Sudan University of Science and Technology

College of Graduate Studies

Impact of Climate Change on Pastoral Communities and Rangeland Resources at Sennar Locality - Sudan

أثر تغير المناخ على المجتمعات الرعوية والموارد الرعوية في محلية سنار – السودان

A Dissertation Submitted for Partial Fulfillment of the Requirement for the MSc Degree in Range Science

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DEDICATION

To my family

(Father, mother, sisters and brothers)

To Dr. Mohammed Ibrahim

To Ms. Amna Ismaeil

To my friends and my colleagues

in

Range and Pasture General Directorate

To you,,

Samar Gaffar ELSiddig Mohammed

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Abstract

The study was carried out in Sennar locality. The study aimed to assess the impacts of climate change on pastoral community and rangeland resources in Sennar State. Three villages were selected from the state namely Al Auar, Fangoga AlJabal and Almuhamadyea (Aulad Mahala), form the unit of Refi West Sennar, Sennar locality. The sample size was about 5% of the total population of pastoralists in the three villages. A questionnaire was designed according to the objectives of the study in order to collect information from the studied community. The data were analyzed using the statistical analysis program SPSS version 20 in order to find out the mean and significant differences. The study found that in previous, the majority of respondents 76.7 % said there was appropriate income, while recently, there were just 54.9% confirmed that the income in appropriate situation. The amount of rain has increased recently, according to the opinions of the respondents, but the poor distribution of rainfall resulted in disturbing floods, which negatively affected the pastoral community. The majority of pastoral communities were semi sedentary represent 27.4%, the change of life patterns of pastoral communities as a result of changing in climate factors and their behaviors. The majority of respondents confirm that the animal mortality 95.7% increase in the beginning of autumn. Most respondents 50.8% were feed their animals by commercial fodder, 25.4% of them selling part of herds to minimize the number of animals, 12.3% of pastoralist in range site change their animal types into more adaptation of forage shortage. The study concluded that, the impact of climate change strongly affects the plant and animals in rangeland. There are other adaptive strategies used by pastoral community used to avoid fodder scarcity such as change of their source income from animals to agriculture. The study recommended to raise the awareness of pastoral communities, and care with the education, adoption of climate changes strategies and mitigates their impacts.

المستخلص

أجريت الدراسة في محلية سنار، ولاية سنار. هدفت الدراسة إلى تقييم أثر التغيرات المناخية على المجتمعات الرعوية بمحلية سنار. أختيرت ثلاث قرى من محلية سنار عشوائياً ومن ثم تم اختيار نسبة 5% من المجتمع الرعوي بها. تم تصميم إستبيان لجمع المعلومات من مجتمع الدراسة. تم تحليل البيانات بواسطة برنامج التحليل الإحصائي SPSS اصدارة 20 للحصول على المتوسطات والفروقات المعنوية. وجدت الدراسة أن معظم المبحوثين بنسبة 76.7% ذكروا بأن الدخل في السابق كان كافياَ، بينما 54.9% منهم أكدوا أن الدخل الحالي بصورة كافية. بناءاً على آراء المبحوثين أن الأمطار زادت في الوقت الحالي لكن عدم انتظام توزيع الأمطار أدى إلى حدوث فيضانات مدمرة مما أثر سلباً على المجتمع الرعوي. غالبية المبحوثين شبه مستقرين بتمثيل 27.4% ، التغير الذي حدث لهم نتيجة تغير عوامل المناخ وسلوكياتهم. غالبية المبحوثين أكدوا بأن الفقد في القطيع زاد في بداية موسم الخريف بنسبة 95.7%. أغلب المبحوثين بنسبة 50.8% يقوموا بتغذية حيواناتهم عن طريق شراء الأعلاف التجارية و25.4% منهم يقوموا ببيع جزء من حيواناتهم و12.3% من الرعاه يقوموا بتغيير حيواناتهم لحيوانات أكثر تأقلماً مع نقص الأعلاف. خلصت الدراسة إلى أن للتغيرات المناخية تأثير قوي على نباتات وحيوانات المراعي. هنالك بعض استراتيجيات التكيف استخدمتها المجتمعات الرعوية لتفادي نقص الأعلاف مثل تغيير مصدر الدخل من تربية الحيوانات إلى الزراعة. أوصت الدراسة برفع الوعي للمجتمعات الرعوية والإهتمام بالتعليم وتبني استراتيجيات التكيف وتخفيف أثر التغيرات المناخية.

CHAPTER I

Introduction

1.1 General:

Rangelands encompass over 40% of the earth's land area, (McCollum, *et al*, 2017). They are chiefly one of the main feed resources for grazing animals (Abdelrahim and Abdalla, 2015). Rangelands are estimated to store up to 30 percent of the world's soil carbon in addition to the substantial amount of above-ground carbon stored in trees, bushes, shrubs and grasses (White, *et al*., 2000; cited by Fereja, 2017). The rangelands of Sudan contribute to the income and subsistence of a large sector of the population and in addition provide more than 80% of the total feed requirements of the national herd. Rangelands also host wildlife and play a vital role in soil and watershed protection, biological diversity, ecological balance and environmental conservation (Gaiballa, 2014).

Climate change is altering the global hydrologic cycle and is expected to have substantial and diverse effects on precipitation patterns in different regions. Predictions include increased intensity of precipitation events worldwide, increased wet days at high latitudes, and increased drought across many mid-latitude continental interiors. However, there is still considerable uncertainty regarding rates of changes in temperature and the direction of precipitation responses in many regions (Christensen *et al*, 2007).

Pastoralists and agro-pastoralists are one of the most climate-change-vulnerable groups on the globe, Under increased climate variability, the need for diversification of income, a strategy often (and increasingly) employed in pastoral areas, becomes ever more important (Herrero *et al*, 2016). Rangelands deserve special attention in discussions about land acquisitions. They are inherently vulnerable, with their ecology driven by unpredictable and uncontrollable factors such as rainfall (Ykhanbai, *et al*, 2014).

Sennar State is the one of many states in the Sudan suffer of climate change and other factors affected negatively the rangeland resources. This situation will lead to a lower

crop yields and quality as well as the deterioration of rangeland and vegetation cover (HCENR, 2016). This study well tries to assess the effect of climate change on the resources of the rangeland and the pastoralist community.

1.2 Problem Statement:

Rangeland in Sudan was subjected to many constrains that facing the sustainability of these resources, one of the most important issue affected negatively on rangeland resources is the climate change. The climate change and be cases or if hat direct and indirect effect on vegetation cover soil livestock and pastoralism. The rangelands of Sennar State, like most of the rangelands f Sudan, which are located in the arid and semi-arid ecosystems, are more susceptible to climatic changes. The deterioration of the rangelands is negatively affected by the pastoral communities in the state.

1.3 Objectives:

1.3.1 General Objective:

To assess the impacts of climate change on pastoral communities and rangeland resources in Sennar State.

1.3.2 Specific Objectives:

1. To investigate the impact, of climate change on pastoralist in Sennar Locality.
2. To identify the plant species that appeared in Sennar Locality.
3. To evaluate the awareness of pastoral communities to adapt the climate change in Sennar Locality.

1.4 Research Questions:

- How climate change affected the pastoralist community?
- What plant species appeared and disappeared as a result of climate change?
- As the pastoral community is aware of climate change?

1.5 Study Area:

1.5.1 Location:

Sennar state Located in the central Sudan between latitudes 12.5˚ to 14.7˚ N and longitudes 32.58 ˚ to 35.42˚ E in middle of the mud belt, bordered by Gezira state to

the north, White Nile State to the west, Gedaref state to the east, Blue Nile and Upper Nile state to the South, with an area of 40.680 square kilometers (HCENR, 2016).

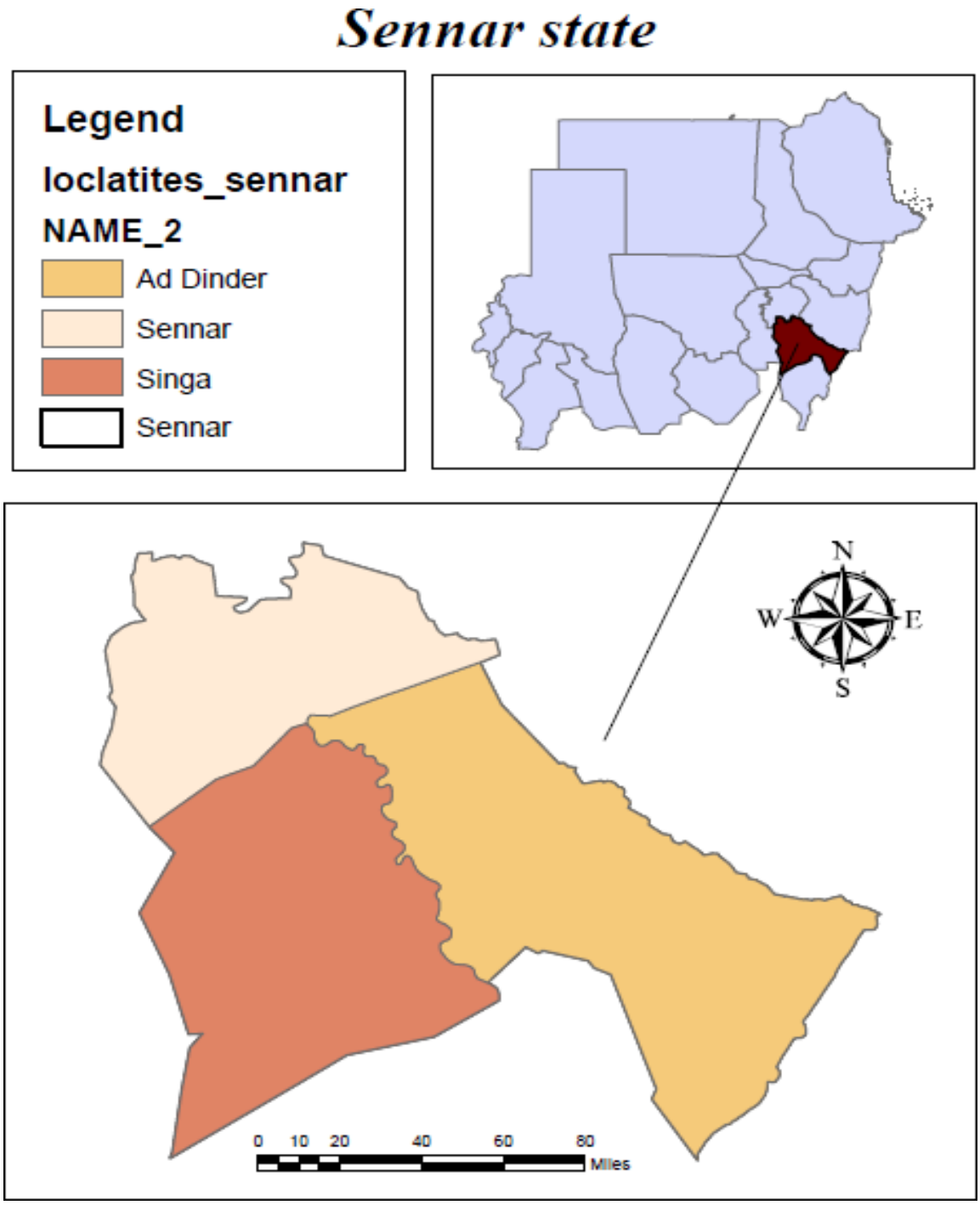

Figure 1.1 Map of the Sennar State, Modified by Researcher.

1.5.2 Climate:

Sennar found in low rainfall savannah in the southeastern part of Sudan. The state has a diverse ecosystem that includes the Dinder National Park as well as rivers, khors and a semi alluvial plain. The average annual temperature ranges between 20 to 37C° and the average annual rainfall 427 mm/year. The state is vulnerable to rainfall variability, rising temperatures, increasing wind speed and an intensifying cycle of floods and drought (HCENR, 2016).

1.5.3 Population:

Sennar State population us about (1,918,692) according to 2018 estimation (Wikipedia, 2022). People in Sennar state is a mix of Arab and African tribes and some tribes of western Sudan. The people of Sennar state depend mainly on agriculture and pastorals and trade in crops in their livelihood.

1.5.4 Agriculture:

The main economic activity is agriculture with the irrigated scheme of Suki, the Sugar factory of Sennar. The main types of agricultural products in Sennar State are, Grains, Cash crops, Vegetables and Fruits and the market capacity of these products is fairly good locally and outside the state.

1.5.5 Land-use Patterns:

The main land uses include: farming land, traditional and mechanized agriculture and irrigated agriculture rainfall, irrigated farming land, urban, forest, horticulture and grazing. However, the land under private ownership, various forms of communal ownership vested in a "tribe" or one of its sections were recognized by nomadic pastoralists. Among rain land sedentary cultivators, land use was legitimized through membership in a village community.

1.5.6 Sennar Dam:

The Sennar Dam is a dam on the Blue Nile near the town of Sennar Sudan It was built in 1925 by the British engineer, desert explorer and adventurer, Stephen "Roy" Sherlock, under the direction of Weetman Pearson. The dam is 3025 meters (9925 feet) long, with a maximum height of 40 meters (130 feet). It provides water for crop irrigation in the Al Jazira region. Once completed, the dam was managed by Roy Sherlock until the 1970's.

1.5.7 Animal Resources:

The animal husbandry/livestock is practicing by most of resident in the state due to availability of wide land and the nature of people as most of them living in the rural areas and people prefer owning sheep and cattle, (NSDDRC-SC/ UNDP, 2010). The total number of animals in Sennar state 4992767, (Statistical Bulletin, 2021).

CHAPTER II

Literature Review

2.1 General:

Rangeland is an important component of terrestrial ecosystems and lays the foundation for animal husbandry and sustainable livestock development. Besides supplying forage for livestock, rangelands provide critical ecosystem goods and services for human beings. However, rangelands are prone to degradation (Duan, *et al*, 2017). The deterioration of rangelands is severely affecting the livestock farming community. The production potential of livestock is being affected due to overuse of these rangelands. The worst affected owing to deterioration of these land are the landless farmers who are solely dependent on livestock. They sell animals and their products to meet their daily needs. Consequently, poverty of the landless farmers is increasing. The destruction of rangelands and poverty is resulting in urban migration. The poor peasants in search of livelihood, abandoning their hearth and home, are moving towards cities. For any future planning there is a need to initiate studies to gather data of the rangelands keeping in view their geographical and seasonal situation, to identify the main issues coupled with their production potential (Dawn, 2011). Rangelands are no exception as they are under stress from conversion into cropland and pressure from livestock and excessive fire. Other important drivers of change include climate change, habitat fragmentation, and the development of infrastructure (Alkemade, *et al*, 2013). The rangelands in Sudan vary from poor to rich according to ecological zones and climate factors (Abdelsalam, *et al*, 2016).

2.2 Rangeland Resources:

Rangelands are areas of naturalized vegetation that support herbivores, and are managed for multiple uses and or values. Rangeland is a type of land not suitable for cultivation of intense agricultural production, having inherent restrictions such as soil moisture, soil nutrients, soil temperature, soil texture, topography, etc., that limit productive capabilities. Rangeland management strives to maintain biodiversity and

ecological integrity of the landscape while ensuring support for environmental goods and services, including, but not limited to livestock grazing, watershed protection, carbon capture, wildlife habitat and recreation (AIA, 2018). According to the Society for Range Management, rangelands are a type of land on which the natural vegetation is dominated by grasses, forbs and shrubs and the land is managed as a natural ecosystem (Rinehart, 2008).

Rangelands cover great parts of the world and are home of many people worldwide. They provide a wide variety of ecosystem goods and services requested by humans. This includes livestock forage, wildlife habitat, water, mineral resources, wood products, wildland recreation, open space and natural beauty (Sandhage-Hofmann, 2016).

Recently rangeland resources has deteriorated significantly due to exploitation and timber cutting and conventional farming in the rangeland which led to the loss of the ability to sustain production, and reflected the deterioration in the vegetation cover (Abdelsalam, *et al*, 2017a).

2.3 The Importance of Rangeland:

Large number of livestock in Sudan depends on natural range land in their feeding (Abdelsalam, *et al*, 2017b). Rangelands produce a wide variety of goods and services desired by society including livestock forage, wildlife habitat, water, mineral resources, wood products, and wildland recreation. They also provide natural beauty, open spaces, and the opportunity to study the natural ecosystem. The diverse ecosystem provides a wide range of tangible commodities and values for society. Rangeland watersheds are important regulators of the quantity and quality of water in streams, lakes, and aquifers. Many species of fish and wildlife depend on rangelands and their associated streams and lakes for habitats.

Rangeland is provides forage for livestock, but just as importantly it provides wildlife habitat, recreational opportunities, and off-site water for millions of people around the world. Rangeland is the resource for the future when it will become more important for food, fiber, recreation, and water (Schuster, 1984).

2.4 Factors Affected Rangelands:

Rangelands are characterized by low and/or erratic precipitation, poor drainage, rough topography, and often have low soil fertility. Rangelands have an important role in ecological stabilization and the terrestrial carbon cycle in arid and semi-arid regions of the world (Getabalew and Alemneh 2019). There are many factors affected negatively on rangeland productivity such as:

2.4.1 Edaphic factors:

The distribution, pattern, and abundance of plant species in arid and semi-arid areas have most often been related to three groups of factors including physical environmental, soil chemistry, and human factors (Eghdami, *et al*, 2019). The edaphic factor includes the physical, chemical, and biological properties of soil that result from biologic and geologic phenomena or anthropogenic activities (Getabalew and Alemneh 2019). The properties of soils exert almost unlimited influence upon the nutrient content of plants. According to Oten *et al* (2020), the environmental variables had an effect on botanical species composition.

2.4.2 Livestock:

Livestock grazing is the widespread agricultural use of natural and semi natural landscapes throughout the world (Barry and Huntsinger, 2021). Livestock grazing affects over 60% of the world's agricultural lands and can influence rangeland ecosystem services. Livestock production systems can influence carbon sequestration on rangelands by affecting plant photosynthesis through tissue removal by grazing and incorporating plant material into the soil with their hooves (Holechek, *et al*, 2020). Concomitantly, livestock grazing has the potential to be detrimental to some wildlife species while benefiting other rangeland organisms (Dettenmaier, *et al*, 2017). Biodiversity in rangelands is decreasing, due to intense utilization for livestock production and conversion of rangeland into cropland. The effects of grazing on rangeland biodiversity include the removal of biomass, trampling and destruction of root systems, and replacement of wild grazers by livestock (Alkemade, *et al*, 2013). Abdou, (2019) found that the main impacts of livestock on vegetation, soil and surface water.

2.4.3 Wildlife:

Direct competition for forage resources between wild herbivores and livestock can lead to changes in foraging behaviors and diet selection, which alter performance and population dynamics (Odadi, *et al*, 2007).

2.4.4 Impacts of Grazing:

Grazing management plays a large role in the quality and extent of wildlife habitat. Livestock grazing is the most widespread land management practice in the world (Krausman, *et al*, 2009). Grazing in semi-arid area is characterized by strong feedback mechanism s between economic and ecological factors. Economic yield is directly linked to livestock number and hence to range condition while ecological resources are easily damaged by inappropriate use (Taha and Khidr, 2011). Historically, overgrazing of rangelands has led to the degradation of water resources, soil structure, and plant communities. Reducing landscape fragmentation on rangelands supports climate change. Integrating livestock into established cropland operations can increase access to additional livestock forage, reduce feed costs, eliminate manure concentration areas, and improve a farm's overall efficiency. Natural plant diversity across rangelands minimizes the risk of catastrophic events (wildfire, disease, and pests) and improves consistency of livestock production (Petersen, *et al*, 2019).

2.4.5 Climate Change:

Climate change contributes to: reduced water resources; changes in the primary productivity of crops, forage and rangeland; changes in the composition of plant varieties and quality of plant material; and reduced biodiversity (IFAD, 2010). Climate change has contributed to a rise in extreme weather events - including floods and higher-intensity hurricanes (Matawal and Maton, 2013).

2.5 Rangelands and Climate Change:

Rangelands are complex, intricate, interconnected, and dynamic socio-ecological systems comprised of humans, livestock, and natural wildlife. The climatic volatility currently in progress involving global warming and increased extreme weather events will undoubtedly have major impacts on world rangelands and rangeland users over the next decade and beyond. Accelerated climate change is a global challenge that is increasingly putting pressure on the sustainability of livestock production systems that heavily depend on rangeland ecosystems (Holechek, *et al*, 2020). Climate change impacts rangeland ecosystems in complex ways (Izaurralde *et al*, 2011cited by Petersen, *et al*, 2019). Climate change affects soil health directly and indirectly by increasing nutrient loss, reducing water retention, and limiting filtration during extreme heat, drought, and heavy precipitation events (Petersen, *et al*, 2019). Climatic changes such as increased atmospheric concentration of CO2, changes in temperature, and changes in precipitation patterns have the potential to affect rangeland ecosystems. The stresses imposed on rangeland by livestock production continue to rise, driven by rapid economic development and growing demand by urban people for more meat in diets. Climate change and variability will have serious implications, impacting on ecosystems goods and services upon which poor people and livestock keepers depend, thus exacerbating current development challenges (Fereja, 2017). Livestock can also be affected by climate. Specifically, livestock can be affected in two ways by climate change: the quality and amount of forage from grasslands may be affected and there may be direct effects on livestock due to higher temperatures. The warmer summer temperatures are estimated to have a suppressing effect on livestock appetite, which leads to lower weight gain,

2. 6 Climate Change and Warming:

Global warming and climate change refer to the increase in average global temperatures due to the increase in greenhouse effect by the increase in the greenhouse gases (Sivaramanan, 2015). Greenhouse gases can effect on climate parameters such as precipitation and temperature which are the most important factors. The Greenhouse gases can cause reduces rainfall by increasing dry spells and increasing temperature significantly. With further efforts to reduce carbon dioxide, it

is possible to prevent the warming of the earth, but the effects of climate change that we have already created cannot be reduced (Javadinejad, *et al*, 2020).

However, if the greenhouse effect becomes stronger, and it is, more heat is trapped than needed, and the Earth is becoming less habitable for humans, plants and animals. It can thus be inferred that the ability of greenhouse gases to absorb sunlight is the root cause of global warming. Global temperatures are believed to be on an ever increasing high, with its attendant consequences and it is feared that the trend will continued if not controlled (Matawal and Maton, 2013).

The strongest evidence for surface warming comes from widespread thermometer records that, in some places, extend back to the late 19th century. The estimation of average surface temperature of earth, show that 1989 to 2019 was very likely the warmest 30-year period in more than 800 years; the most recent decade, 2010-2019, is the warmest decade (The Royal Society, 2020).

The warming in Africa is projected to be above the global annual mean warming throughout the continent and in all seasons. The dry subtropical regions will warm more than the moister tropics (Mertz, *et al*, 2009).

2.7 Climate Change Strategies:

Several mitigation methods such as use of alternative green energy sources, reducing the use of fossil fuels, use of greenhouse gas reduction techniques during the emission, carbon capture & carbon sequestration, afforestation, reforestation, protection of existing forest reserves, silviculture and agroforestry are being facilitated by several international, government and non-governmental organism. Climate change issue can be handled either adapting to the change or disaster risk reduction (Sivaramanan, 2015).

2.7.1 Adaptation:

Adaptation to climate change is given increasing international attention as the confidence in climate change projections is getting higher, (Mertz, *et al*, 2009). Adaptive Management and social responses, such as restoration of degraded rangelands, opening additional rangeland for grazing, or restricting livestock grazing can mitigate adverse effects (McCollum, *et al*, 2017).

Climate change and climate alteration are reflected in the implications of the need for adaptation and reform in both natural and human systems. Such adaptations say adaptability that balances damages or exploits useful opportunities. Independent adaptation, through ecological changes in natural systems, through changes in the market or wellbeing services in human organizations, instead of a sensible reaction to climate alteration. One of the most important factors for adaptation of climate change is analyzing capacity of economic value and policies in a specific region (Javadinejad, *et al*, 2020).

Over the centuries, human societies have developed the capacity to adapt to environmental change and climate variability. These adaptations include practicing shifting cultivation, adopting new crop varieties and modifying grazing patterns (IFAD, 2010).

2.7.2 Mitigation:

Mitigating climate change is about reducing the release of greenhouse gas emissions that are warming our planet. Mitigation strategies include retrofitting buildings to make them more energy efficient; adopting renewable energy sources like solar, wind and small hydro; helping cities develop more sustainable transport such as bus rapid transit, electric vehicles, and biofuels; and promoting more sustainable uses of land and forests (GEF, 2021). Conventional mitigation technologies focus on reducing fossil-based CO2 emissions. There are three main climate change mitigation approaches. First, conventional mitigation efforts employ decarburization technologies and techniques that reduce CO2 emissions, such as renewable energy, fuel switching, efficiency gains, nuclear power, and carbon capture storage and utilization. A second route constitutes a new set of technologies and methods that have been recently proposed (Fawzy, *et al*, 2020).

2.8 Drought and Rangelands:

Drought is common in arid and semiarid ecosystems. Multiyear droughts can have very negative effects on crop and animal production systems (Coppock, 2011). Drought, as defined as “a prolonged period of abnormally low rainfall that adversely affects vegetation growth and negatively impacts land managers, ranching enterprises, and pastoral systems. Planning for drought can include maintaining flexibility in

rangeland management and use as well as diversifying livestock operations and types of land use (Petersen, *et al*, 2019). Forage production in rangelands is strongly dependent on the magnitude and timing of precipitation. The effects of drought on rangeland production can also be mediated by other factors which affect the spatial distribution of rain, such as latitude and topography. Drought also threatens the ecology of rangeland vegetation. Low rainfall in rangelands can push livestock to concentrate their grazing around a smaller number of water sources (USDA, 2012). There is some management strategies can reduced the drought effects on rangelands such as:

2.8.1 Conservation:

Historically, overgrazing of rangelands has led to the degradation of water resources, soil structure, and plant communities. Reducing landscape fragmentation on rangelands supports climate change. Integrating livestock into established cropland operations can increase access to additional livestock forage, reduce feed costs, eliminate manure concentration areas, and improve a farm's overall efficiency. Natural plant diversity across rangelands minimizes the risk of catastrophic events (wildfire, disease, and pests) and improves consistency of livestock production (Petersen, *et al*, 2019).

2.8.2 Restoration:

According to the Society for Ecological Restoration International, ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Restoration of rangeland ecosystems may be particularly important in building resilience in degraded landscapes (Petersen, *et al*, 2019).

2.9 Climate Change and Pastoralists:

Pastoralism is a livestock production system that is based on extensive land use and often some form of herd mobility, which has been practiced in many regions of the world for centuries. Pastoralism is globally important for the human populations it supports, the food and ecological services it provides, the economic contributions it makes to some of the world's poorest regions, and the long-standing civilizations it

helps to maintain. Climate change and climate variability are driving fragile pastoral ecosystems into more vulnerable conditions. Socioeconomic factors, such as changes in land tenure, agriculture, sedentarization, and institutions are fracturing large-scale pastoral ecosystems into spatially isolated systems. Climate patterns are changing in pastoral areas and variability is increasing; agriculture is displacing rangelands; settlement is reducing the seasonal migration of grazing herds; and pastoral economies are undergoing tremendous changes (Dong, *et al*, 2011).

Climate induced changes on rangelands and livestock production would have effects on economies and societies at farm, national, and international levels. These impacts are likely to be seen as changes in income and prices, and hence changes in livelihood, employment, and investment (Fereja, 2017).

2.10 Climate Factors Affected by Climate Change:

An understanding of the severe impact of climate change on natural and human systems as well as the risks and associated vulnerabilities is an important starting point in comprehending the current state of climate emergency. Changes in climate indicators, namely temperature, precipitation, seal-level rise, ocean acidification and extreme weather conditions have been highlighted (Fawzy, *et al*, 2020**).**

2.10. 1 Temperature:

The surface temperature extremes have likely been affected by anthropogenic forcing. This assessment was based on multiple lines of evidence of temperature extremes at the global scale including the reported increase in the number of warm extremes and decrease in the number of cold extremes at that scale. Temperature extremes on land are projected to warm faster than global annual mean temperature in many regions and seasons, implying large changes in extremes in some places, even for a global warming of 2 or 3°C with scaling factors for the SRES A2 scenario ranging between 0.5 and 2 for moderate seasonal extremes (Seneviratne, *et al*, 2012).

2.10.2 Rainfall:

Reductions in mean or total precipitation lead to drought. The climates are so diverse across different parts of the world; it is difficult to provide a single definition of extreme or heavy precipitation. The observed changes in heavy precipitation appear to

be consistent with the expected response to anthropogenic forcing (increase due to enhanced moisture content in the atmosphere, but a direct cause-and-effect relationship between changes in external forcing and extreme precipitation had not been established at the time. The climate change affected in increases in the number of heavy precipitation events in more regions than there have been statistically significant decreases, but there are strong regional and subregional variations in the trends (Seneviratne, *et al*, 2012). The rainfall variability represents a major challenge to sustainable grazing management in rangelands, especially in variable, vulnerable semiarid and arid regions (Duan, *et al*, 2017).

2.10.3 Wind:

Extreme wind speeds pose a threat to human safety, maritime and aviation activities, and the integrity of infrastructure. As well as extreme wind speeds, other attributes of wind can cause extreme impacts. Trends in average wind speed can influence potential evaporation and in turn water availability and drought. Changes in wind extremes may arise from changes in the intensity or location of their associated phenomena or from other changes in the climate system such as the movement of large-scale circulation patterns. Wind extremes may be defined by a range of quantities such as high percentiles, maxima over a particular time scale (e.g., daily to yearly), or storm-related highest values (Seneviratne, *et al*, 2012).

CHAPTER III

Materials and Methods

3.1 General:

Sennar State was chosen as the country of the Sudan states affected by the phenomenon of climate change, and there are many pastoral communities that practice the profession of grazing, which are considered highly vulnerable to climate change. This study well tries to highlight the effects of climate change on the resources of rangelands in the state and negative impacts of it in the pastoral community.

3.2 Data Collection:

3.2.1 Primary Data:

3.2.1.1 Research Population:

The study focus on the pastoral communities which practice animal grazing in natural rangeland, to know their views on the impact of climate change on them, on the herds they raise, and on pastoral resources.

3.2.1.2 Sample Unit Size:

Three villages were selected from the state namely Al Auar, Fangoga AlJabal and Almuhamadyea (Aulad Mahala), form the unit of refi West Sennar, Sennar locality, to represent the pastoral community under study, and 5% of the population was selected from these villages to represent the studied sample. The total population of the three villages was 1090 people (390, 700, and 300 person of Al Auar, Fangoga AlJabal and Almuhamadyea, respectively. The number of samples was 73 which represent more than 5% of the total population.

3.2.1.3 Questionnaire Design:

A questionnaire was designed according to the objectives of the study in order to collect information from the studied community. This questionnaire was judged by

three expert reviewers, their opinions were taken, and the questionnaire was modified and printed in its final form.

The main topics covered in the questionnaire:

Initial information, Socio economics aspects, Marital status, Job, Kind of animals, Rangeland resources, Vegetation cover, Grazing patterns, Current situation, Information related to the phenomenon of climate change, Impact of climate change on rangeland resources, Impact of climate change on the pastoral community, Impact of climate change on livestock and The most important methods of adaptation practiced by pastoral communities when forage is scarce.

3.2 .2 Secondary Data:

Secondary data were collected by reviewing the conducted research, books and references related to the subject of the study, scientific papers and articles, in addition to the Internet sites.

3.3 Data Analysis:

The information collected by the questionnaire is coded and prepared for the purpose of analysis. The data were analyzed using the statistical analysis program SPSS version 20 in order to find out the mean and significant differences, and then put them in tables and graphic forms in preparation for discussion.

CHAPTER IV

Results and Discussion

4.1 Social Data of Pastoralists in Sennar Locality:

4.1.1 Gender:

According to results represented in table 4.1, there was high significant difference between the family structures of Sennar locality (Sig 0.000). The majority of respondents were male of about 71.2% of the community, while the female represents just 28.8 %. This result explains the dominant of male in pastoral community which practice the herding.

Table 4.1 Gender of the respondents in Sennar locality:

Six	Frequency	Percentage
Male	52	71.2
Female	21	28.8
Total	73	100
Sig	0.000 ***	

4.1.2 Age Group in Sennar Locality:

The result obtained from table 4.2 illustrated that the majority of the respondents ages concentrated between 30-50 years, group 30-40 represent 36.1% and group 40-50 reach about 29.2% of the total community of Sennar locality (Sig 0.000). This result explains that about 65.3% of the community in young age, which may contributed significantly in any action face the climate changes in the future.

Table 4.2 Age of respondents in Sennar locality:

Age	Frequency	Percentage
Less than 30	2	2.8
30-40	26	36.1
40-50	21	29.2
50-60	5	6.9
More than 60	18	25.0
Total	72	100.0
Sig	0.000***	

4.1.3 Education in Sennar Locality:

From results shown in table 4.3 there was highly significant difference between education levels of pastoral community (Sig 0.000). The majority of the pastoral community was illiterates of about 27.8% follow by basic level 22.2%, primary (Khalwa) 19.4%, secondary 18.1% graduate 11.1% and post graduate 1.4%. The result illustrates that there was high percentage of pastoral community were illiterates.

Table 4.3 Education levels in Sennar locality:

Education level	Frequency	Percentage
Illiterate	20	27.8
Primary (Khalwa)	14	19.4
Basic	16	22.2
Secondary	13	18.1
Graduate	8	11.1
Post graduate	1	1.4
Total	72	100.0
Sig	0.000***	

4.1.4 Occupation of Pastoralists in Sennar Locality:

According to result shown in table 4.4 there was highly significant difference between pastoralist works (Sig 0.000). The majority of them were pastoralist and agrosilvopastoralist, 24.7 and 19.2% respectively. This results confirms that the main occupation of the community were pastoralists.

Table 4.4 Occupation in Sennar locality:

Occupation	Frequency	Percentage
Pastoral	18	24.7
Farmer	10	13.7
Business	10	13.7
Employee	11	15.1
Others	10	13.7
Agrosopastoral	14	19.2
Total	73	100.0
Sig	0.000***	

4.2 Kind of Animals Rising in Sennar Locality:

The results shown in fig 4.1 pastoral community of Sennar locality raise in the past 36% goats follow by cattle 28%, sheep 27.2% and 8.8% camels. While the composition of herds recently change into sheep 37.2% as a big proportion followed by goats, cattle and camel with percentages 35.4%, 23 % and 4.4% respectively. The change of the herds' composition from the past and today, it may be due to the change in pastoral behavior or resulting to the climate changes. Changing the herd composition to small ruminants (sheep and goat) is one of mitigation practices against climate changes. According to Rojas-Downing *et al* (2017), concluded that the climate change well affect negatively livestock production, especially in arid and semiarid area.

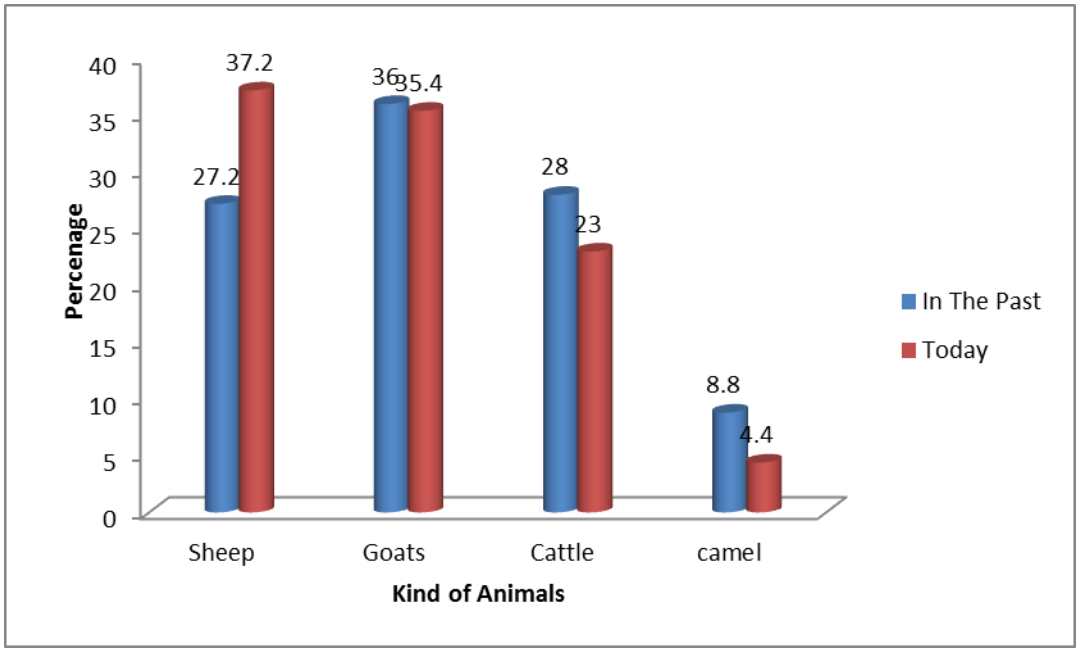

Figure 4.1 Animal Species in Sennar locality

4.3 Level of Income in Sennar Locality:

The results represent in table 4.5 illustrates that there was highly significant differences between the pastoral communities in the past current situation of their income, (Sig 0.000). Previously, the majority of respondents 76.7 % said there was appropriate income, while recently, there were just 54.9% confirmed that the income in appropriate situation. The declaration of the pastoral income it may attribute to the rangeland degradation which affects negatively on their animals. The impact of climate change strongly affects the plants and animals in rangeland.

Table 4.5 Income in Sennar locality:

Income	Previous		Current	
	Frequency	Percentage	Frequency	Percentage
Appropriate	56	76.7	39	54.9
Inappropriate	17	23.3	32	45.1
Total	73	100	71	100.0
Sig	0.000 ***			

4.4 Rainfall in Sennar Locality:

According to result shown in fig 4.2 there were a variation in the amount of rainfall in Sennar locality between the previous and recent situation of precipitation. The majority of respondents said the rainfall stable 59.8% followed by decrease 27.4% and increase 12.8%. While, in the current situation there were about 85.7% pastorals confirmed increased. It is obvious that the amount of rain has increased recently, according to the opinions of the respondents, but the poor distribution of rainfall resulted in disturbing floods, which negatively affected the pastoral community. This result confirmed by metrological data that found the amount of rainfall was increased in last five years (see appendix 2).

With comparison to the years of heavy rains in Sennar Rangelands, the respondents confirmed in table 4.6 the rainy season of 2020 was more heavy than season 2019, with percentages 81.9 and 18.1% respectively. The change in the amount of rainfall yearly may lead to fluctuation precipitation, which affected negatively on rangeland vegetation cover.

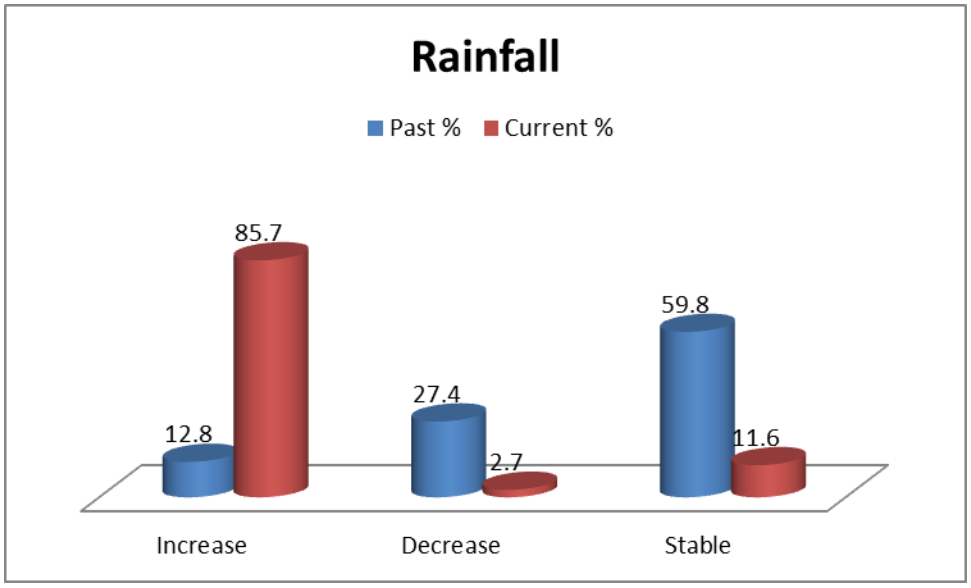

Figure 4.2 Rainfall in Sennar locality

Table 4.6 The rainy years in Sennar locality:

The most rainy year	Frequency	Percentage
2020	59	81.9
2019	13	18.1
Total	72	100
Sig	0.000***	

4.5 Temperature in Sennar Locality:

The most pastoralists in table 4.11 confirm that the temperature was increased in recent time 58.6% which compare at the past 50.8%. Increasing the temperature indicates for the climate change. The increase in temperature has negative effects on the vegetation cover and grazing animal, as well as its impact on the pastoral community. This result was disagreed of metrological data that found the temperature was decreased in the last five years (see appendix 3),

Table 4.7 Temperature in Sennar locality:

Temperature	Previously		Currently	
	Frequency	Percentage	Frequency	Percentage
High	33	50.8	41	58.6
Low	32	49.2	29	41.4
Total	63	100	70	100

4.6 The Season of Wind in Sennar Locality:

The result obtained from table 4.12, illustrates that there was highly significant difference among respondents opinions according to the seasons of wind in the range site, (Sig 0.000). Most of the respondents 66.7% said the winy season was winter, followed by 25% said in autumn and 8.3% in summer.

Table 4.8 The most windy seasons in Sennar locality:

The most windy seasons	Frequency	Percentage
The autumn	18	25.0
The summer	6	8.3
Winter	48	66.7
Total	72	100
Sig	0.000***	

4.7 Causes of Wind Increase in Sennar Locality:

According to the result represent in table 4.13, there was highly significant difference between the causes of the wind in range site. The majority of respondents mentioned that there are major reason cause increase wind range site trees cutting of about 58.8%, while the second reason was weed removal from rangeland 37%.

Table 4.9 Causes of increased wind in Sennar locality:

Causes of increased wind	Frequency	Percentage
Cut down trees	70	58.8
Weed removal	44	37.0
Other	5	4.2
Total	119	100
Sig	0.000***	

4.8 The Grazing Patterns of Pastoralists in Sennar Locality:

The results obtained in table 4.6, the majority of pastoral community were semi sedentary represent 60.3%, the second pattern sedentary 27.4% while nomadic just 12.3%. This result explains the change of life patterns of pastoral community as a result of changing in climate factors and their behaviors. The change in the grazing pattern may be due to the ineffectiveness of migrating in search of pasture due to the deterioration of the natural rangeland due to climatic changes. Therefore, most of the nomadic pastoralists have turned to semi-sedentary and sedentary, practicing agriculture in addition grazing. Hartmann *et al,* (2010), reported that the climate change had several impacts on pastoralism's, which affected land degradation has caused food insecurity among the pastoral communities. Livelihoods have suffered very much from consecutive droughts and most people do not see any future in pastoralism.

Table 4.10 Grazing patterns in Sennar locality:

Grazing style	Frequency	Percentage
Nomadic	9	12.3
Sedentary	20	27.4
Semi-sedentary	44	60.3
Total	73	100
Sig	0.000***	

4.9 Plant Composition of Sinnar Locality:

Based on the result presented in Table 4.7 the more plants dominant in Sennar locality grazing area were unpalatable plants such as *Senna obtucifolia* and *Sonchus cornutu* with percentages 22.2% and 18.7% respectively. While palatable plant species were just records 10.5% for *Ipomoea cordufana*, *Indigofera spp* 8.8% and 7% for *Aristida spp*. The dominance of unpalatable plants specie considers is one of the negative

impacts of climate change on rangeland. Also the over grazing of grazing animals lead to change in vegetation composition. Abdelsalam *et al* (2017) concluded that the continuous grazing has a negative impact; it led to change the botanical composition of range plants of undesirable species.

Table 4.11 Dominant Plants in Sinnar locality:

Plant	Habit	Frequency	Percentage
Senna obtucifolia	Herb	38	22.2
Sonchus cornutu	Herb	32	18.7
Ipomoea cordofana	Herb	18	10.5
Indigofera spp	Herb	15	8.8
Aristida spp	Grass	12	7.0
Crotalaria thebaica	Herb	8	4.7
Sparobolus marginatus	Grass	8	4.7
Ocimum basilicum	Herb	7	4.1
Xanthium brazilicum	Herb	4	2.3
Trianthema spp	Herb	3	1.8
Aristolochia bracteolate	Grass	3	1.8
Echiniachloa colona	Grass	3	1.2
Frankenia hirsute	Herb	2	1.2
Surghum sudaninsis	Grass	2	1.2
Cenhrus ciliaris	Grass	1	0.6
Echinochloa phramidalis	Grass	1	0.6
Dactyloctenium gegyptium	Grass	1	0.6
Total	100		

4.10 Invasive Plant in Sennar Locality Rangeland:

There were many invasive species appeared in table 4.8 in the rangeland of Sennar locality. The dominant one was *Senna obtucifolia* which contributed about 42.5% overall invasive plants in range site, followed by 25.5 % for *Xanthium brazilicum* and *Ocimum basilicum* reached about 13.5% of the total invasive plant composition.

Table 4.12 Invasive Plants in Sinnar locality:

Plant	Habit	Frequency	Percentage
Senna obtucifolia	Herb	60	42.5
Xanthium brazilicum	Herb	36	25.5
Ocimum basilicum	Herb	19	13.5
Indigofera spp	Herb	11	7.8
Senna alexanderina	Herb	7	4.9
Striga spp	Herb	3	2.1
Cenhrus ciliaris	Grass	2	1.4
Aristida spp	Grass	1	0.7
Tribulis terrstris	Herb	1	0.7
Chloris virgate	Grass	1	0.7
Total	100		

4.11 Drought Occurrence in Sennar Locality Rangelands:

Table 4.10 illustrated that there are many drought years occurred in Sennar rangeland. The majority of respondents confirmed that the driest year was 2015 which represent 32.9%, followed by 2013, 2016, 2017 and 2018 with percentages of 25.7%, 17.1%, 15.7% and 8.6% respectively. The frequent drought in range site consider as one of climate change indicator.

Table 4.13 The most drought years in Sennar locality:

The Least rainy years	Frequency	Percentage
2015	23	32.9
2013	18	25.7
2016	12	17.1
2017	11	15.7
2018	6	8.6
Total	70	100
Sig	0.000***	

4.12 Management Practice by Herders for Animal Reproduction in Sennar Locality:

The result represent in table 4.14 confirms that the majority of pastoralists said the best season of animal reproduction the autumn as a high percentage 68.5%, while the other seasons were winter and summer with percentages 17.8 and 13.7% correspondingly.

Table 4.14 Reproduction time for animals in Sennar locality:

Reproduction time	Frequency	Percentage
Autumn	50	68.5
Winter	13	17.8
Summer	10	13.7
Total	73	100
Sig	0.000***	

4.13 The Time of Animal Death in Sennar Rangeland:

According to the result shown in table 4.15 there were highly significant differences between grazing animal mortality in range site (Sig 0.000). The majority of respondents confirm that the animal mortality increase in the beginning of autumn 95.7% while just 4.3% of the pastoralists in the study area said the mortality of animals happened in the middle of autumn.

Table 4.15 Most of time the animals died in Sennar Locality:

Most of time the animals died	Frequency	Percentage
Beginning of autumn	66	95.7
middle of autumn	3	4.3
Total	69	100
Sig	0.000***	

4.14 Pastoralists Strategies to Fulfill the Gap of Forage in Sennar Locality Rangeland:

The result shown in table 4.16 explains that the most respondents 50.8% were feed their animals by commercial fodder, 25.4% of them selling part of herds to minimize the number of animals, 12.3% of pastoralist in range site change their animal types into more adaptation of forage shortage. Also there are other adaptive strategies used by pastoral community used to avoid fodder scarcity such as change of their source income from animals to agriculture.

Table 4.16 Alternative feeding in drought in Sennar Locality:

Alternative feeding	Frequency	Percentage
Buy feed	66	50.8
Selling part of the herd	33	25.4
Change animal type	16	12.3
Forage from Natural pastures	6	4.6
Other	5	3.8
Change the source of income	4	3.1
Total	125	100
Sig	0.000***	

CHAPTER V

Conclusion and Recommendations

5.1 Conclusion:

The study concluded that:

- The majority of the pastoral communities were illiterates of about 27.8% in Sennar locality.
- The change of the herd composition was due to the change in pastoral behavior and resulting to the climate changes.
- The impact of climate change strongly affects the plant and animals in rangeland of Sennar locality.
- The change of life patterns of pastoral communities in Sennar locality is due to changing in rainfall fluctuation and their behaviors.
- The dominance of unpalatable plants specie in rangeland of Sennar locality considers is one of the negative impacts of climate change on rangeland. There were many invasive species appeared in the area.
- The change in the amount of rainfall yearly may lead to fluctuating precipitation, which affected negatively on rangeland vegetation cover in Sennar locality.
- There are many drought years that occurred in Sennar rangeland, the frequent drought in range sites consider one of the climate change indicator.
- There are other adaptive strategies used by pastoral communities used to avoid fodder scarcity such as a change of their source income from animals to agriculture.

5.2 Recommendations:

The study recommended that:

1. Raise the awareness of pastoral communities, and care with the education.
2. Change the botanical composition to the desirable plant species.
3. Avoid the trees cutting and plant removal.
4. Adoption of climate changes strategies and mitigates their impacts in Sennar locality.
5. Farther studies must be done in different range sites.

References:

Abdelrahim, A and Abdalla, N. (2015). Assessment of Rangelands in Semi Arid Areas of Sudan - South Kordofan State (Eldebeibat Area). ARPN Journal of Science and Technology. VOL. 5,.117-124.

Abdelsalam M. I, Abdalla N. I and Abdelkreim M. (2017b). The Effect of Rangeland Protection and Reseeding on Vegetation Attributes at Alazzazah Area, Blue Nile State, Sudan. Modern Agricultural Science and Technology, ISSN 2375-9402, USA, 3 (1), 43-47.

Abdelsalam M. I, Abdalla N. I, Abdelkreim M, Ibrahim M . E. A and Mohammed M. M (2017c). The Impact of Continuous Grazing on Natural Rangeland in Alazzazah area-Blue Nile State, Sudan. *Journal of Rangeland Science*, 7 (4), 309-315.

Abdelsalam M. I, Elsaer A. A Babeker S. El-S and Hassan H. A (2017a). Determination of soil seed bank and orgainc matter in different range sitesof Altadamon locality- South Kordofan State- Sudan. Agrica , 6 (2), 111-116.

Abdelsalam M. I, Ibrahim G. A, Almagboul A. H and Fashir G. A (2016). Determination of Range Plant Attributes in Kadugli Locality, South Kordofan State, Sudan. International Journal of Innovative Research in Science, Engineering and Technology, 5 (2), 1525-1529.

Abdou, H. Y. (2019). Enveronmental Impacts of Livestock Hussbandry: Approaches to Improving Rangelands in Niger. United Nation University, Land Restoration Training Programme. Keldnaholt, 112 Reykjavik, Iceland.

AIA, Alberta Institute of Agrologists (2018). Rangeland and Pasture Management Practice Standard.

Alkemade R, Reid, R. S, van den Berg, M, de Leeuw, J and Jeuken, M. (2013). Assessing the impacts of livestock production on biodiversity in rangeland ecosystems. PNAS, 110 (52), 20900–20905. www.pnas.org/cgi/doi/10.1073/pnas.1011013108

Barry, S. and Huntsinger, L. (2021). Rangeland Land-Sharing, Livestock Grazing's Role in the Conservation ofImperiled Species. Sustainability,13, 4466. tps://doi.org/10.3390/su13084466

Coppock, D. L. (2011). Ranching and Multiyear Droughts in Utah: Production Impacts, Risk Perceptions, and Changes in Preparedness. Rangeland Ecol Manage 64:607–618 | November 2011 | DOI: 10.2111/REM-D-10-00113.1.

Dettenmaier, S. J. Messmer, T. A. Hovick, T. J. and Dahlgren, D. K. (2017). Effects of livestock grazing on rangeland biodiversity: A meta-analysis of grouse populations: *Ecol Evol*.:1–9. https://doi.org/10.1002/ece.

Dong, S., L. Wen, S. Liu, X. Zhang, J. P. Lassoie, S. Yi, X. Li, J. Li, and Y. Li. (2011). Vulnerability of worldwide pastoralism to global changes and interdisciplinary strategies for sustainable pastoralism. *Ecology and Society* **16**(2): 10. [online] URL: http://www.ecologyandsociety.org/vol16/iss2/art10/

Duan Cg, Shi, P, Zhang X, Zong, N, Chai, X, Geng, S and Zhu, W. (2017). The Rangeland Livestock Carrying Capacity and Stocking Rate in the Kailash Sacred Landscape in China. Journal of Resources and Ecology, 8(6): 551–558.

Eghdai, H, Azhadri, G, Lebailly, P and Azadi, H. (2019). Impact of Land Use Changes on Soil and Vegetation Characteristics in Fereydan, Iran. Agriculture, 9, (58) 1-17.

Fawzy, S, Osman, A, Doran J and Rooney, D. W, (2020). Strategies for mitigation of climate change: a review. Environmental Chemistry Letters (2020) 18:2069–2094 https://doi.org/10.1007/s10311-020-01059-w.

GEF, (2021). Climate Change Mitigation. https://www.thegef.org/what-we-do/topics/climate-change-mitigation. 24-3-2022, 3:48 pm.

Getabalew M, and Alemneh T (2019). Factors Affecting the Productivity of Rangelands. J Plant Sci Agri Res Vol.3 No.1:19.

Hartmann, I. Sugulle, A. J and Awale, A. I (2010). The Impact of Climate Change on Pastoralism in Salahley and Bali-gubadle Districts, Somaliland. Heinrich Böll Stiftung, East and Horn of Africa. ISBN 9966-7172-3-4.

HCENR, (2016). National Adaptation Plan. Higher Council for Environment and Natural Resources, Ministry of Environment, Natural Resources & Physical Development. Khartoum, Sudan. 1-105.

Herrero, M, Addison, J, Bwdwlian, C, Carabine, E, Havlik, P, Hwnderson, B Steeg J. van de and Thornton, P. K. (2016). Climate change and pastoralism: impacts, consequences and adaptation. Rev. Sci. Tech. Off. Int. Epiz., 2016, 35 (2), 417–433.

Holechek, J. L, Geli, H. M. E, Cibils, A. F, and Sawalahah, M. N (2020). Climate Change, Rangelands, and Sustainability of Ranching in the Western United States. Sustainability 2020, 12, 4942; doi:10.3390/su12124942.

https://en.wikipedia.org/wiki/List_of_Sudanese_states_by_population. 15-3-2022. 4:30 pm.

IFAD, (2010). Climate Change Strategy. Enabling poor rural people to overcome poverty.

Izaurralde, R. C., Thomson, A. M., Morgan, J. A., Fay, P. A., Polley, H. W., and Hatfield, J. L. (2011). Climate impacts on agriculture: implications for forage and rangeland production. Agronomy Journal, 103(2), 371-381.

Javadinejad, S, Dara, R, Jafary, F and dolatabadi, N (2020). Climate Change Management Strategies to Handle and Cope with Extreme Weather and Climate Events. Journal of Geographical Research, (3), 4. 22-28. DOI: https://doi.org/10.30564/jgr.v3i4.2324

Matawal, D. S. and Maton D. J, (2013). Climate Change and Global Warming: Signs, Impact and Solutions. *International Journal of Environmental Science and Development, (4), 1, 62-66.* DOI: 10.7763/IJESD.2013.V4.305

McCollum, D. W., J. A. Tanaka, J. A. Morgan, J. E. Mitchell, W. E. Fox, K. A. Maczko, L. Hidinger, C. S. Duke, and U. P. Kreuter. (2017). Climate change effects on rangelands and rangeland management: affirming the need for monitoring. Ecosystem Health and Sustainability 3(3):e01264. 10.1002/ehs2.1264

Mertz, O, Halsnæs, K, Olesen, J. E and Rasmussen, K (2009). Adaptation to Climate Change in Developing Countries. Environmental Management (43):743–752. DOI 10.1007/s00267-008-9259-3

Odadi, W. O, Young, T. P and Okeyo-Owuor, J. B (2007). Effects of Wildlife on Cattle Diets in Laikipia Rangeland, Kenya. Rangeland Ecol Manage 60:179–185

Oten, M, Erdurmus C, Kiremitci, S, Soysal, M, Avci, M Yucel, CInal, I, Kabas, O and Surmen, M. (2020). A Multivariate Analysis in Relation to Edaphic and Environmental Factors of Rangelands Vegetation of Mugla Province. Journal of Agricultural Sciences. 26 (2020) 254-262. DOI: 10.15832/ankutbd. 522347.

Petersen, S., Basaraba, A., Hauser, S., Kesling, J., Malcom, A., (2019). Climate Change Adaptation Strategies for Rangeland Managers. A Literature Review. Funded by the USDA Northwest Climate Hub.

Rinehart, L, (2008). Pasture, Rangeland and Grazing Management. ATTRA - National Sustainable Agriculture Information Service • 1-800-346-9140 • www.attra.ncat.org.

Dawn, (2011). Importance of rangelands in rural economy. From Inpaper Magazine Published December 19, 2011.

Rojas-Downing, M. M, Nejadhashemi, A. P, Harrigan, T and Woznicki, S. A (2017). Climate change and livestock: Impacts, adaptation, and mitigation. Climate Risk Management 16: 145–163.

Sandhage-Hofmann, A (2016). Rangeland Management. Reference Module in Earth Systems and Environmental Sciences. Elsevier.

Schuster, J. L. (1984). The importance of rangeland and range conservation. Rangelands, 6(5), 221-222.

Seneviratne, S.I., N. Nicholls, D. Easterling, C.M. Goodess, S. Kanae, J. Kossin, Y. Luo, J. Marengo, K. McInnes, M. Rahimi,M. Reichstein, A. Sorteberg, C. Vera, and X. Zhang, (2012). Changes in climate extremes and their impacts on the natural physical environment. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F.

Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 109-230.

Sivaramanan, S (2015). Global Warming and Climate change causes, impacts and mitigation. DOI: *10.13140/RG.2.1.4889.7128*

Statistical Bulletin, (2021). Ministry of Animal Recourses, Sudan. Annual report.

Statistical Bulletin, (2022). Ministry of Animal Resources, Statistical Bulletin. Issue 29-30. 1-132.

Sudan Meteorological Authority (2019). Annual Report

Taha E.A., Khidr R.E. (2011). Rangeland management and animal production sustainability under arid and semi -arid conditions: Egypt overview. Economic, social and environmental sustainability in sheep and goat production systems. Zaragoza : CIHEAM / FAO / CITA-DGA, 2011. p. 317-322 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 100).

The Royal Society, (2020). Climate Change Evidence and Causes. An overview from the Royal Society and the US National Academy of Sciences. National Academy of Science.

USDA, (2012). Drought Impacts on Rangelands. California Drought Fact Sheet Series, 5.

Ykhanbai, H, Garg, R, Singh, A, Moiko, S,Beyene, C. E, Roe, D, Nelson, F, Blomley, T and Flintan, F. (2014). Conservation and "Land Grabbing" in Rangelands: Part of the Problem or Part of the Solution? Rangelands, (5), 1-44.

Appendices

Appendix 1: Questionnaire

بسم الله الرحمن الرحيم

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا

عنوان البحث : تقييم أثر تغير المناخ على المجتمعات الرعوية والموارد الرعوية في منطقة سنار– ولاية سنار

المعلومات الواردة في الاستبيان تستعمل فقط في نطاق البحث العلمي

اولا : محور البيانات الشخصية:

ضع علامة (√) امام العبارة التي توافق عليها :

1/النوع : ذكر [ ]انثي [ ]

2 /العمر :٣٠ – ٤٠ [ ] ٤٠ - ٥٠ [ ]٦٠ – ٧٠ [ ]

3 /المستوى التعليمي : أمي [ ] خلوة [ ] ثانوي [ ]جامعي [ ] فوق جامعي [ ]

ثانيا :-المحور الاجتماعي الاقتصادي:

1 /الحالة الاجتماعية : متزوج [ ]غير متزوج [ ] مطلق/ة [ ] ارمل/ة [ ]

2 /المهنة : راع [ ] مزارع [ ] اعمال حرة [ ]موظف [ ]

3 /نوع الحيوانات التي تربيها سابقا :

ضأن [ ] ماعز [ ] ابقار [ ] ابل [ ]

4/نوع الحيوانات التي تربيها الان :

ضأن [ ] ماعز [ ] ابقار [ ] ابل [ ]

5 /هل الدخل مناسب سابقا ؟ نعم [ ]لا [ ]

6/ هل الدخل مناسب الان ؟ نعم [ ]لا [ ]

7 /هل هنالك نزوح من المنطقة الي المدينة ؟ نعم [ ]لا [ ]اذا نعم السبب؟.....

8 /هل هنالك مشاكل بين السكان بسبب المراعي ؟ نعم [ ]لا [ ]اذا نعم السبب؟.....

ثالثا : محور الموارد الرعوية :

1 /نمط الرعي : ترحال [ ]مستقر [ ]شبه مستقر [ ]

2 /الحالة العامة للمرعى : وضع المرعى سابقا :ممتازة [ ] جيدة [ ]وسط [ ] متدهورة [ ]

السبب؟.....

الوضع الراهن للمراعي :ممتازة [ ] جيدة [ ]وسط [ ]متدهورة [ ]

السبب؟ .....

3 /الغطاء النباتي : وضع الغطاء النباتي سابقا :وافر [ ] وسط [ ]قليل [ ]

الوضع الراهن : وافر [ ] وسط [ ]قليل [ ]

4 /اهم النباتات السائدة في المنطقة:.....

5 /اهم النباتات التي انقرضت في المنطقة :

.....

6 /النباتات الدخيلة و الغازية في المنطقة -:

.....

رابعا : محور التغير المناخي:

1 /معدلات الأمطار سابقا :زائدة [ ] ثابتة [ ]ناقصة [ ]

معدلات المطار حاليا :زائدة [ ] ثابتة [ ]ناقصة [ ]

2 /انتظام الأمطارسابقا :منتظمة [ ]غيرمنتظمة [ ]

انتظام الأمطارحاليا :منتظمة [ ]غيرمنتظمة [ ]

أكثر سنة هطلت فيها امطار غزيرة ؟ .....

هل صاحبتها سيول؟ نعم [ ] لا [ ]

اذا كان نعم

السبب؟.....

أكثر سنة قلت فيها الأمطار

(الجفاف)؟.....

أكثر فترة نفقت فيها الحيوانات : بداية الخريف وسط الخريف نهاية الخريف

زمن موسم التكاثر (البهلة): الخريف [ ]الصيف [ ]الشتاء [ ]

3/ درجة الحرارة سابقا:مرتفعة [ ] منخفضة[ ]

درجة الحرارة حاليا:مرتفعة [ ] منخفضة [ ]

الرياح:هل توجد عواصف في المنطقة سابقا: نعم [ ] لا[ ]

هل توجد عواصف في المنطقة حاليا: نعم [ ] لا[ ]

وما هو سبب زيادة الرياح ؟قطع الأشجار[ ]ازالة الحشائش[ ]

اخرى[ ]

اذكرها.....

ماهي أكثر مواسم السنة تكثر فيها الرياح:الخريف[ ]الشتاء [ ]الصيف[ ]

هل توجد حرائق في المنطقة : نعم [ ] لا[ ]

اذا كانت الاجابة بنعم في اي زمن

تحدث؟.....

اذكر اسباب حدوث

الحرائق؟1.....2.....3.....

هل توجد حيوانات برية في المنطقة سابقا؟ نعم [ ] لا [ ]

اذا وجدت اذكرها :

1.....2.....3.....

هل توجد حيوانات برية في المنطقة حاليا؟ نعم [ ] لا [ ]

اذا وجدت اذكرها

1:.....2.....3.....

ما هو سبب عدم تواجد الحيوانات البرية؟

تتغير الموائل قلة الامطار [ ] تدهور الغطاء النباتي [ ] ارتفاع درجات الحرارة [ ]

الصيد الجائر[ ]الحرئق [ ] الأنشطة الزراعية [ ]

خامسا : محور التحقق من وعي المجتمعات الرعوية للتأقلم على التغير المناخي :

1/ في سنين المحل عند نقص العلف ماهي الخطط البديلة للحفاظ على القطيع :

بيع جزء من القطيع[ ]تغيير نوع الحيوان[ ]شراء الأعلاف [ ]

أعلاف طبيعية من المراعي[ ]تغيير مصدر الدخل[ ]أخرى[ ]

2/ في حالة حدوث الأمراض ما هي الطرق التي تتبعها لتفادي موت القطيع ؟

1. التبليغ لدى السلطات البيطرية [ ]
2. شراء الدواء من الصيدليات البيطرية [ ]
3. المعالجة بالطرق التقليدية [ ]

Appendix 2: Table of Rainfall

Years	Means (mm)
1994-1998	426.7
1999-2003	439.3
2004- 2008	404.8
2009-2013	388.0
2014-2019	482.7

Source: Metrological station 2019

Appendix 3: Table of temperature metrological station

Years	Means (^{o} C)
1994-1998	37.0
1999-2003	37.1
2004- 2008	37.12
2009-2013	37.44
2014-2019	36.9

Source: Metrological station 2019

Appendix 4: Statistical Analysis

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
الاستمارة رقم	130	1.59	1.224	.107
النوع	141	4.68	2.256	.190
المرعى بسبب مشاكل	71	.31	.466	.055
الرعي نمط	72	1.42	.868	.102
غزيرة امطار فيها هطلت سنه اكثر	72	.82	.387	.046
(الجفاف) الامطار فيها قلت سنه اكثر	51	3.90	2.914	.408
(البهلة)التكاثر زمن	111	.78	.814	.077
الرياح زيادة سبب هو ما	196	2.89	1.746	.125

One-Sample Test

	Test Value = 0					
	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
الاستمارة رقم	14.828	129	.000	1.592	1.38	1.80
النوع	24.636	140	.000	4.681	4.31	5.06
المرعى بسبب مشاكل	5.606	70	.000	.310	.20	.42
الرعي نمط	13.848	71	.000	1.417	1.21	1.62
غزيرة امطار فيها هطلت سنه اكثر	17.951	71	.000	.819	.73	.91
الامطار فيها قلت سنه اكثر (الجفاف)	9.563	50	.000	3.902	3.08	4.72
(البهلة)التكاثر زمن	10.150	110	.000	.784	.63	.94
الرياح زيادة سبب هو ما	23.190	195	.000	2.893	2.65	3.14

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
الاستمارة رقم	130	1.59	1.224	.107
النوع	141	4.68	2.256	.190
المرعى بسبب مشاكل	71	.31	.466	.055
الرعي نمط	72	1.42	.868	.102
غزيرة امطار فيها هطلت سنه اكثر	72	.82	.387	.046
(الجفاف) الامطار فيها قلت سنه اكثر	51	3.90	2.914	.408
(البهلة)التكاثر زمن	111	.78	.814	.077
الرياح زيادة سبب هو ما	196	2.89	1.746	.125

One-Sample Test

	Test Value = 0					
	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
الاستمارة رقم	14.828	129	.000	1.592	1.38	1.80
النوع	24.636	140	.000	4.681	4.31	5.06
المرعى بسبب مشاكل	5.606	70	.000	.310	.20	.42
الرعي نمط	13.848	71	.000	1.417	1.21	1.62
امطار فيها هطلت سنه اكثر غزيرة	17.951	71	.000	.819	.73	.91
الامطار فيها قلت سنه اكثر (الجفاف)	9.563	50	.000	3.902	3.08	4.72
(البهلة)التكاثر زمن	10.150	110	.000	.784	.63	.94
الرياح زيادة سبب هو ما	23.190	195	.000	2.893	2.65	3.14

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
النوع	130	1.59	1.224	.107
المرعى بسبب مشاكل	71	.31	.466	.055
الرعي نمط	72	1.42	.868	.102
غزيرة امطار فيها هطلت سنه اكثر	72	.82	.387	.046
(الجفاف) الامطار فيها قلت سنه اكثر	51	3.90	2.914	.408
(البهلة)التكاثر زمن	111	.78	.814	.077
الرياح زيادة سبب هو ما	196	2.89	1.746	.125

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
النوع	14.828	129	.000	1.592	1.38	1.80
المرعى بسبب مشاكل	5.606	70	.000	.310	.20	.42
الرعي نمط	13.848	71	.000	1.417	1.21	1.62
امطار فيها هطلت سنه اكثر غزيرة	17.951	71	.000	.819	.73	.91
الامطار فيها قلت سنه اكثر (الجفاف)	9.563	50	.000	3.902	3.08	4.72
(البهلة)التكاثر زمن	10.150	110	.000	.784	.63	.94
الرياح زيادة سبب هو ما	23.190	195	.000	2.893	2.65	3.14

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
المدينة الى المنطقة من نزوح	72	.63	.488	.057
المرعى بسبب مشاكل	71	.31	.466	.055
الرعي نمط	72	1.42	.868	.102
غزيرة امطار فيها هطلت سنه اكثر	72	.82	.387	.046
(الجفاف) الامطار فيها قلت سنه اكثر	51	3.90	2.914	.408
(البهلة)التكاثر زمن	111	.78	.814	.077
الرياح زيادة سبب هو ما	196	2.89	1.746	.125
ماهي العلف نقص عند المحل سنين في القطيع على للحفاظ البديلة الخطط	130	1.59	1.224	.107

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
المدينة الى المنطقة من نزوح	10.878	71	.000	.625	.51	.74
المرعى بسبب مشاكل	5.606	70	.000	.310	.20	.42
الرعي نمط	13.848	71	.000	1.417	1.21	1.62
امطار فيها هطلت سنه اكثر غزيرة	17.951	71	.000	.819	.73	.91
الامطار فيها قلت سنه اكثر (الجفاف)	9.563	50	.000	3.902	3.08	4.72
(البهلة)التكاثر زمن	10.150	110	.000	.784	.63	.94
الرياح زيادة سبب هو ما	23.190	195	.000	2.893	2.65	3.14
نقص عند المحل سنين في البديلة الخطط ماهي العلف القطيع على للحفاظ	14.828	129	.000	1.592	1.38	1.80

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
الرياح زيادة سبب هو ما	111	.78	.814	.077
الرياح فيها تكثر اكثرمواسم هي ما	72	1.42	.868	.102

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
الرياح زيادة سبب هو ما	10.150	110	.000	.784	.63	.94
فيها تكثر اكثرمواسم هي ما الرياح	13.848	71	.000	1.417	1.21	1.62

Appendix 5: Meteorological Data

THE MINISTRY OF IRRIGATION AND WATER RESOURCES
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Snaara Data (1994-2018)

Year	Maximum Temperature	Minimum Temperature	Relative Humidty %	Total Rainfall	Wind Speed
1994	36.6	17.8	46	489.5	4
1995	37.1	17.5	46	451.7	4
1996	36.9	18.8	48	562.6	5
1997	37.0	20.2	43	261.1	4
1998	37.2	20.3	45	368.5	3
1999	36.9	20.7	46	455.8	3
2000	36.7	20.4	46	550.9	3
2001	37.0	20.6	47	398.9	3
2002	37.5	20.3	41	372.0	4
2003	37.4	20.4	43	419.1	4
2004	37.7	20.4	40	217.7	4
2005	37.7	20.7	42	293.8	4
2006	37.0	20.1	48	354.2	4
2007	36.5	20.1	51	773.9	4
2008	36.7	20.3	41	384.4	3
2009	37.7	20.6	47	309.1	4
2010	37.3	21.2	52	461.6	6
2011	37.3	19.7	46	290.4	6
2012	37.5	18.1	48	489.2	6
2013	37.4	19.6	48	389.7	5
2014	36.7	20.6	51	568.5	4
2015	37.4	20.8	43	477.3	4
2016	37.2	20.8	47	361.5	4
2017	36.8	20.7	48	506.2	4
2018	36.6	19.9	49	500.2	5

Maximum and Minimum Temperature In C°
Total Rainfall In (MM)
Wind Speed In Knots