OVENI VA AFRICA

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

3E

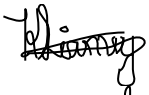
TACKLING CLIMATE CHANGE IN RURAL NAMIBIA

MAY 2021 TO MAY 2022

DECLARATION

We as a team *Oveni va Africa* with mentioned team members in the below table, hereby declare that the work contained in the scientific document for the project entitled "Tackling Climate Change in Rural Namibia", is our own original work and that we have not previously in its entirety or in part submitted it at any university or other higher education institution for the research initiative.

We further declare that as a team we will fully acknowledge any sources of information use for the research work in accordance with the *3Es 4 Africa* policy and rules.

Name	Surname	Student Number	Signature
Kalapufye Keitavelo Kaume	Ngenomesho	219070636	
JD	Erasmus	220038716	
Uahengisa	Katjizuko	220040850	
Shaun	Kamesiepo	220053685	
Warren Wayne	Thomas	220069492	
Jo-dee	Van der Byl	220054037	

SIGNATURE OF THE SUPERVISOR

I, Arpit Jain, herewith declare that I accept this research proposal for my supervision

Signature: 

Date: 10/10/2021

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ABSTRACT

The global climatic condition is changing rapidly which impacts almost every region on the earth. Africa is one of the most vulnerable continents to climate change. Climate change is a prominent issue on the African continent especially in the southern part of Africa which results in major effects on many sectors important to society such as human health, agriculture sector, food and water security, biodiversity, and ecosystem. Observed changes include uneven weather patterns, variations in temperature, sea levels and atmospheric conditions. This will continue and become more disruptive in the coming decades. Many steps are taken to handle the situation but there are requirements to tackle climate change which includes the awareness and best practices to save nature. With this aim, our team will focus on the regions of Namibia to understand the impact of climate change and research the possible ways to mitigate the issues that arise due to climate change. The researchers will identify and elaborate on the climatic conditions of the areas which are most affected and have the impacts on the economic sectors in the specified area. Major factors contributing to the negative effects of climate change on the local populace will be discovered through survey studies, climate, and weather data analytics. Based on the analysis on major contributing factors in climate change, the conceptual model will be proposed to alleviate the current situation. This study will bring awareness about the climatic condition of Namibia and prepare people to follow the best practices to contribute to a sustainable ecosystem.

1. INTRODUCTION

Climate change is a critical aspect which is caused due to natural and anthropogenic sources. This results in shifting of weather patterns. Due to this variation in weather patterns including global warming the world is suffering from the effects these changes cause. With this study, it is analysed how it is affecting the people and planet, and what steps can be taken to handle it.

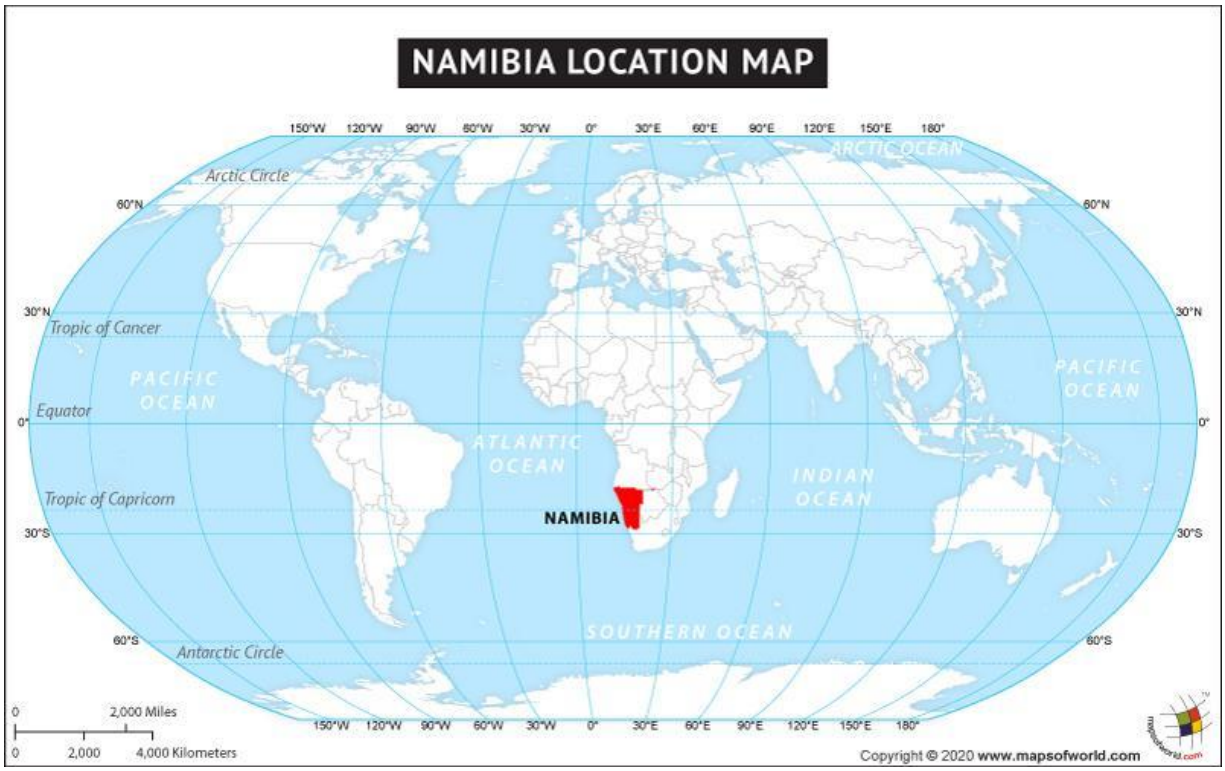
In this research work, the study focuses on climate change in rural areas of Namibia. The areas are considered rural due to their relatively low population density, the shelter and homes being mainly villages, town, and farms; and lastly the lack of consistent and widespread development that reflect the challenge of the municipal government from being able to cater to the people's needs (National Geographic Society, 2012). The populace mainly practices agricultural and pastoral activities as well as a plethora of other service activities e.g., retail, tailoring and hospitality to mention a few (Okatyali - OshanaRC - GRN Portal). Unfortunately, Namibia has been recording ever increasing temperatures and a resultant sporadic and inconsistent rainfall pattern. Additionally, the recurring natural disasters like droughts and floods have had a devastating effect on the local farmers, their land, and livestock (Climate Change Manifestation into Drought - Namibia, 2019).

Due to an increase in temperature, crop volatility is forecasted to decrease yields in prominent crop types. Ultimately, according to Woetzel et al. (2020) African countries like Ethiopia and Mozambique will experience an intense dip in their GDP. In this study, the gathered geo-political information about the targeted areas is presented in a tabular format.

1.1. Background

Namibia is distinctly vulnerable to the effects of climate change. Given our population's reliance on sectors that are climate sensitive like agriculture, the management of livestock, and fishing, with which the potential consequences of these alterations could be disastrous

for our people. There is an expectation for climate change to have a major impact on the country's key economic sectors and livelihoods. Overall, climate change and variability could result in a 6.5 percent annual decrease in GDP, impeding economic development. Food security, water resources, human health, infrastructure, biodiversity, energy, tourism, coastal zones, urban development, and sustainable resource base management have all been prioritized by Namibia.



https://www.mapsofworld.com/namibia/namibia-location-map.html

Figure 1: Namibia Location Map

According to (Climate Change Manifestation into Drought - Namibia, 2019b), droughts and floods have been the most visible manifestations of climate change in Namibia, while unusually high temperatures can be found in more arid areas such as the south and west. Since 2013, Namibia has been experiencing recurrent drought conditions, which have impacted the drier regions of the country, including the south, west, and northwest, to the point where human lives have been lost as a result.

According to Ham(n.d.), Namibia has a subtropical desert climate with significant temperature differences between day and night time, little to no rainfall, and low humidity. Namibia is one of the sunniest countries on the planet, with a mean of 300 days of sunshine per year. Because the climate is generally arid, potential evaporation is greater than precipitation, resulting in extremely low humidity. However, there are significant climatic differences between the regions in terms of precipitation and temperature. From the southwest to the northeast, annual precipitation increases from 0 millimetres to a maximum of 600 millimetres. From December to March, the weather is generally hot across the country. The rainy season officially begins in January (often with thunderstorms). The vegetation turns a vibrant shade of green. Rainfall is still possible in April and May. The temperature begins to drop gradually. Winter in Namibia lasts from June to September. There is no more precipitation (except in the far south – in winter rain areas), and temperatures are moderate to warm during the day. The nights are bitterly cold, with frost forming overnight in the inland and desert areas. The vegetation turns brown as it progresses from green to brown. Temperatures begin to rise in October and November, and it becomes hot once more. The Benguela Current cools the coast, and rainfall averages less than 50 millimetres per year. The Central Plateau and the Kalahari have wide diurnal temperature ranges, with summer days reaching more than 30°C and winter days reaching less than 10°C. The average December temperature in Windhoek, on the plateau, is 24°C, with a maximum of 31°C. The average temperatures in July are 13°C and 20°C, respectively. Rainfall ranges from 250 millimetres in the southern and western parts of the plateau to 500 millimetres in the north-central part and more than 600 millimetres in the Caprivi Strip and Otavi Mountains (Namibia - Climate, n.d.).

1.2. Problem Statement

Climate change is an increasingly dreadful global issue that affects everyone, especially developing countries that lack appropriate resources and infrastructure that could potentially assist them in addressing the issues at hand. Furthermore, rural areas receive the bulk of the impact due to even more inadequate access to scarce essential services and resources. Inhabitants in these areas are currently enduring intense and erratic impacts of climate change, be it heat and temperature fluctuations, sporadic rainfall patterns and low yields in agriculture activities.

The problem at hand is the negative impacts of climate change, and how they affect the socio-economic and political sphere of the most affected areas. These negative effects also have a potential to spread into the rest of the nation, primarily as these areas contribute to the national GDP and food production. Other notable impacts of climate change in these areas are:

- Severe droughts
- Intense heat
- Increasing malnutrition and food deficits
- Malaria and other waterborne disease outbreaks
- Low income and GDP

Additional resultant impacts in the chain of issues caused by climate change in Namibia (World Bank Climate Change Knowledge Portal, n.d.). By virtue of tackling a problem, one needs to begin by researching it extensively to assess and build on potential solutions. Conclusively, it is fundamental to research the impacts of climate change in order to document and propose evidence-based solutions to improve the status quo of the regions and country at large.

During 2021 heavy rain caused flash floods in the capital city of Namibia, Windhoek. These floods affected people's houses and washed over roads stopping traffic (Davies, Namibia – Heavy Rain Continues, Flash Floods in Windhoek – Flood List 2021). The south of Namibia was also greatly affected by the floods in 2021, many rivers overflowed their banks. The overflowing of one river, the Dabib, which is a tributary of the fish river, caused some maize fields along its bank to be submerged in water (TheNamibian, Flooding in south 'biggest since the 90s' 2021).

The northern parts of Namibia are also greatly affected by floods and excessive rainfall, the North of Namibia sees a lot more rain than the rest of Namibia. Throughout the last 20 years there have been many floods affecting the region and causing immense damage. The 2008 floods in Namibia, that displaced and affected an estimated 65,000 people, act as a warning sign to future, more devastating floods (2008 Namibia floods - Wikipedia 2021).

1.3. Research Objectives

The project requires us to have clearly defined and tangible objectives that are to be laid forth. This allows for level-headedness in the path we will traverse to achieve what is expected, in accordance with tackling climate change in Namibia. The following four objectives are concise, yet explicitly summarise the efforts of our work for anyone reading:

1. Finding & understanding the current problems faced due to climate change in the targeted region based on Data Analysis.
2. Spread awareness about climate change to the people of the affected region and guide them to follow the best practices to contribute to the improvement of the region's climatic conditions.
3. Identifying required improvements in areas affected by climate change.
4. Creating a scenario based Conceptual Model that can be implemented in the future to tackle climate change in rural Namibia.

2. LITERATURE REVIEW

In the past few years, various studies have been conducted to handle climate change. The major concerns were balancing between cooling and warming phases, unawareness amongst people and how to reduce the emission of greenhouse gases (GHG). Many studies have contributed to improve and handle climate change and its effect.

2.1. Climate Change and Rural Development

The world and its requirement to adapt to the exacerbating situation of world poverty and hunger are changing. There is a dire need to alleviate the natural landscape and practice more sustainable methods of operating. Twenty-Five percent of natural disasters affect the agriculture sector, these climatic fluctuations put an even greater stress on the agriculture sector. Climate change and use of land in a way not suitable for the local conditions will further lead to soil degradation. Climate change is predicted to reduce area productivity in sub-Saharan Africa by 14-27% by the year 2080, with an 18-32% decrease projected for South-East Asia (Sustainable Agriculture sector project (NAREN), 2020, Climate change and rural development).

2.2. Existing Solution of Climate Change

There is a need for policy and massive financial support to execute projects that tackle climate change in Africa. Hence the projects are high level and require extreme planning and forecast of potential impacts (Solutions for a Changing Climate: The African Development Bank's Response to Impacts in Africa).

Popular solutions for reducing the effects of climate change on the agricultural sector include, diversifying crop growth, having disaster risk management systems, conservation, and rehabilitation of soil (Sustainable Agriculture sector project (NAREN), 2020, Climate change and rural development).

Solutions to ensure greater water security:

- Large, stable water supplies, such as deeper groundwater, are being targeted for improvement and conservation.
- Water supply technology must be matched to groundwater conditions, with sources in the most productive areas of the aquifer cited.
- Conserving and sustainably using existing water sources so that more are available at the start of a drought.
- Assuring that water sources are neither contaminated nor flooded on a regular basis.

  (Potential impact of climate change on improved and unimproved water supplies in Africa).

2.3. Difficulties of Tackling Climate Change

Africa has many problems it needs to deal with first before it can properly address the problem of climate change properly. Combating climate change in Africa is difficult due to:

- Coordination and organisation are a prevailing issue in tackling climate change
- Weak policies and low investments
- Poor human resource support
- Poor management of financial resources.

- Organisations like the African Union are aware of the problem and have plans and frameworks in place to tackle climate change, but are not financially prepared and independent to carry out these plans (Climate-related Security Risks and the African Union, 2020).
- Fractionation of funding entities worsens the situation

(Solutions for a Changing Climate: The African Development Bank's Response to Impacts in Africa).

Natural disasters like droughts and floods wipe out years of national development investments and infrastructure, forcing many African countries to divert much of their limited resources intended for other national development initiatives to disaster response and recovery, including relief efforts. According to the statistics Africa only contributes 4% of global emissions

- 40% of Africans do not have access to quality water
- 68% of Africans do not have access to sanitation facilities

(African strategy on climate change, 2014)

Climate change's possible impact on Africa's improved and unimproved water supply is examined. Climate change will affect improved and unimproved water sources in rural areas of Africa and may reduce water security in these areas. Other factors contributing to water security/availability or access are considered as well to have an accurate prediction on future water security. Absolute water resource availability, access to these water resources, and changing water demand and use are the three elements that determine water security.

Other factors (such as population growth and increased food demand) will certainly put more strain on rural water supplies. Another factor of climate change that influences water security is higher temperatures which will increase the evaporation rate. During this century, Africa is very likely to warm, and the warming will be greater than the global annual average of 2 degrees Celsius. Warming will occur across the continent and at all seasons, with drier subtropical parts warming faster than humid tropics. (African strategy on climate change, 2014)

Due to higher evaporation rates Africans will be less reliant on surface water and rely more on groundwater. A change of rainfall patterns will lead to more irregular recharge rates of groundwater. Higher temperatures can lead to more frequent and more intense rainfall events. Contamination from soil can be flushed into rivers and groundwater during heavy rain storms. Warmer atmospheric conditions will lead to greater intensity of rainfall and of greater spatial and temporal variability. Tropical storms, floods, and droughts are expected to become more common and intense in the future.

However, accurately predicting the effects that climate change will have on water sources is very difficult. Climate change prediction is uncertain due to Africa being a data poor region. 90% of Global Circulation Models (GCMs) fail to properly mimic current climatic conditions in major portions of Africa, indicating a high margin of error. In Sub-Saharan Africa, rainfall can be exaggerated by up to 20%, and sea-surface temperatures can be underestimated by up to 20%. According to study, GCMs generally predict rainfall to decrease by 30% in southern Africa (Potential impact of climate change on improved and unimproved water supplies in Africa).

3. GEOGRAPHICAL ANALYSIS

3.1. Namibia

The Great Escarpment, which separates southern Africa's interior from the Kaokoveld and Namib Deserts, is home to the Namibian Savanna Woodland ecozone. This broken and deeply dissected escarpment is a region consisting of a high rate of indigenous plants, mammals, birds, invertebrates, amphibians, and reptiles (Africa: Namibia | Ecoregions | WWF. (n.d.). World Wildlife Fund. Retrieved October 11, 2021). The northern area of the escarpment, the Kaoko escarpment, is an endemism "hotspot" (When used to describe species of plants or animals that are found only within a specific place, it has the same meaning as native or indigenous)

Namibia's rainfall has been notoriously unpredictable in the past. The average annual rainfall is 278 mm, ranging from 650 mm in the northeast to less than 50 mm in the southwest and near the shore. Rainfall is extremely scarce in the Namib Desert, most of

the rain falls as thunderstorms in the summer months which is from October to March. There is a great fluctuation between years, with the driest years having the smallest amount of predictable rainfall. The predictability of the rainfall is more positive towards the east as the rainfall percentage rises. The coldest month is July with an average maximum temperature of 20°C (68°F), the wettest month is February and the driest is August. The low humidity of the area, without the cooling effect of the Benguela Current, leads to extreme temperatures. Mean minimum monthly temperatures drop to -9°C in places, and absolute readings are even lower. Due to winter temperatures, winter frosts occur frequently. The mean maximum monthly air temperature can exceed 40°C (Climate and average weather in Namibia. (n.d.). World Weather & Climate Information. Retrieved October 11, 2021).

Namibia is truly a sunny place, with an average of 300 days of sunshine per year. Summer lasts from October to April, with temperatures reaching 40 degrees Celsius (104 degrees Fahrenheit) during the day and dropping to cool levels at night. Average monthly night-time temperatures range from 20°C to 34° C (68-93° Fahrenheit) in summer. Namibia is considered one of the most vulnerable countries in the world to the effects of climate change. The expected rise in temperature and evaporation, as well as greater rainfall susceptibility, would compound Namibia's current issues as the driest country south of the Sahara.(National policy on Climate Change for Namibia, 2011) (Climate and average weather in Namibia. (n.d.). World Weather & Climate Information. Retrieved October 11, 2021).

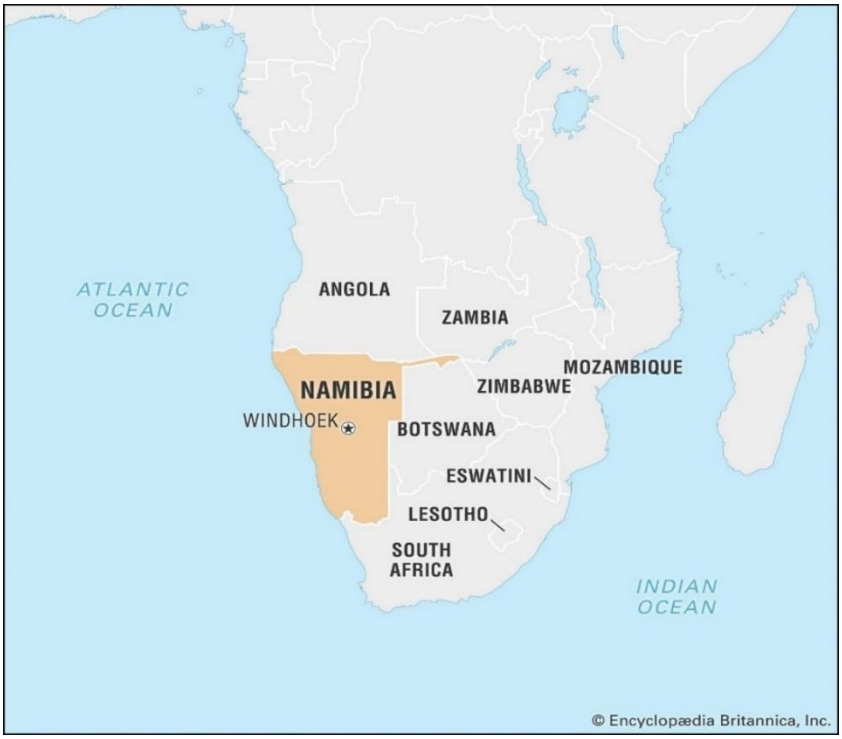


Figure 2: Namibia on the Map of Africa

Namibia was declared the world's thirty-fourth largest country and still the second least densely populated with an estimated 2 598 516 (based on the Worldometer elaboration of the latest United Nations data.) therefore making the Namibian population 0.03 percent of the world's population as of October 2021. The total land area is 823,290 Km2 (317,874 sq. miles) making the population density in Namibia is 3 per Km squared (8 people per meters squared) (Namibia Population (2021) - Worldometer. (n.d.). Worldometer. Retrieved October 11, 2021)

3.2. Oshana and Ohangwena Region

The Oshana region is situated in north-central Namibia. It consists of 11 constituencies with Oshakati as its capital. According to the latest census records, the region has the second largest population density in Namibia, after the Ohangwena region. The name Oshana refers to the area's most notable geographical feature: shallow, seasonally flooded depressions that support the local agro-ecosystem. The fish which breed in the oshanas provide an important source of dietary protein. This area is infrequently inhabited due to the excessive saline of the land and water, which makes it unsuitable for grazing or farming. The big, vast metropolitan centres of Oshakati, the regional capital, Ongwediva, and Ondangwa are located in the northern section of the Oshana Region, which is much more

densely inhabited. Annual flooding is common in the Oshana flood plains of the Cuvelai drainage system. Basic infrastructure is lacking in the Oshakati, Ongwediva, Ondangwa complex, and most services and amenities are typically located in metropolitan regions. The bulk of enterprises in northern Namibia are based here, and this region employs a substantial number of people.

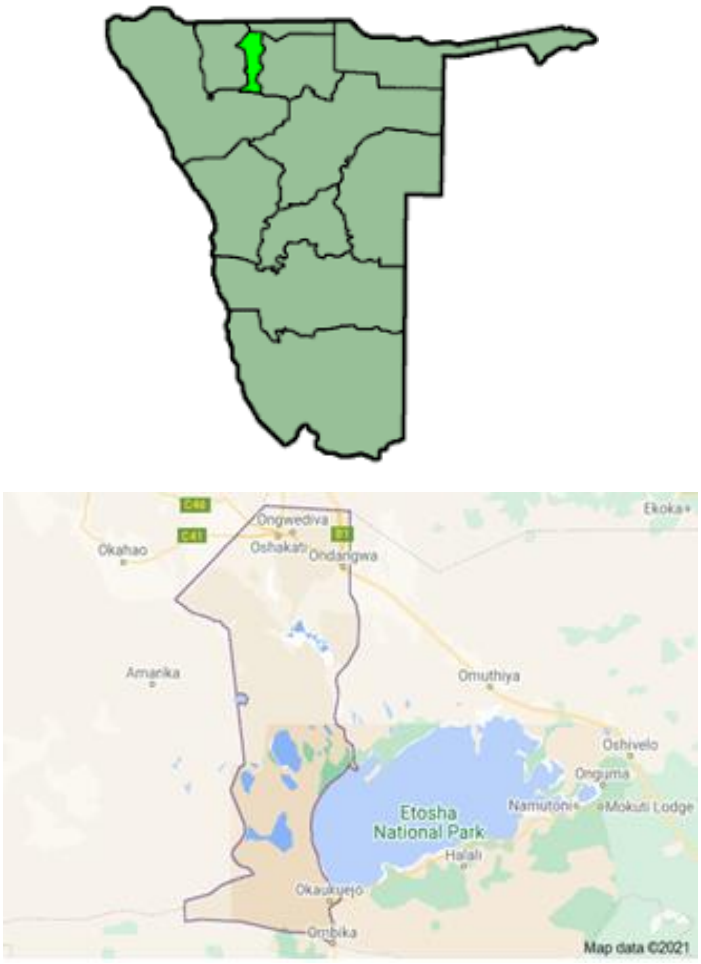


Figure 3: Oshana region

The Ohangwena region is situated in north Namibia. Ohangwena is situated on a flat plain and extends east to west along the Angolan border. In the west, the ephemeral wetlands of the Oshanas support an open landscape with palm and marula trees, while the eastern parts consist of woodlands. The region has no permanent rivers, it consists of 12 constituencies with Eenhana as its capital. It has by far the highest population density in Namibia at 21.3 people per km2 (the country average is 2.1).

Ninety-nine percent of the population lives in rural regions and subsists nearly entirely on rain-fed agriculture. The Ohangwena Region's rainfall supports dry land cultivation, particularly of pearl millet (mahangu) in the western sections of the region, as well as cattle grazing that extends into the eastern forests. Non-timber forest products are used to augment farming.

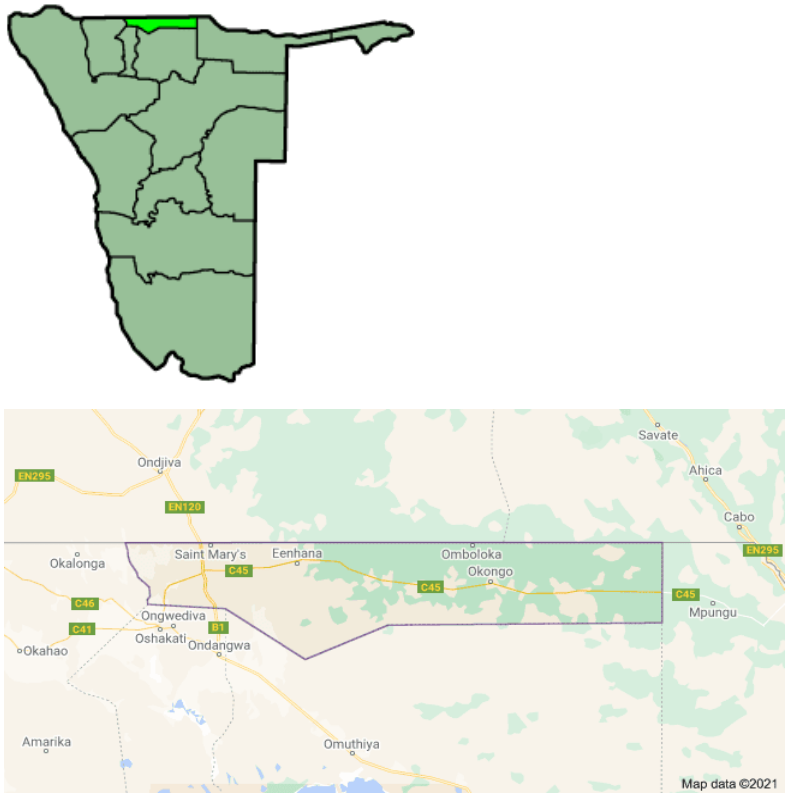


Figure 4: Ohangwena region

Table 1: Details of Oshana region and Ohangwena region

Metrics	Oshana Region	Ohangwena Region
Area size	8,647 km^2	10,706 km^2
Geographical location	Oshakati (17°47'14.4"S 15°42'13.8"E) Oshitayi (17° 51' 0" S15° 58' 59"E) Okatana (S 17° 46. 561°, E 015° 40.103°)	Epembe (17° 45' 59.99" S16° 11' 60.00" E) Omundaungilo (17° 51' 0" S15° 58' 59"E)
Capital	Oshakati	Eenhana
POPULATION	The Oshana region has a population of 176,674 as of the latest census (2011)	The Ohangwena region has a population of 245,446 as of the latest census (2011)

DEMOGRAPHIC INFORMATION	○ 55% of the population lived in rural areas ○ The other 45% live in urban areas. ○ The region's official language is English. ○ Oshiwambo is the most widely spoken language in the area. ○ Other languages, such as Afrikaans, Portuguese, and other Namibian languages, are also spoken, although not widely.	○ 99% of the population lived in rural areas ○ The other 1% live in urban areas. ○ The region's official language is English. ○ Oshiwambo is the most widely spoken language in the area. ○ Other languages, such as Afrikaans, Portuguese, and other Namibian languages, are also spoken, although not widely. ○ Literacy rate in the area is 79%.
GOVERNANCE	○ Elia Irimari is the current sitting Regional Governor, who represents the office of the President and all government institutions. ○ There are 3 Local Authorities: Ondangwa, Ongwediva, and Oshakati. ○ There exist 3 traditional authorities, namely, Uukwambi, Ondonga, and Oukwanyama that serve as advisors on communal land and customary matters.	○ Governor Walde Ndevashiya.
NUMBER OF CONSTITUENCIES	The region comprises eleven (11) constituencies: ○ Okaku ○ Okatana ○ Okatyali ○ Ompundja ○ Ondangwa Rural ○ Ondangwa Urban ○ Ongwediva ○ Oshakati East ○ Oshakati West ○ Uukwiyu ○ Uuvudhiya	The region comprises twelve (12) constituencies: ○ Eenhana ○ Endola ○ Engela ○ Epembe ○ Ohangwena ○ Okongo ○ Omulonga ○ Omundaungilo ○ Ondobe ○ Ongenga ○ Oshikango ○ Oshikunde
VEGETATION & SOIL CONDITION	○ The soil is exhausted over much of the central area where subsistence farming is dominant. ○ The southern portion of Oshana is an extensive savannah plain stretching as far as the Etosha Pan, ○ The high salinity of soil and water render it unsuitable for grazing or cultivation.	○ Ohangwena Region has a sub-tropical climate with hot summers and cools to warm winters. ○ The region is semi-arid due to the climate and rainfall.
POPULAR CROPS YIELD	Mahangu is the principal staple crop grown.	Mahangu is the principal staple crop grown.
RAINFALL PER ANNUM	528 mm	Annual rainfall varies from 480 mm in the western part to 600 mm in the east.
GEOGRAPHICAL WATER SYSTEM	The Namibian-Angolan border river Kunene supplies the present water delivery system via pipes. Other water sources in the region include "Oshana water," which comes from hand-dug wells or shallow excavation dams,	Most of the region relies on underground water sources and boreholes. These boreholes are aging, and the water has become salty in some villages.

	although it is of poor quality due to evaporation, which rises substantially in the summer when it gets hot.

3.3. Climatic Conditions

The climate in the Oshana regions is classified as a local steppe climate while the Ohangwena region has a Subtropical steppe climate. The Oshana and Ohangwena Regions receive very little rain throughout the year. The Oshana region has a Köppen-Geiger climate classification, BSh, for hot semi-arid climates. The average annual temperature in Oshana is 23.5 °C, and the annual rainfall is 528 mm while the average annual temperature of the Ohangwena region is 31°C and the rainfall is about 250 mm. Arid broad-leaved savannah on arid, nutrient-rich, and clay soils characterizes the vegetation of the Oshana while the Ohangwena region has Kalahari woodlands, shrubs, and bushy concoction characterizing its vegetation.

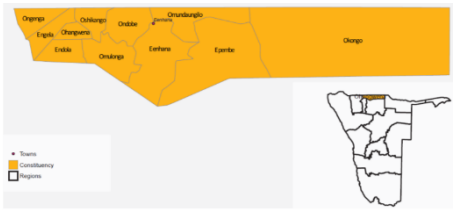
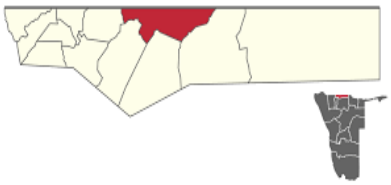
3.3.1. Targeted Areas of Ohangwena Region

Due to the media coverage of Ohangwena's predicaments - specifically water scarcity, as well as its rural characteristics, it seems appropriate to study it's the climate change impacts and how it exacerbates the region's sustainability. The following tables provide a detailed background on the area.

Figure 5 Polluted water sources, Epembe (2021), Floods in the Ohangwena region (2017)

Table 2: Constituency of Ohangwena region

Area name	Epembe constituency	Omundaungilo constituency

Map of targeted area in Ohangwena		
Area size	N/A	N/A
Geographical location	(-17° 45' 59.99" S 16° 11' 60.00" E)	(17° 51' 0" S15° 58' 59"E)
Population	16,229 (population) – 2011	10,006
Demographic Information	○ 34 % unemployment rate (2011) ○ Main sources of income are farming, mainly subsistence.	○ 45% unemployment rate (2011) ○ Main sources of income are farming, mainly subsistence
Governance	○ The constituency councillor is Hon. Matheus Nanghama	○ The constituency councillor is Hon. Festus Ikanda
Housing conditions	○ According to the 2011 census the percentage of households that meet the following criteria are: ○ Safe water 23 % ○ No toilet facility 93 % ○ Electricity for lighting 4 %	○ According to the 2011 census the percentage of households that meet the following criteria are: ○ Safe water 22 % ○ No toilet facility 85 % ○ Electricity for lighting 2 %

3.3.2. Targeted Areas of Oshana Region

The Oshana region is home to a great deal of Namibians who have migrated to the Capital city Windhoek, due to the poor living conditions and lack of opportunities in the area. Amongst the Namibian people, it is common knowledge that there are intense and fluctuating temperatures in the region. Furthermore, there have been research studies that have identified more frequent natural disasters that plague the local farmers and populace. This study shall attempt to identify the explicit climate change impacts on the area and its inhabitants.

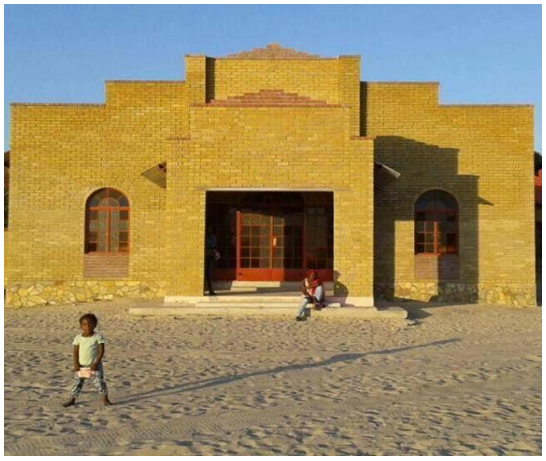


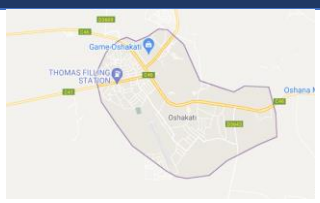
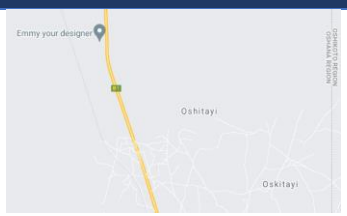
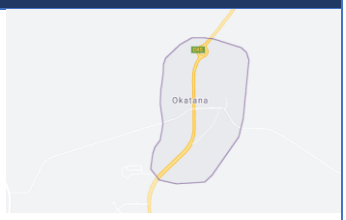
Figure 6: Okanata Church

Figure 7: Oshitayi field failed crop

Figure 8: Oshakati rural area for Farming

Figure 9: General landscape of northern Namibia

Table 3: Constituency of Oshana region

Area	Oshakati	Oshitayi	Okatana
Map of targeted area in Oshana			
Area size	17.34 km^2	N/A	2.5 km^2
Geographical location	(17°47'14.4"S 15°42'13.8"E)	17°46'33.7"S 15°40'06.2"E	S 17° 46. 561°, E 015° 40.103°
Population	37,000 (2011)	Less than 500, estimated	4,550 (2019)
Governance	Onesimus Shilunga – Mayor	N/A	Hon. Edmund Iishuwa

3.4. Impacts of Climate Change

Climate changes have been observed from the World's perspective with erratic weather patterns. The solid predictions state an increase in the global temperature by 2°C by 2050 with notable effects like a reduction in the average precipitation in regions like Southern Africa (Ongoma, 2021).

Southern African countries like Namibia are influenced by the El Nino and La Nina events which have resulted in severe droughts or rainfall that causes devastating floods. Furthermore, the temperatures exceed 35°C during the days in the summer seasons and below 5°C in winter. Notable impacts in the Oshana and neighbouring Ohangwena Regions are water scarcity, shifts of biodiverse ecosystems, reduction in soil fertility and in crop production, pest and disease upsurges and poor land productivity (Angula & Kaundjua, 2012).

Groundwater quality in many areas in Oshana and Ohangwena regions is poor and unfit for consumption by humans and in some cases even livestock, with very high levels of salinity. The expected climatic changes may aggravate this situation, with higher evaporation rates leading to increased salinity. Run-off from the Oshanas will produce seasonal water resources, which may increase or decrease depending on rainfall in southern Angola. The

temperature fluctuations previously mentioned affect livestock and crops negatively predominantly due to heat stress that increases their volatility. Not only does this affect the health of the agricultural assets but according to Laudika, R., Supervisor, H., & Pelser, A. it applies pressure on water resources that are already in short supply.

The agriculture sector in mentioned areas are detailed issues relating to observed variations in climate and weather and their impacts (The Changing Climate and Human Vulnerability in North-Central Namibia). Red locust swarms, which are common to sub-Saharan Africa and breed prolifically in conditions of drought followed by rain and rapid vegetation growth, began in December 2020. In April 2021, farmers were battling swarms of locusts that arrived in the Okaku and Ongwediva constituencies of the Oshana Region. Since they are more common in the Zambezi region, their presence may act as evidence that climate change is causing a shift in migration patterns of the locusts, and this could worsen over time. According to the Ministry of Agriculture, the swarms have destroyed 719,000 hectares of grazing land and 1,207 hectares of crop fields in 10 of the country's 14 regions.

4. SIGNIFICANCE OF STUDY

The economy of Namibia is very dependent on natural resources that are sensitive to any change in climatic conditions. The main sectors of the economy that are affected are, agriculture, fisheries, and mining, which accounted for 24% of the total Gross Domestic Product (GDP) in 2008 (Central Bureau of Statistic, National Planning Commission, 2009).

Apart from affecting the economy, climate change also affects the health of Namibians. The health system in Namibia has a limited capacity which is more focused on the central and coastal parts of Namibia. The limited medical resources in the rural parts of Namibia are stretched too thin and will be overwhelmed during outbreaks of diseases. Namibia is a very hot and dry country, a further increase in temperature due to climate will cause an increase of heat strokes, skin diseases and dehydration cases. A change in precipitation will have drastic effects, the occurrence and severity of droughts will increase leading to more people being susceptible to respiratory and gastro-intestinal infections as well as poor nutrition and sanitation. Cholera outbreaks are common in the Northern regions of Namibia during the rainy season. Furthermore, an increase in both participation and

temperature will cause more incidents of waterborne diseases such as cholera, bilharzia, and vector-borne diseases such as malaria.

The occurrence and severity of natural disasters in Namibia and around the world is increasing due to climate change. Wildfires are more frequent than ever, in 2021 thousands of hectares of bush, agricultural land and forests have been burned down. Forest and veld fires devastated around 2.5 million hectares (25,000 square kilometres) of grazing grounds in Namibia alone between January 2021 and September 2021, including fields on 604 farms and in several protected areas. (Huaxia, Namibia warns of more veld fires - Xinhua 2021). Apart from wildfires in Namibia, many parts of the world face the same problem. Wildfires have also left Rundu, a large town in Namibia, without power for 3 days when a transformer was damaged. This left many residents and businesses without power and water.

The frequency and severity of droughts are also increasing due to climate change. Since Namibia is a dry and arid country, it is prone to droughts. Droughts are becoming more common as a result of climate change. Due to water constraints caused by droughts, three states of emergency have been proclaimed since 2013. (The consequences of decades of drought in Namibia – HAAN Ready 2021). These incidents have been occurring every 3 years since 2013. During the 2013 drought it was estimated that more than 12.5% (300,000) of Namibians faced food insecurity. Many sectors of the Namibian economy were affected as well, the agriculture sector's production was drastically reduced, and many farmers lost livestock. The drought had an impact on both the manufacturing and construction industries in Namibia as well. Although Namibia is dry and arid it experiences floods due to heavy rainfall in short periods of time.

5. RESEARCH METHODOLOGY

5.1. Research Design and Stages

Research design is the process or plan to conduct research or study in a manner to minimise the issues and effect of climate change. This comprehensive study is to achieve the mentioned objectives to tackle the climate change in rural Namibia. The research work is designed in such a way that it is broadly divided into eight stages of which are as follows:

STAGE 1 - GEOGRAPHIC INFORMATION

This initial stage will focus on gathering necessary and detailed geographical information about the specific areas within the target regions that have been identified. The first region being Ohangewena, with the two key areas in the region being the Epembe and Omundaungilo Constituencies. The second and final region is Oshana with an importance on Oshakati, Oshitayi and Okatana. The categories of geographic data obtained include vegetation, soil conditions, landscape, water systems in the area, as well as the land size accompanied by satellite imagery.

STAGE 2 - CLIMATIC CONDITION IN THE AREA

Collection of information that paints a picture on the climatic conditions of the two regions will take place in this stage. Factors that influence climatic conditions such as weather patterns, temperature, rainfall, humidity are highlighted. This is vital for creating a baseline of what climatic conditions are supposed to be, how they are changing and how it alludes to the existence of climate change.

STAGE 3 - IMPACT OF CLIMATE CHANGE

The third stage requires the research done to be applied in order to point out the change in the previously established climate conditions altering and how that in turn affects the environment and especially the populace. Ripple effects of unstable climate conditions are pinpointed and identified in all aspects that may be possible, especially those that are easily observable which have the greatest consequences in that of human daily life.

STAGE 4 - MAJOR FACTOR AFFECTING THE DIFFERENT SECTORS

On a larger scale in terms of economic conditions and that of sectors that are present in the two regions, the fourth stage is meant to compile information on how the economy is being influenced. Due to the activities that take prominence in the northern part of Namibia, one sector that needs to be taken note of is the agricultural sector. A lot of lives depend on farming activities to either provide food or income to support families, additionally agriculture contributes a large percentage to the country's GDP.

STAGE 5 - UNDERSTANDING THE PROBLEM: CLIMATE CHANGE

With the help of surveys and collected information about the climate change effect on the individual and their routine life, the study will understand the actual problem. A key step to problem solving is the action of understanding whatever the problem is in the first place. Observing the problem from all the possible angles and identifying the complexities interlaced with the issues at hand places you in the best position to be able to create long lasting and innovative solutions.

STAGE 6 - TACKLING THE IDENTIFIED PROBLEM

After understanding and identification of the problem, this stage will provide the broad overview to tackle the problem. This stage has the purpose of brainstorming what steps can be taken to combat said problem. The study will analyse the techniques and measures to handle the problem in such a way that will leads to support sustainable development.

STAGE 7 - ACTION PLAN TO TACKLE MAJOR CONTRIBUTING FACTORS

It will involve creating a meticulous map on what the final actionable steps will be and will allow anyone that is presented with the action plan to be able to visualise the final end goal of tackling the major contributing factors of climate change.

STAGE 8 - CONCEPTUAL MODEL

The final stage will revolve around creating a solution with the aid of a conceptual model. This will act as an abstract compilation of the solutions that are deemed to be the best fit to solve the identified problem.

5.2. Research Methods

5.2.1. Surveys & Information Collection

In order to collect data and information, surveys (online and physical) and interviews will be conducted. With the help of surveying software like Google Forms, Survey Monkey and Microsoft Access the data will be composed instead of using a large amount of printed paper. The survey and information collection will be done in an environment friendly way and COVID Regulations with best practices will be observed.

5.2.2. Data Filtration and processing

After data collection, the filtration process will be done to get quality data for next step. In this procedure data will be tested to find the incomplete and faulty data. The data will be categorised based on various parameters such as targeted regions, constituency, age group and occupations. With the help of software and programming languages (e.g., Python, R) the data filtration will be done.

5.2.3. Data Analysis

Based on the filtered data, data analysis will be completed using different methods. Data analysis will be conducted in the following ways such as Descriptive analysis, exploratory analysis, Diagnostic analysis, and Sentimental analysis. These techniques will help to study and understand the actual problem with various parameters. Analysed data can then be interpreted to attempt to explain the patterns. Further data visualization will enhance the research work which will give the graphical representation of collected data and inferences.

After collecting sufficient data on the regions, the subsequent step involves converting all the raw figures and statistics into more meaningful data that is easily interpreted. Through the use of tables, images, articles, we can create a coherent explanation of identifying what problems are present, what factors have caused their existence and why they continue to persist.

Cultivating an atmosphere of knowledge and understanding of the changes and accompanying effects that occur in the environment, is a vital grassroots method that is key to combating climate change. Equipping the populace that is most at risk of the

negative effects of climate change with relevant information gives them a sense of responsibility and a drive to improve their living conditions by working together for a common purpose. The best ideas and innovations come from those that possess intimate experiences from the problems that require solutions and therefore providing awareness is important for developing these solutions. The awareness will include meetings, adverts, speeches, and public dialogue that involve international as well as region specific content involving climate change.

This objective focuses on outlining improvements as well implementing the best practices to help the Oshana and Ohangwena regions, specifically the areas of interest within these regions to cope with the previously established effects of climate change. Examples of this include how to conserve, and treat water to be used in daily life, more efficient farming practices and so forth. These practices will be developed in tandem with the population to ensure that this is a collaboration and not something that is dictated towards them, furthermore the efficiency of the implements will surely be higher.

Crafting a possible conceptual model that is native to the regions and is also problem specific is a very desirable outcome that we aim to achieve with our work. This conceptual model will act as the collection of refined solutions that we hope to put in place, although it will still be subject of an iterative process involving constant adjustments and improvements until the final deployment.

6. FINDINGS

Succeeding the physical survey carried out in the Oshana Region, the data collected was analysed with the use of myriad of platforms, like Jet brain's Data lore, Google Collab and Jupyter Notebooks, in order to extract useful conclusions. (More elaborate information can be retrieved from the Published Notebook: TACKLING CLIMATE CHANGE IN RURAL NAMIBIA (TCCRN))

Notable survey comments and informal interviews compilations:

Interview 1:

A young woman spoke about how the decreased amount of rain affected her and her family. There used to be a lot more rain. Some of their subsistence crops failed. Which forced them to buy mahangu instead, their staple food. The heavy rains in the past also caused damage, forcing people to abandon their businesses

Interview 2:

This man was concerned about pollution and how it was affecting the climate. Concerned about burning rubbish causing climate problems, burning rubbish at dumping sites is the main way of removing rubbish. Droughts have not been a big problem for him and his family. His family grows small amounts of mahangu. Which is used as surplus food, or is sold for an extra income. But, if there is a drought they lose that income and surplus of food and rely more on buying food from shops.

Interview 3:

There was one young female, who commented on her doubts of climate change in her area or whether it is a rather a natural repeating cycle of the climate because in her opinion records have not been existing for a long time and to her knowledge are not publicly available, therefore statistics can form a proper image of what is going on with our environment.

Interview 4:

After I had explained to the participant about water security and what it meant, they mentioned that in the rural areas, villagers have to walk far distances to collect water at water points which points to there being a lack of water infrastructures.

Interview 5:

A Woman I spoke to said that there are many problems within the regions and she is dissatisfied with the support the region is receiving from the Namibian Government. Her primary worry has always been the poor agricultural performance and output due to the lack of resources and investments in the sector but she mentioned how America is the cause of issues such as climate change - not elaborating on exactly what she means, as well as the Novel Coronavirus.

Interview 6:

This gentleman, older in age 55-65 years, explained that we have an internal issue that pertains to our culture as a society in the sense of poor management and enforcement schemes. The resources may be distributed to the locals but they are misuses, wasted and there are no proper repercussions to deter irresponsible behaviour.

Interview 7:

This young man elaborated on the impacts of climate change in the region. He specifically spoke about the floods that occurred in 2007, 2009, 2015, and 2017. He said we should investigate the detriment of the 2015 flood which wiped out homes, businesses and schools in the area.

Interview 8:

One conversation I had with a local barber due to the survey was the whole scheme of ideation, implementation and management. In regards to coming up with ideas to combat certain problems, the parliament needs to implement open-door policies to attract members of society to approach and deliver their ideas.

Currently, this gentleman believes the government and the people at large and calls for more of the aesthetics of progress and development than the genuine progress itself. This hampers the development of our country of which he believes is underpopulated and should be easily managed.

Management of the resources is terrible due to poor leadership. He said that he identified the poor leadership skills within the younger demographic due to poor training and a very flawed education system.

He also remarked that the current leaders are of poor quality. He alleges that good leaders need to know their struggle intimately. They need to have suffered to gain a sense of handwork and compassion.

The summary of the Analysis:

According to the participants of the survey

- The representation of the genders favoured the women by *4%*, having surveyed a total 168 locals of the Oshana Region, Namibia.
- The female section of the population attained an increased percentage of higher education
- In both genders the level of education drop proportional to the increase in age
- The individuals of the Oshana region are cognizant threats like poverty, a lack of clean water and the spread of infectious diseases
- The resulting effects of climate change are deemed to be the change in weather conditions and global warming which are a by-product of human activities
- An increase of natural disasters and average temperature has been observed
- A lack of climate change related activities and information has been observed by the locals
- Critical problems to be addressed are

    - Poor Environmental Education
    - Recycling
    - Deforestation
- The water availability issue is significantly exacerbated by climate change

In order to effectively combat climate change, the participants of the survey opted to

- Improve municipal services and local collaboration in efforts to coordinate information and services to improve water access and water resource maintenance
- Improving environmental education to facilitate the increase the comprehension of what the benefits and disadvantages of not taking care of the environment may cause, as well as methods on how to go about certain efforts and campaigns.

7. LIMITATION

While conducting the research it is realised that there were few limitations which can be resistance to the progress which are listed below:

1. Access to real time data for climatic conditions.
2. The climate exposure – comprising weather, climate variability and climate trends – poses difficulties. There is no obvious "unexposed" group to act as a baseline for comparison. Different exposure between individuals within the same geographical location.
3. Challenges in communicating the climate aspects and interconnectivity.
4. Some internal areas of the targeted region do not have internet connectivity which will limit the efforts in collecting the data.
5. Language barriers and long distances with small a team could be a challenge for performing the research up to the mark.

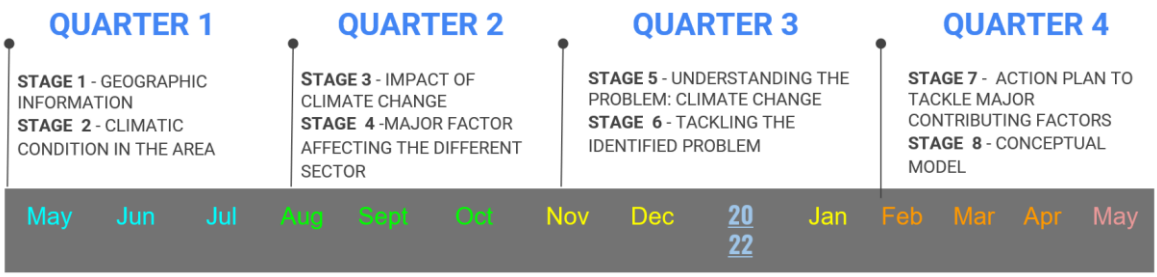
8. ASSUMPTION

With this research work it is assumed that the data provided by the people of the targeted region will be correct and according to their belief. Also, the assumption is taken in the

communication network, that the bandwidth is sufficient and stable so that the communication will be without disturbance. The research will be scenario based and assume that the fluctuation of climatic conditions based on previous research and literature reviews the given data is appropriate.

9. WORKPLAN

The overall research work has been divided into four quarters of three months each on the timeline of one year as shown below in the figure:



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