		Frequency	Percent
Perception of ISHAEs W-Y on temperature vary over the past years	Yes	259	88.1
	No	35	11.9
	Total	294	100.0
Perception of ISHAEs W-Y indicating whether the vary is increasing or decreasing	Increased	253	97.7
	Decreased	6	2.3
	Total	259	100.0

The purpose of temperature to the potential Agronomical Crops commodity production is to influences photosynthesis, water and nutrient absorption, transpiration, respiration, and enzyme activity. These issues direct germination, flowering, pollen viability, fruit set, rates of maturation, yield, quality, harvest duration, and shelf life. Different plants have different temperature requirements. Depending on the situation and the specific Agronomical Crops crop, ambient temperatures higher or lower than the effective growth range will reduce growth and delay development, and subsequently decrease yield and quality. The extremes may be considered burnt by frosts or by heat.

In table 1, ISHAEs W-Y most participants (88,1%) noticed a vary in temperature, mainly 97,7% shows that it increased in the production area. Temperature during the cropping season often exceeds the optimum for physiological processes such as phenology, leaf area development, assimilate accumulation and grain filling. The occurrence of high soil temperature during crop establishment is also a threat in semi-arid and arid environments. A study by Shahi, (2011) [32] supports the finding that ISHAEs W-Y perception of climate variability are based on what people observe in their local environment, such as changing temperature patterns. However, Lynam, and Brown., (2011) [19] believe that perceptions of increased temperature are shaped by observations of changing weather patterns.

3.1.2. Perception of ISHAEs W-Y on rainfall changes over the past years

Rainfall quantity and its distribution are key factors determining the rainy season characteristics, farming systems, field crop production. In semi-arid tropics, unreliable rainfall combined with high evaporative demand and soils with low water-holding capacity and high run-off potential result in a high risk of water deficit at any stage of crop growth (Muchow and Bellamy, 1991) [21]. Rainfall is very important for the recharge of the water source and is absolutely essential for field Crops production. Field Crops can be grown according to their natural habitats with respect to water supply. Water is crucial for field Crops productivity and quality. However, water requirements of field Crops differ according to field Crops and soil types. Water needs of a plant include crop water uses by itself and also the losses due to evapotranspiration, water supply, land management, and water leaching at the time of the crop growth period. Therefore, the distribution of the rainfall to the selected field Crops production area is very important.

Table 2: Perception of ISHAEs W-Y on rainfall vary over the past years

Variable		Frequency	Percent
Perception of ISHAEs W-Y on rainfall vary over the past years	Yes	224	76.2
	No	70	23.8
	Total	294	100.0
ISHAEs W-Y indicating whether the vary is increasing or decreasing	Increased	26	11.6
	Decreased	198	88.4
	Total	224	100.0

In terms of ISHAEs, rainfall is a vital climatic variability in its existence or sustenance. In addition to seasonal rainfall variability, higher growing season temperatures can have dramatic impacts on agricultural productivity, farm incomes and food security (Battisti and Naylor, 2009) [2]. Rainfall remains the single most important climatic factor that influences the availability and changing use of water in the ISHAEs. In table 2, ISHAEs W-Y, most participants (76,2%) noticed a change in rainfall, mainly 88,4% indicates that it decreased.

3.1.3. Perception of ISHAEs W-Y on drought occurrence over the past years

Climate variability has direct impact on irrigated smallholder agricultural enterprises and livelihood opportunities in the agriculture sector. Most participants (48,3%) agreed that the frequency of drought increased, while 27,6% strongly agreed. Most participants (75,9%) indicated that droughts increased (Table 3).

Table 3: Perception of ISHAEs W-Y on drought occurrence over the past years

Variable		Frequency	Percent
Perception of ISHAEs W-Y on frequency of drought increasing in the past years	Strongly agree	81	27.6
	Agree	142	48.3
	Uncertain	67	22.8
	Disagree	4	3.3
	Total	294	100.0
ISHAEs W-Y observation on increasing or decreasing of drought occurrence	Drought increased	223	75.9
	Drought decreased	11	3.7
	Drought stayed the same	18	6.1
	Not observed any changes in drought	42	14.3
	Total	294	100.0

Future droughts are predicted to be outside of historical ranges (Hall, Grey, Garrick, Fung, Brown, Dadson and Sadoff, 2014) [15], exposing ISHAEs W-Y to conditions worse than those they have previously experienced. Although it is not possible to eliminate drought, its impacts can be managed through preparedness forecasting and resilience building. Failure to adapt to drought, especially in the context of a changing climate, causes and will continue to cause serious financial impacts for farmers, reducing employment in rural areas, affecting food availability and prices, driving a significant number of people into poverty, and triggering migration from rural to urban areas (Udmale, Ichikawa, Manandhar, Ishidaira and Kiem, 2014) [36]. As stated by Hall, *et al.*, (2014) [15], Agricultural output is affected most by extreme events (mainly droughts and floods) and extreme variability in climatic variables resulting in both direct short-time and long-term impacts on agriculture output and overall sector performance. In concur with the above, Davis and Vincent, (2017) [8], shows that drought conditions contribute to environmental degradation, and encroachment of marginal conditions on agriculture production areas and desertification.

3.1.4. Perception of ISHAEs W-Y on flood occurrence over the past years

Flood is a major threat to the social acceptability and economic viability and they can easily wipe out the ISHAEs wealth accumulated in the past. Flood risk is predictable to increase in many regions due to effects of climate conditions. Most participants (63.9%) indicated that floods are increasing (Table 4). The study revealed that the ISHAEs W-Y perception on flood shows that flood is increased and ISHAEs W-Y with recent flood experience can do well in flood mitigation Although many efforts have been done to reduce the risk and damage from natural disasters, floods remain the most devastation natural hazard in this ISHAEs production area. According to Botzen, Aerts and Van den Bergh (2009) [5] indicated that studying ISHAEs W-Y perception level is conducive to the implementation of effective flood risk management and disaster reduction policies, which has very important practical significance. The flood occurrence identifies the key impact factors of the flood perception of respondents and examine the influence of its impact factors. The flood occurrence of the respondents had been found to be positively and highly significant in this study. As quantified by Nott (2006) [25], the causes of floods can be broad caused by climatological forces. The most common causes of floods are climate related, most notably rainfall. Prolonged rainfall events are the most common cause of flooding worldwide. These events are usually associated with several days or weeks of continuous rainfall.

Table 4: Perception of ISHAEs W-Y on Flood occurrence over the past years

Variable		Frequency	Percent
Perception of ISHAEs W-Y on frequency of Flood increasing in the past years	Floods increased	188	63.9
	Floods decreased	62	21.1
	Not observed any changes in floods	44	15.0
	Total	294	100.0

3.2. Impacts of climate variability on the ISHAEs field crop production

The impacts of change in climate variability on agriculture can no longer be ignored as agricultural production is largely dependent on the amount of water available (Shrestha, Thin and Deb, 2014) [33]. The change in climate variability have impacts on agriculture resulting in the decline in crop yield which may increase food insecurity globally (Bhatt, Maskey, Babel, Uhlenbrook, and Prasad 2014) [4]. Such impacts are significant in arid and semi-arid areas, which include an area like Madimbo corridor and Upper Mutale Valley irrigated smallholder agricultural enterprises. This area receives a mean annual rainfall of less than 500 mm and this is where most of the agronomic activity takes place in Vhembe District. As specified by Nana, Corbari and Bocchiola, (2014)[22] in supplement of the above, agricultural crops relevant to food security such as Maize, Sweet potatoes and Dry beans require significant amounts of water for production. Table 5, below indicate that some of the participants (61.9%) said climate variability caused excessive heat/ cold which resulted in field crops failure. Climate conditions range from changing rainfall distribution patterns, reduced crop productivity and increased evapotranspiration. Rate of plant growth and development is dependent upon the temperature surrounding the plant and each species has a specific temperature range represented by a minimum, maximum, and optimum. High temperatures affect plant growth and development along with crop yield, this also happen during cold spell.

In Flood and drought, most participants (63.3%) said climate variability caused floods and drought which resulted in loss of field crops. Extreme drought conditions exacerbate the productivity of crops by causing nutrient immobilization and salt accumulation in soils making them dry, unhealthy, saline and finally infertile. prevalence of heavy rainfall which lead to drought, result in decline of agricultural land. This results lead to stress in crops such as decreased respiration, photosynthesis and transpiration, ultimately jeopardizing food availability and security in field crop production.

Table 5: Perception on the impacts of climate variability on the field crop production

Variable		Frequency	Percent
Crops/ vegetables failure due to excessive heat or cold	Yes	182	61.9
	No	112	38.1
	Total	294	100.0
Loss of field crops due to extreme floods or drought	Yes	182	63.3
	No	108	36.7
	Total	294	100.0
Increase in prevalent of pest in ISHAEs W-Y	Yes	218	74.2
	No	76	25.9
	Total	294	100.0

As far as, increased pest population, most participants (74.2%) said climate variability increased pest populations. Most of the field crop production had a problem with pest and according to Cranshaw, (2004) [7]; Pedigo and Rice, (2006) [26], insect pests damage crop plants mainly through direct feeding on plant parts, and the type of damage is related to the type of mouth parts of the insect pest. All these lead to yield reduction and loss of profit. Through implications for food security and income for ISHAEs W-Y households in Vhembe district. The increase in average temperature that characterizes climate conditions, when taken together with changing rainfall patterns, is likely to shift optimum growing areas for the selected field crops, generate an increase in the frequency and harshness of extreme and moderate weather events, and result in pests and diseases finding new ranges. This converts into increased vulnerability in field crop production over the medium to long term and poses new risks to farming and food production unless measures are taken to strengthen the resilience of production systems and to learn to adapt to cope with this climate conditions.

3.3. Mitigation of ISHAEs W-Y on the climate variability during field crop production

3.3.1. Action or measure undertaken by ISHAEs W-Y to mitigate climate variability during field crop production

Efficiency and improvements in irrigation systems have potential to save water that can be reallocated to other economic sectors (Jägermeyr, Gerten, Schaphoff, Heinke, Lucht and Rockström, 2016) [16]. In addition to the above the authors indicated that, adaptation in water resources should consider opportunities to increase soil water availability through interventions that maximize soil water infiltration, minimize evapotranspiration, innovative water conservation measures, harvest surface runoff to provide supplemental water for irrigation, and expand area under irrigation using saved water (improve irrigation systems). Climate projections for South Africa indicate increased temperatures across the country, an increase in precipitation in some parts of the country and a decline in precipitation in other parts; as well as increases in the magnitude and frequency of extreme events such as floods and droughts (Bell, Namoi, Lamanna, Corner-Dollof, Girvetz, Thierfelder, and Rosenstock, 2018) [3]. Table 6 shows that most of the participants (43.8%) do not know what action or measures should be undertaken followed by 16,6% who said Awareness of climate condition to ISHAEs W-Y could assist. The most common action or measure mentioned by participants was provision of inputs (16.3%). The ISHAEs W-Y preparedness and planning of managing the agro-ecosystems for extreme events such as water scarcity, heat waves, foods and so on can play a role in mitigating climatic conditions and Its variability. Sensitizing farmers to sustainable technologies and activities is of utmost importance as they are the ones who can play a major role in implementation of the agro- ecological practices.

Table 6: Action or measure undertaken by ISHAEs W-Y to mitigate climate variability during field crop production

Variable		Frequency	Percent (n=281)
Actions or measures undertaken by ISHAEs W-Y to mitigate climate variability during field crop production	Awareness of extreme weather condition to ISHAEs W-Y	49	16.6
	Do not know	129	43.8
	Nothing	46	15.6
	Provide food	7	2.3
	Provide funding	15	5.1
	Provision of inputs	48	16.3
	Total	294	100.0

3.4. Climate conditions at the study area

The expected climatic conditions in Southern Africa include increasing temperatures and drying conditions, and the increase in the intensity and frequency of climate variability (Nhamo, Nhemachena, Matchaya, Nhemachena, Muchara, Karuaihe, and Mpandeli, 2020) [2020]. The study involved preliminary situation analysis of the field production area with the inclusion of farmer's view. Information collected during situation analysis which used to develop a theoretical framework that consisted of the full set of climatic parameters known to influence crop production. The climate of the area is obtained from the Vhembe (Venda), Sigonde weather station which is the nearest available data for the chosen region (Table 7). Its coordinates are -22.39661S and 30.71308E.

(i) Temperatures

This determine the lowest and highest temperatures, and also define which crops may be planted and when they can be planted as determined by the temperature of a ISHAEs location. Temperatures vary from an average monthly maximum and minimum of 31.37ºC and 21.33ºC for January to 26.44ºC and 8.78ºC for June respectively. The area can be considered frost appears at minimal. Mosase and Ahiablame, (2018) [20], shows that in Limpopo river basin of which Madimbo corridor is part, minimum daily temperature across the basin varies from 0 ◦C in winter to 36 ◦C in summer. These stressors have detrimental effect on agricultural sector performance, and economic development (Faramarzi, Abbaspour, Vaghefi, Farzaneh, Zehnder, Srinivasan and Yang, 2013) [10]. As supplemented by (Nhamo, Ndlela, Nhemachena, Mabhaudhi, Mpandeli, and Matchaya, 2018) [23] who indicated that the projected increases in warming conditions across most parts of the region would worsen the challenges associated with water insecurity (mainly due to reduced rainfall), adversely affecting both rainfed and irrigated agriculture production, as well as negatively impacting energy generation.

Table 7: Average Climate Data (Past 40 years) for the nearest weather station (Sigonde)

Month	Rainfall (mm)	Evapo-transpiration (ETO) (mm)	Average Min. Temp (⁰C)	Average Max. Temp (⁰C)	Average relative Max. Humidity (%)	Years
Jan.	95.00	143.89	21.33	31.37	79.07	40
Feb.	74.62	137.70	21.46	31.84	83.91	40
Mar.	35.43	134.60	30.86	31.31	82.99	40
Apr.	20.08	125.00	16.58	29.41	84.79	40
May	6.83	105.90	11.87	27.86	81.60	40
Jun.	3.89	86.62	8.78	26.44	78.63	40
Jul.	3.29	92.50	8.54	25.89	76.72	40
Aug.	8.36	109.10	10.44	28.21	72.46	40
Sept.	12.67	130.70	14.41	30.10	70.73	40
Oct.	19.43	153.00	17.83	31.04	72.86	40
Nov.	50.81	152.70	19.94	31.86	76.06	40
Dec.	67.33	149.20	21.34	32.61	79.28	40
Total Average	397.74	1520.91	203.38	357.94	939.10	

(ii) Rainfall

The adaptation for agricultural cropping systems requires a higher resilience against both excess of water due to high intensity rainfall and lack of water due to extended drought periods (FAO, 2013) [12]. For the ISHAEs W-Y to arrange irrigation in the selected field crops at Vhembe district, there is a need to know how much rain has fallen. It is crucial to subtract the amount of water that must be administered at a given time (monthly and/or per season) from the total amount of water that must be applied. It is critical to time the irrigation according to the plant's developmental cycle but, the coherent trends between rainfall variability and field crop production in Vhembe ISHAEs W-Y over time depicts a decreasing trend with high levels of variability, which has been intensifying in recent past as rainfall sums uncertainty. According to Mosase and Ahiablame, (2018) [20], in Limpopo river basin of which Madimbo corridor is part, monthly rainfall during wet years can reach 340 mm, from a minimum of 50 mm to a maximum of 100 mm for normal rainy months. Long-term average annual rainfall is 397.74 mm, of which 342.62 mm, or 86.14%, falls from October to March. The average evaporation over the same period is 1520.91 mm. In further support of the above, decreasing trends in rainfall suggest decreased available water in the basin; however, population increase, changes in land use, and intensification of agriculture activities continue to put pressure on water resources in the basin. Significant adverse impacts in upstream water resources systems adversely affect economic activities and natural ecosystems (Abell, Vigerstol, Higgins, Kang, Karres, Lehner, Sridhar, and Chapin 2019) [1]. As indicated by Nhamo, *et al.*, (2018) [23], the general trend and changing pattern in rainfall indicates the high rainfall variability, with incidences of floods and droughts.

(iii) Evapotranspiration

According to Green (1985) [13] for the Limpopo basin which Madimbo corridor is part of, shows that the evapotranspiration for tomatoes is between 748 and 894 mm. The minimum of 86.62mm of evapotranspiration in June as compared to 153mm maximum evapotranspiration in December (Table 7). Evaporation over the basin is 1970 mm/year on average, with a range of 800 to 2400 mm/year (FAO, 2004) [11]. The potential evapotranspiration higher than precipitation as this area is arid and characterized by low rainfall, will require frequent irrigation to supplement the depleted water through utilized by crop, evaporation and infiltration.

4. Conclusion and recommendations

4.1. Conclusion

Effect in Climate conditions lead to rises in temperature, evaporative demands, and changes in rainfall and runoff patterns in Southern African regions (Strzepek, Mccluskey, Boehlert, Jacobsen and Fant, 2011) [35], resulting in increased frequency of flooding and drought as well as a reduction in groundwater recharge (Schulze, 2011) [30]. This study analyzes the perceptions of ISHAEs climate variability around the Suitability on the Selected Commodities Potential of Field Crops on Irrigated Smallholder Agricultural Enterprise in Vhembe District, preferably, the Madimbo corridor as production area and searches literature according to the purpose of the study. The aim of this research is to discover the responsible factors of climatic resource for Suitability on the Selected Commodities Potential of Agronomical Crops on Irrigated Smallholder Agricultural Enterprise in Vhembe District. It reveals that there is a great impact of climatic resource on Suitability Review on the Selected Commodities Potential of Agronomical Crops on Irrigated Smallholder Agricultural Enterprise. The results indicated that This observation was confirmed by long-term recorded climatic data. These indicates that all Agronomical Crops are ideal to be produce in this area, Maize may show some limitation because it require 32 °C as average maximum whereas the available is on the production area is 29.82ºC. to produce its optimal production cannot do well because maximum temperature is not finest during summer and it will need extra management which cost. Adapted well in warm climate. Sensitive to cold/ do not plant until danger of frost is over. Best growth temperature 21 to 30^{0}C. Temperatures vary from an average monthly minimum and maximum of 16.94ºC and 29.82ºC annually.

4.2. Recommendations

The results of this suitability study on the Selected Commodities Potential of Field Crops on ISHAEs W-Y study will also assist with the economic production menus and programs for long term sustainability of the Field Crops commodity enterprises. This validates with work done by (Randela, Groenewald and Alemu, 2006) [27] on the work of irrigation schemes to develop policies and programs for improvements.

References

1. Abell R, Vigerstol K, Higgins J, Kang S, Karres N, Lehner B, etc. Freshwater biodiversity conservation through source water protection: Quantifying the potential and addressing the challenges. Aquat. Conserv. Mar. Freshw. Ecosyst. 2019;29:1022-1038.
2. Battisti DS, Naylor RL. Historical warnings of future food security with unprecedented seasonal heat. Science. 2009;323:240-244.
3. Bell P, Namoi N, Lamanna C, Corner-Dollof C, Girvetz E, Thierfelder C, etc. A Practical Guide to Climate Smart Agricultural Technologies in Africa. Wageningen, the Netherlands: CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS), 2018, 224. Available online at: www.ccafs.cgiar.org
4. Bhatt D, Maskey S, Babel MS, Uhlenbrook S, Prasad KC. Climate Trends and Impacts on Crop Production in the Koshi River Basin of Nepal. Reg. Environ. Chang. 2014;14:1291-1301.
5. Botzen WJW, Aerts J, Van den Bergh J. Dependence of flood risk perceptions on socioeconomic and objective risk factors. Water Resource. Res. 2009;45:15.
6. Bounkoungu EG, Naimir-Fuller M. Biodiversity in drylands: Challenges and opportunities for conservation and sustainable use, 2001. http://undp.org/biodiversitycd/Biodiversityinthedrylands-challenges-paper
7. Cranshaw W. Garden insects of North America. Princeton University Press, Princeton, NJ, 2004.
8. Davis CL, Vincent K. Climate Risk and Vulnerability: A Handbook for Southern Africa, 2nd ed.; Council for Scientific and Industrial Research (CSIR): Pretoria, South Africa, 2017, 202.
9. Derya Ö, Mehmet A, Süha B, Sermet Ö, Tomohisa Y. The use of aridity index to assess implications of climatic change for land cover in Turkey. Turk J Agric. 2009;33:305-314. doi:10.3906/tar-0810-21
10. Faramarzi M, Abbaspour KC, Vaghefi SA, Farzaneh MR, Zehnder AJ, Srinivasan R, *et al*. Modeling impacts of climate change on freshwater availability in Africa. J. Hydrol. 2013;480:85-101.
11. Food and Agriculture Organization. Drought Impact Mitigation and Prevention in the Limpopo River Basin: A Situation Analysis. Land and Water Discussion Paper; Food and Agricultural Organization (FAO): Rome, Italy,

2004.
12. Food and Agriculture Organization. Climate-Smart Agriculture Sourcebook. Rome: Food and Agriculture Organization of the United Nations E-ISBN 978-92-5-107721-4 (PDF), 2013. www.climatesmartagriculture.org/72611
13. Green GC. Estimated irrigation requirements of crops in South Africa. Part 2. Memoirs on the Agricultural Natural resources of South Africa. ISCW, Pretoria, 1985.
14. Griffins J. Handbook of applied Meteorology. (D. D. Houghton, and J. W. Sons, Eds, 1985.
15. Hall JW, Grey D, Garrick D, Fung F, Brown C, Dadson SJ, *et al*. Coping with the curse of freshwater variability. Intergovernmental Panel on Climate Change (IPCC). Summary for policy-makers. 2014;346:429-430.
16. Jägermeyr J, Gerten D, Schaphoff S, Heinke J, Lucht W, Rockström J. Integrated crop water management might sustainably halve the global food gap. Environ. Res. Lett. 2016;11:025002.
17. Leedy PD, Ormrod JE. Practical research: Planning and design (8th Ed.). Upper Saddle River, NJ: Prentice Hall, 2005.
18. Leedy PD, Ormrod JE. Practical research, planning and design. (8th ed.). Pearson Merrill Prentice Hall, New Jersey, 2010.
19. Lynam T, Brown K. Mental models in human-environment interactions: theory, policy implications, and methodological explorations. Ecol. Soc. 2011;17:3-24.
20. Mosase E, Ahiablame L. Rainfall and Temperature in the Limpopo River Basin, Southern Africa: Means, Variations, and Trends from 1979 to 2013. Water. 2018;10:364. doi:10.3390/w10040364. www.mdpi.com/journal/water.
21. Muchow RC, Bellamy JA. Climatic risk in crop production: models and management for the semi-arid tropics and subtropics. Wallingford, UK, CAB International, 1991.
22. Nana E, Corbari C, Bocchiola D. A Model for Crop Yield and Water Footprint Assessment: Study of Maize in the Po Valley. Agric. Syst. 2014;127:139-149.
23. Nhamo L, Ndlela B, Nhemachena C, Mabhaudhi T, Mpandeli S, Matchaya G. The water-energy-food nexus: Climate risks and opportunities in southern Africa. Water. 2018;10:567.
24. Nhamo L, Nhemachena C, Matchaya G, Nhemachena VCR, Muchara B, Karuaihe ST, etc. Climate Change Impacts on Water and Agriculture Sectors in Southern Africa: Threats and Opportunities for Sustainable Development. Water. 2020;12:2673. doi:10.3390/w12102673. www.mdpi.com/journal/water.
25. Nott J. Extreme Events: A Physical Reconstruction and Risk Assessment. Cambridge University Press. New York, 2006.
26. Pedigo LP, Rice ME. Entomology and pest management. 5th ed. Pearson Prentice Hall. Columbus, OH, 2006.
27. Randela R, Groenewald JA, Alemu ZG. Characteristics of potential successful and River, NJ: Prentice Hall. Science, 2006, 6(2).
28. SAS Institute Inc. SAS 9.1.2 *User's Guide*, Cary, NC: SAS Institute Inc, 2009.
29. Schulze RE. Approaches towards practical adaptive management options for selected water-related sectors in South Africa in a context of climate change. Water SA, 2011.
30. Schulze RE. On Observations, Climate Challenges, the South African Agriculture Sector and Considerations for an Adaptation Handbook. In: Schulze, R.E. (Ed.) Handbook for farmers, Officials and other stakeholders on Adaptation to climate change in the Agriculture Sector within South Africa. Section A: Agriculture and Climate Change in South Africa: Setting the scene, 2016.
31. Selvaraju R, Gommes R, Bernardi M. Climate science in support of sustainable agriculture and food security. Climate Res. 2011;47:95-110.
32. Shahi P. Upper Mustang's rain spell has weather experts scratching their heads. The Kathmandu Post, 2011. http://kathmandupost.ekantipur.com/printedition/news/uppermustangs-rain-spell-has-weather-expertsscratching-their-heads.html.
33. Shrestha S, Thin NMM, Deb P. Assessment of Climate Change Impacts on Irrigation Water Requirement and Rice Yield for Ngamoeyeik Irrigation Project in Myanmar. J. Water Climate Change. 2014;5:427-442.
34. Stiger CJ, Dawei Z, Onyewotu LOZ, Xurong M. Using traditional methods and indigenous technologies for coping with climate variability. Climatic Change. 2005;70:255-271. http://dx.doi.org/10.1007/s10584-005-5949-5.
35. Strzepek K, Mccluskey A, Boehlert B, Jacobsen M, Fant I. Climate Variability and Change: A Basin Scale Indicator Approach to Understanding the Risk to Water Resources Development and Management; Water Papers; The World Bank: Washington, DC, USA, 201.
36. Udmale P, Ichikawa Y, Manandhar S, Ishidaira H, Kiem AS. Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. Int. J. Disaster Risk Reduction. 10 Pt A, 2014, 250-269.
37. Welman C, Kruger F, Mitchell B. Research Methodology. (3rd Ed.). Oxford, Cape Town, South Africa, 2005.