DESERTIFICATION

SAHEL REGION

DATA VISUALIZATION

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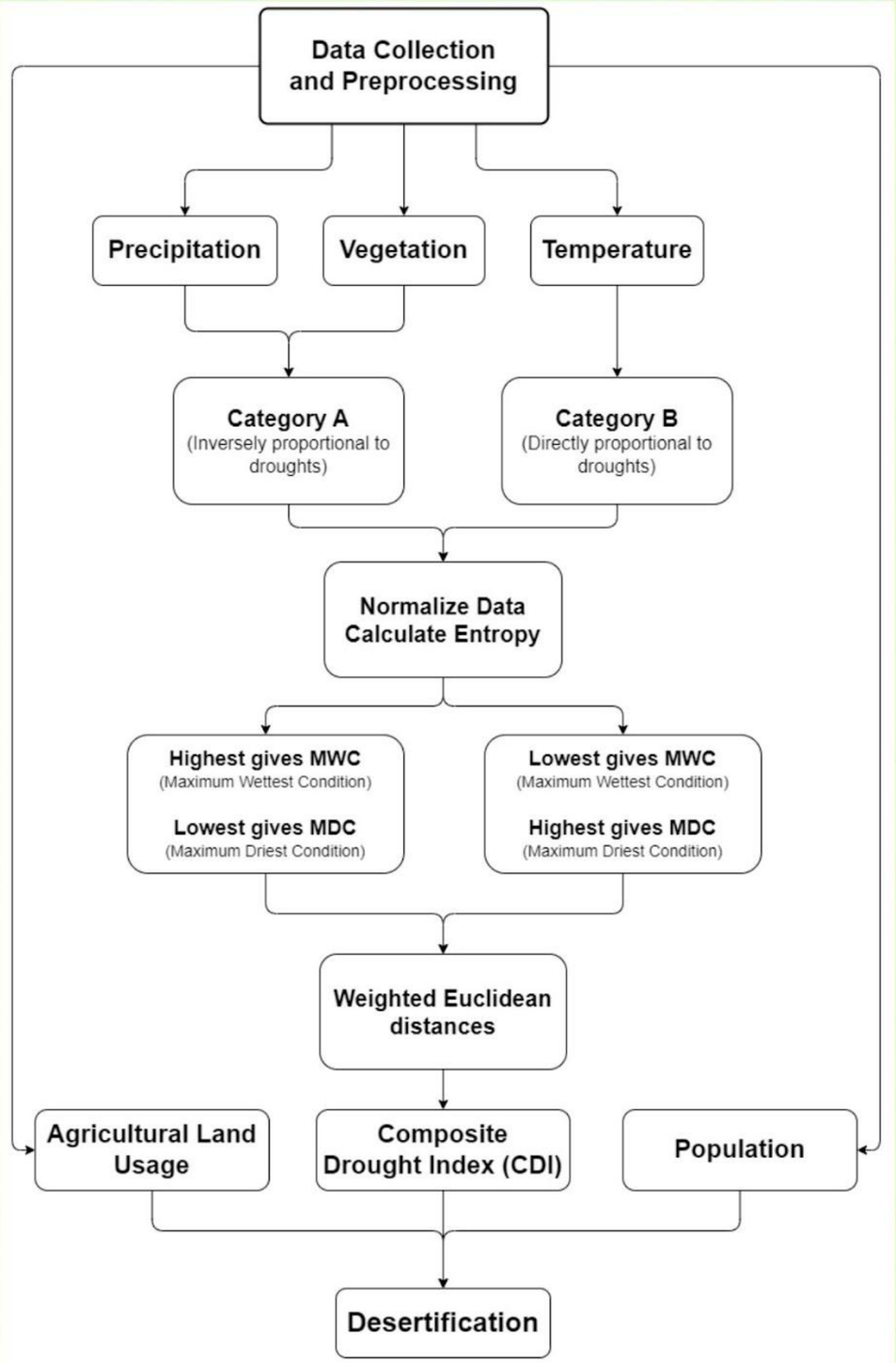
METHOD0LOGY



Data Collection

1. Composite Drought Index - CDI Dataset
2. Niger Agricultural Land - World Bank
3. Niger Precipitation - CHIRPS Dataset
4. Niger Demographics - Worldometer
5. Niger Population - Worldometer
6. Niger Land - Humanitarian Data Exchange

Data Collection

7 Sahel Precipitation - JISAO data

8 Sahel Land - SCIRP Journal

9 Niger Vegetation - AMMA-CATCH Dataset

10 Niger Precipitation - Climate Change Portal

PLOTLY

plotly

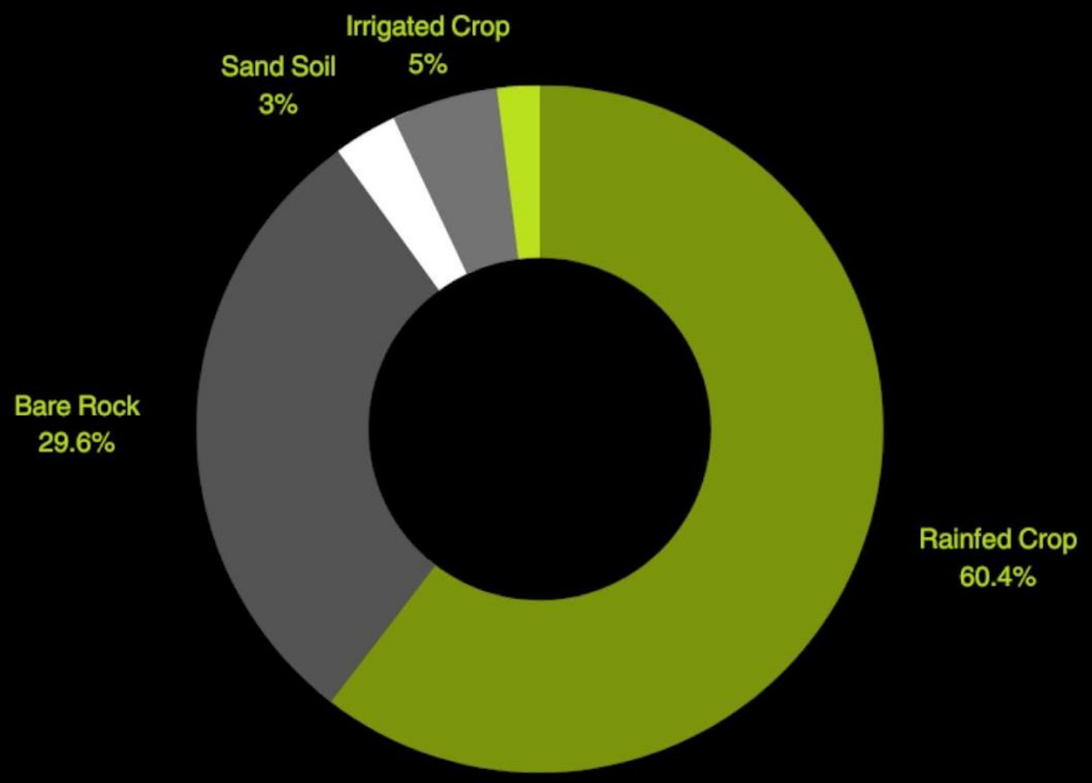
Plotly is a powerful Python library designed for creating interactive and visually engaging data visualizations. This open-source tool offers support for a diverse array of chart types, boasting more than 40 unique options. These charts cater to a broad spectrum of applications, spanning statistical analysis, financial modeling, geographical mapping, scientific research, and even three-dimensional visualizations. Whether you need to present complex data or explore intricate datasets, Plotly equips you with the tools to convey your insights effectively and

Our Project Includes

- *Bar Graphs*
- *Line Graphs*

Data Visualization

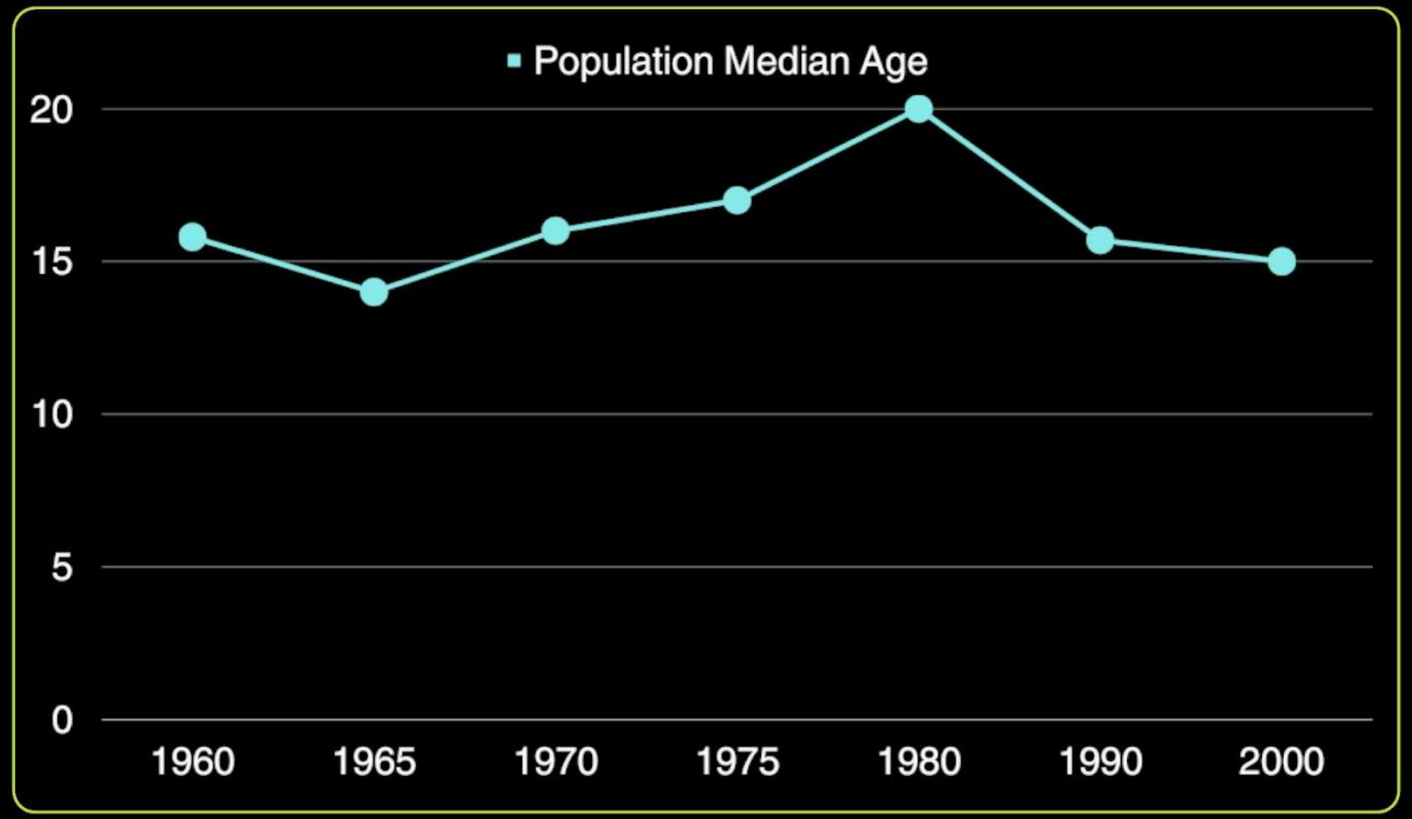
SeaBorn



Our Project utilizes Pie-Charts from library

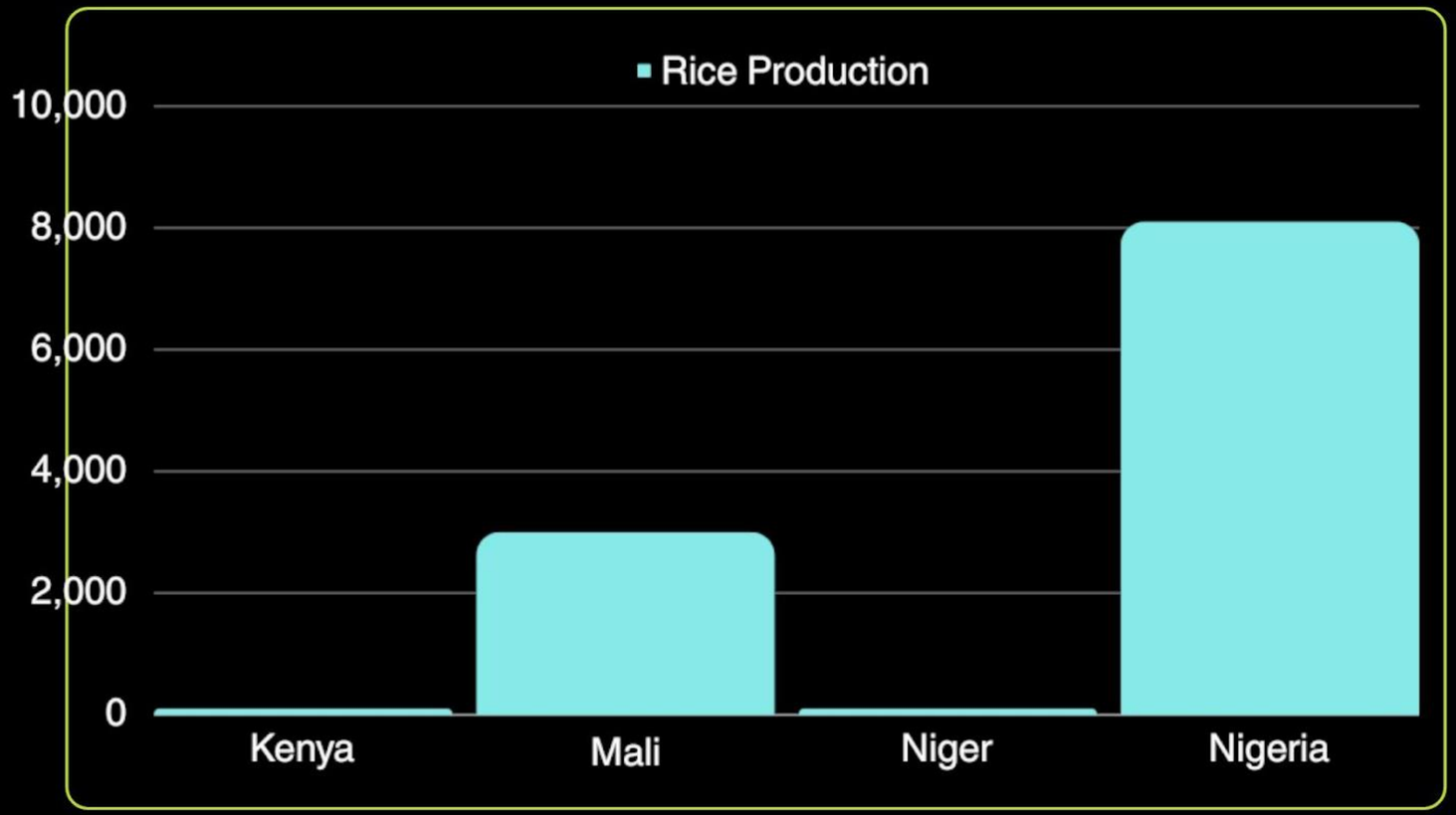
Seaborn stands as a prominent Python visualization library, built upon the foundatio matplotlib. Its primary purpose is to offer a level, user-friendly interface for crafting visu appealing and insightful statistical graphics seamlessly integrating with matplotlib, Seab empowers data scientists and analysts to cr sophisticated and informative data visualizat with ease and precision, making it an indispens tool in the data visualization toolkit

MATPLOTLIB



Matplotlib offers an array of featu
including support for various c
types (e.g., line, scatter, bar,
heatmap), customizable plots,
grained control over plot eleme
and compatibility with multiple
formats. It also allows for annota
3D plotting, and integration
Jupyter notebooks, making it
versatile tool for creating
quality data visualizations.

PYGAL

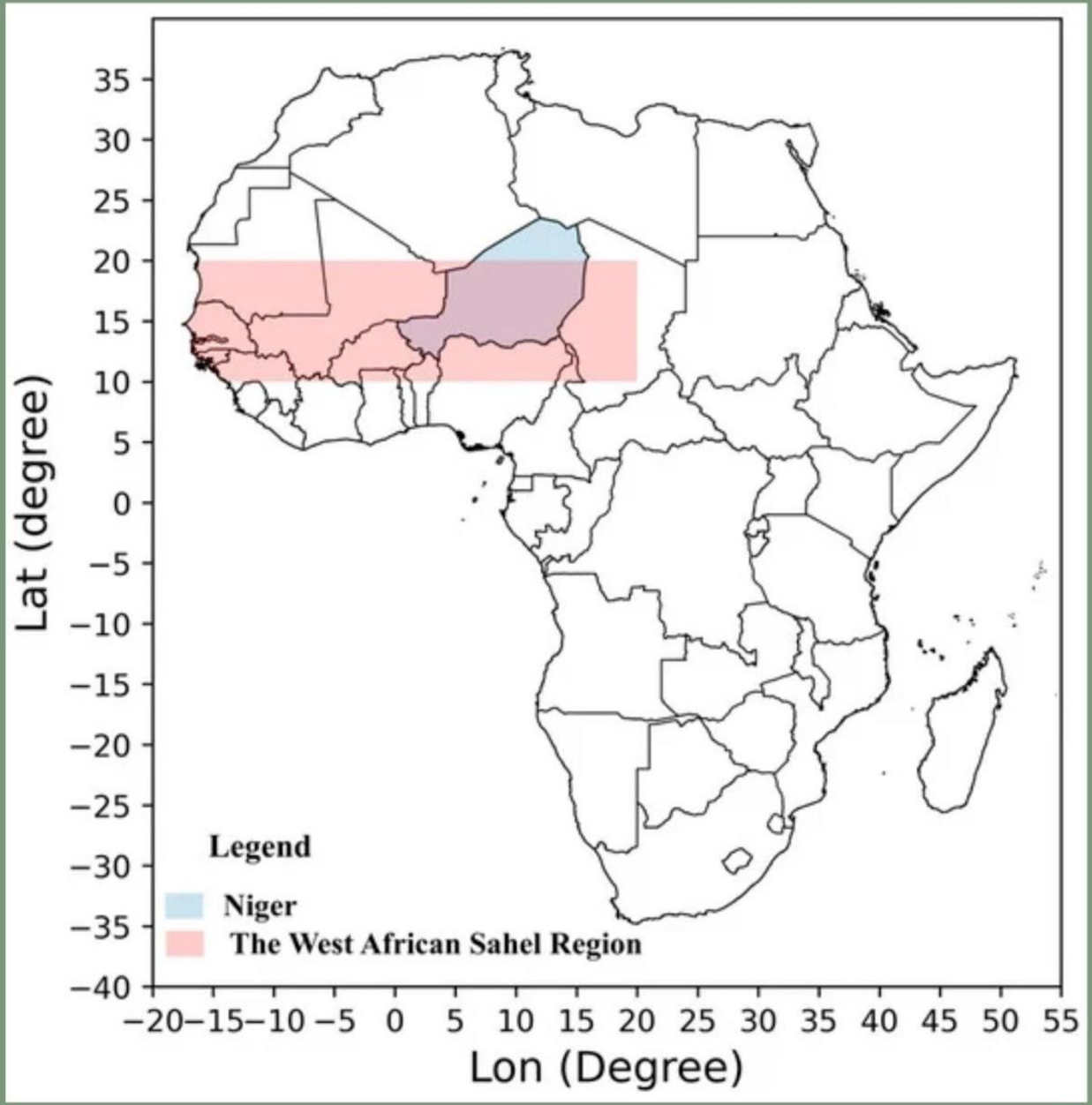


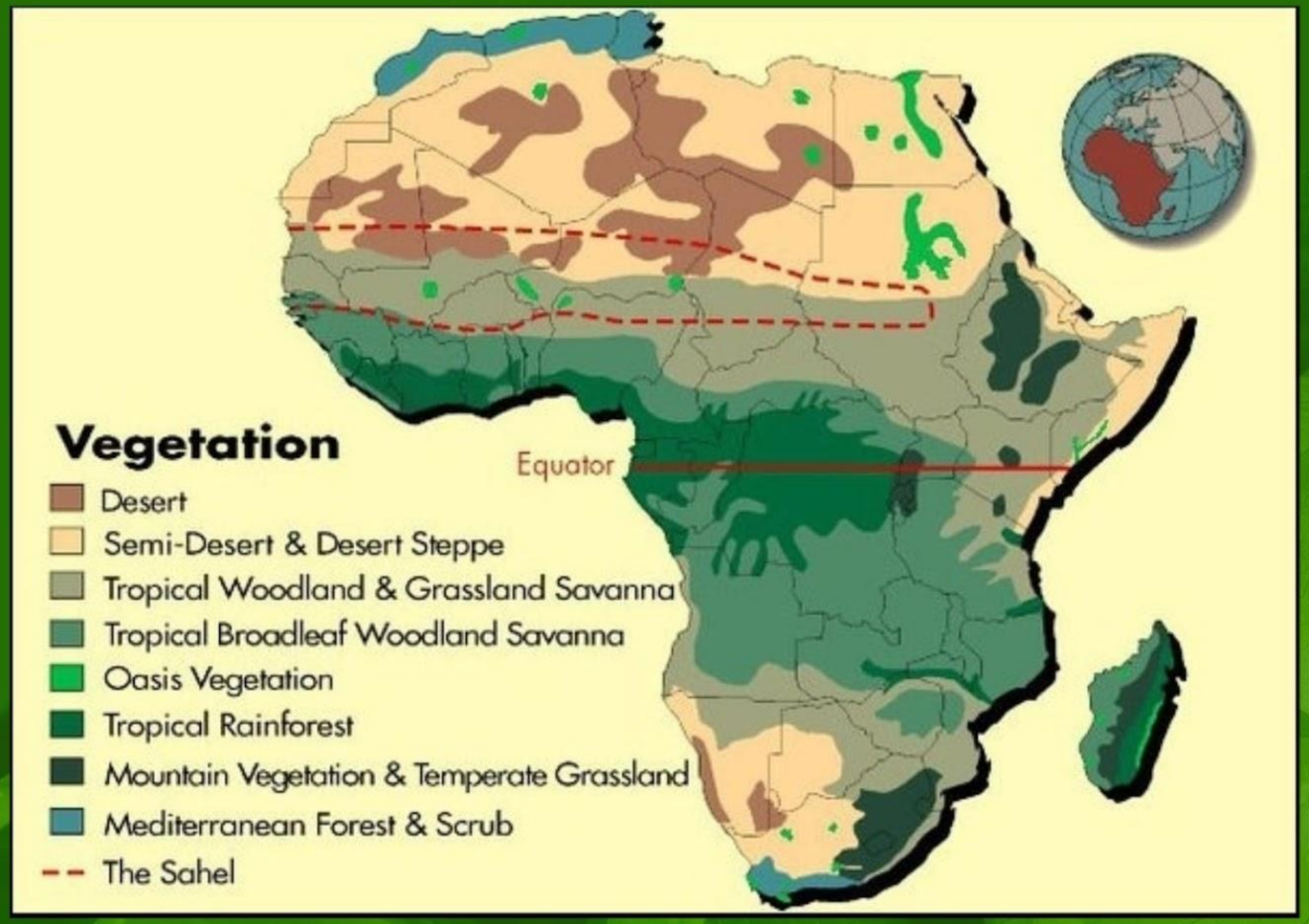
Pygal, a Python visualization libr
simplifies chart creation with intuitive interface, emphasi interactivity. Integrated seamle with Python, it effortlessly gener diverse charts like line, bar, and graphs. Pygal's focus on simpl empowers users to craft compel visualizations, making it a valu tool for data presentation exploration in Python.

Case Study

DESERTIFICATION IN SAHEL REGION

Sahel Region




Vegetation
Desert
Semi-Desert & Desert Steppe
Tropical Woodland & Grassland Savanna
Tropical Broadleaf Woodland Savanna
Oasis Vegetation
Tropical Rainforest
Mountain Vegetation & Temperate Grassland
Mediterranean Forest & Scrub
The Sahel
Equator

VEGETATION

Average vegetation cover [1982–2006] derived from AVHRR satellite data at 8km resolution.

Denser vegetation cover is shown as dark green

Rain normalized vegetation production 1982–2006 derived from the ratio of annual vegetation cover (AVHRR) to annual rainfall.

Rain normalized vegetation production disentangles vegetation changes caused by rainfall variation from other factors.

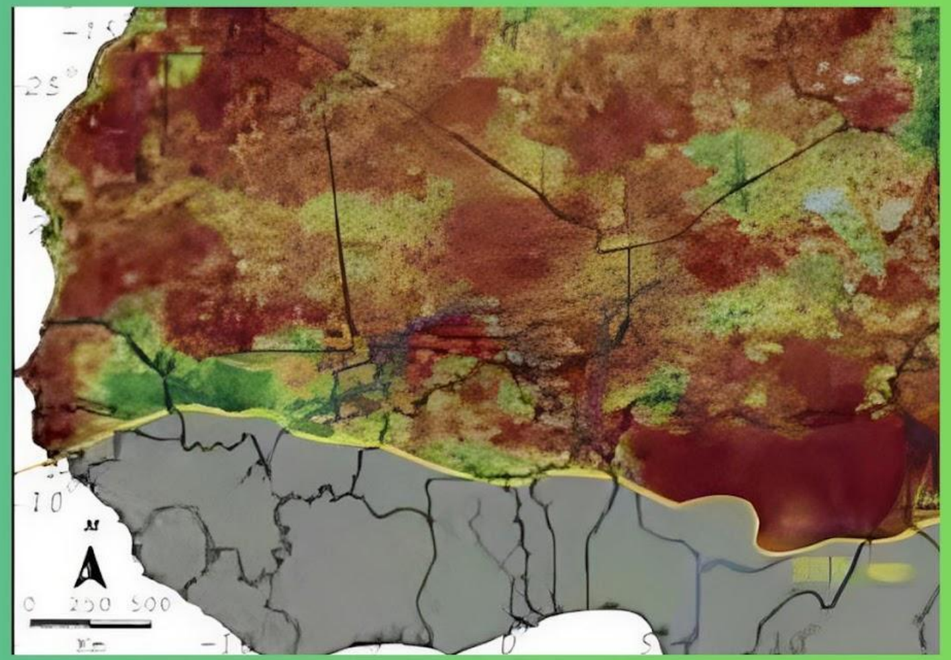
VEGETATION

Greening and browning trends in average vegetation cover 1982–2006.

Absolute vegetation growth has increased (green) in the Sahel since the droughts in the 1980

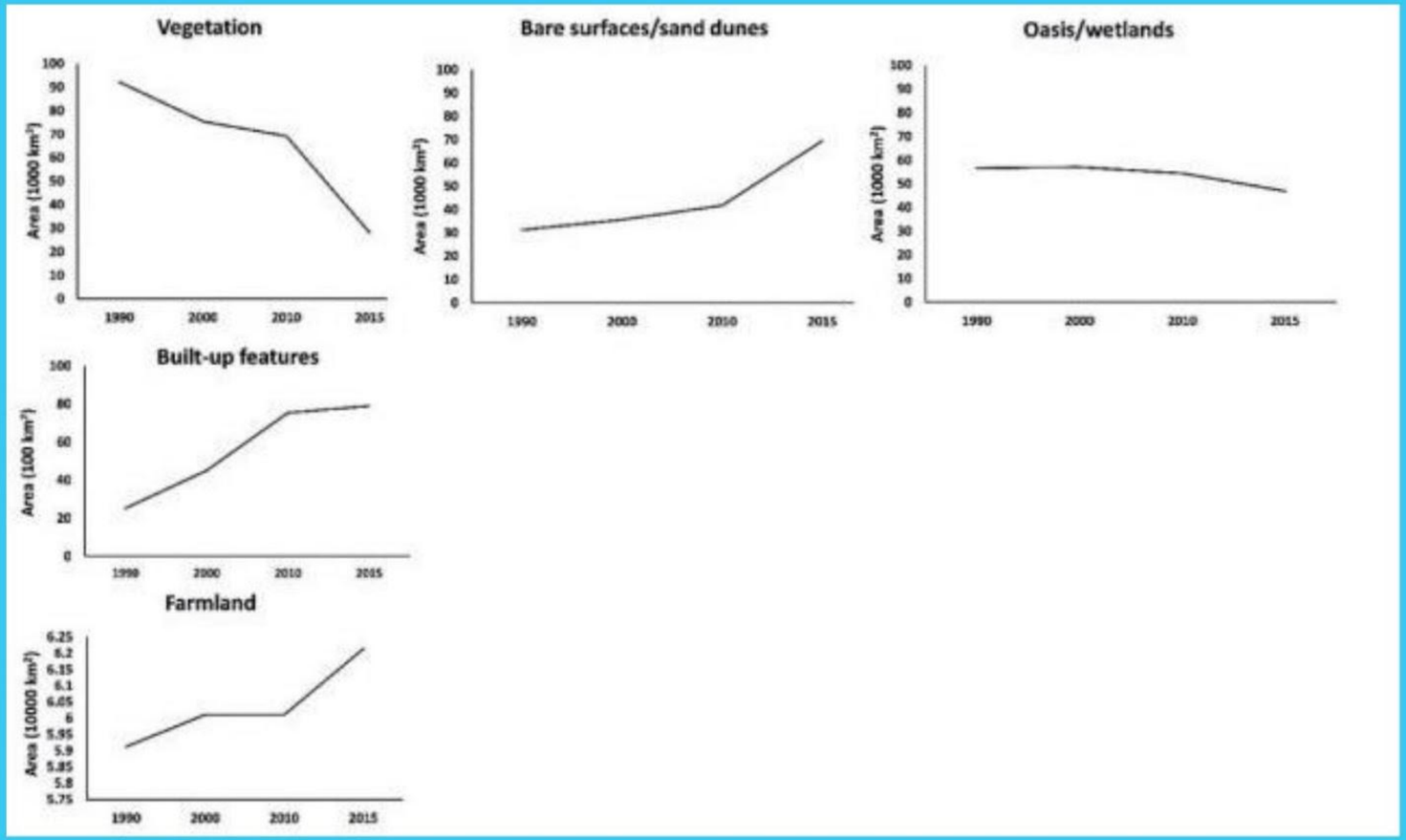
Trends in rain normalized vegetation production 1982–2006. Trends are shown for areas with < 900 mm rainfall per year.

Strong negative trends (brown) indicate that the ability of the vegetation to utilize available rainfall has decreased in this time period



LAND COVER

- The start year demonstrates a low concentration of built-up areas.
- By the year 2015, the built-up areas had increased drastically to about 7893 ha.
- There was a steady decrease in vegetation throughout the time slices examined.
- A similar pattern of decline was observed for the wetland and oasis land cover class.
- FARMLAND REMAINS THE DOMINANT LAND COVER IN STUDY AREA . IT HAS CONSISTENLTY INCREASED THROUGHTOUT THE STUDY PERIOD

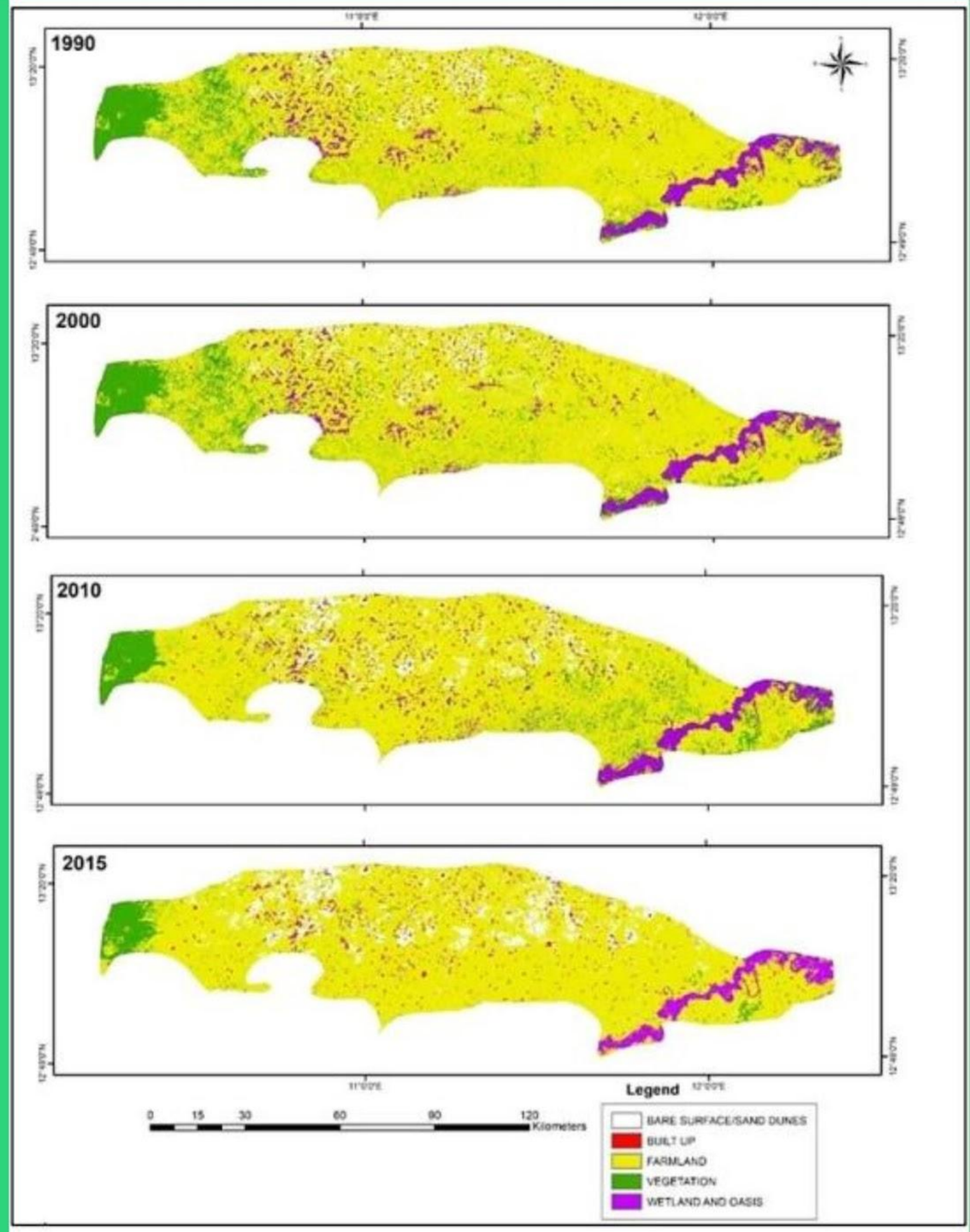


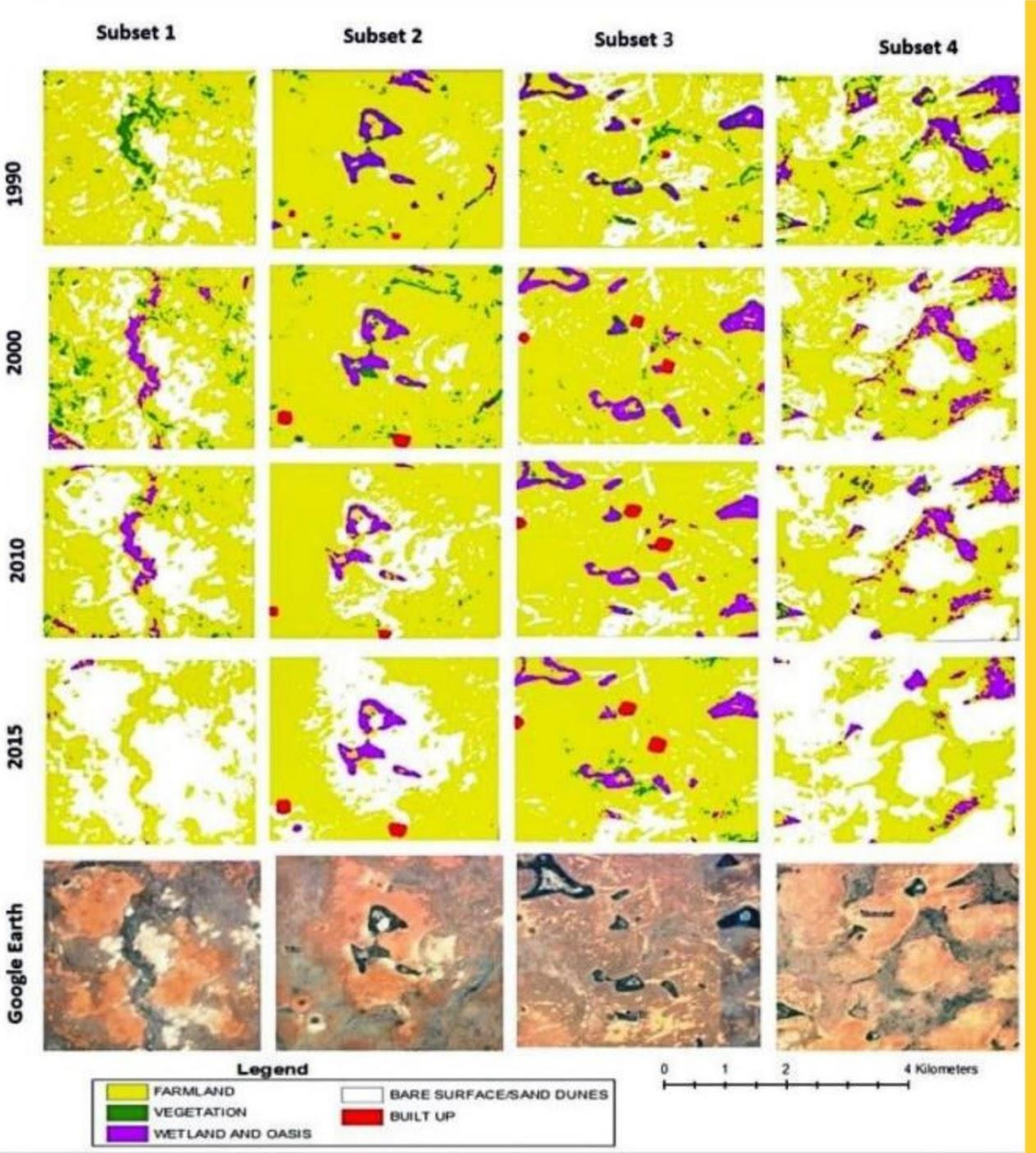
1990-2015

LAND COVER MAPS →

TRENDS IN LAND COVER CHANGE

- By the year 2015, the built-up areas had increased drastically to about 7893 ha, which is about 1% of the total land area.
- The rate of built-up expansion however slowed down between 2010 and 2015. The reverse was the case for vegetation. There was a steady decrease in vegetation throughout the time slices examined.
- In 1990, vegetation occupied about 11.9% of the total area, with about 92,126 ha. This reduced to 75,409 ha in 2000 (9.7% of the study area).
- There was even a further decrease in 2010 and 2015, with 69,120 ha in 2010, and only 28,143 ha in 2015, representing 8.9% and 3.6% of total land, respectively





IMPACT ON SAND DUNE FEATURES

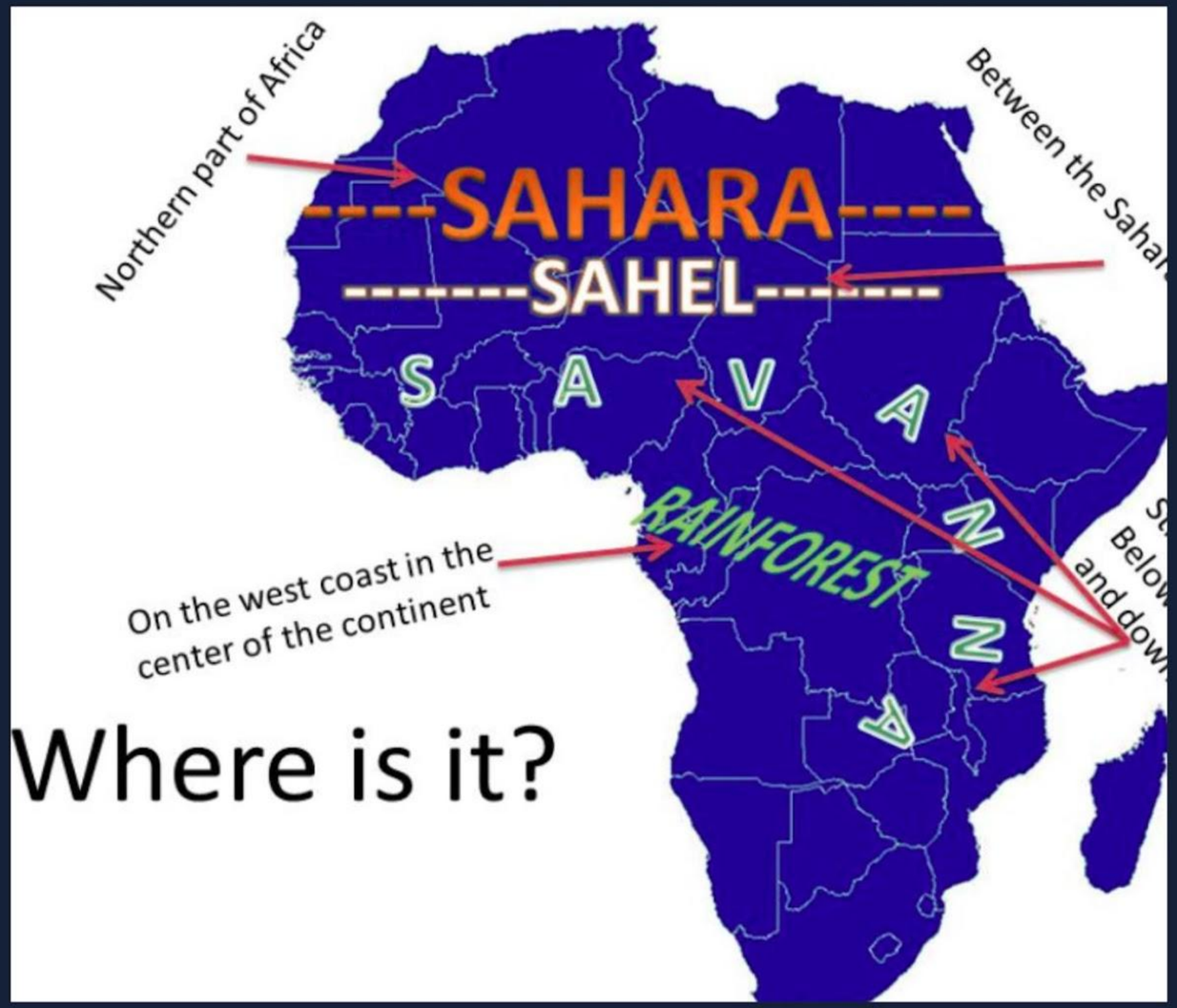
- Similarly Observed , was a substantial advancement in sand dune features in the study area.
- The figure shows various degrees of sand dune progression in different locations across the study area .
- On average , results reveal that the sand dune in the study area is progressing at a meAN annual rate of 1524 ha
- The Sand Dune Coverage Expanded from 4.1% to 9% of Total Landmass

Land Degradation Hotspots

- Soil erosion by wind and water, soil physical degradation (for example crust development) and salinisation are important processes of soil degradation in the Sahel, impoverishing soils and decreasing food production.
- During the droughts in the 1970s and 1980s, exposed soils were vulnerable to wind erosion, and large areas lost their top soils.
- Analysis shows that vegetation recovery has not been as strong as the increases in rainfall after the droughts of the 1980s.
- This is indicated both by the rainfall front having moved approximately twice as far north as the vegetation front and that vegetation seems less efficient in converting each drop of rainfall into biomass. Vegetation is not responding fully to increases in rainfall.

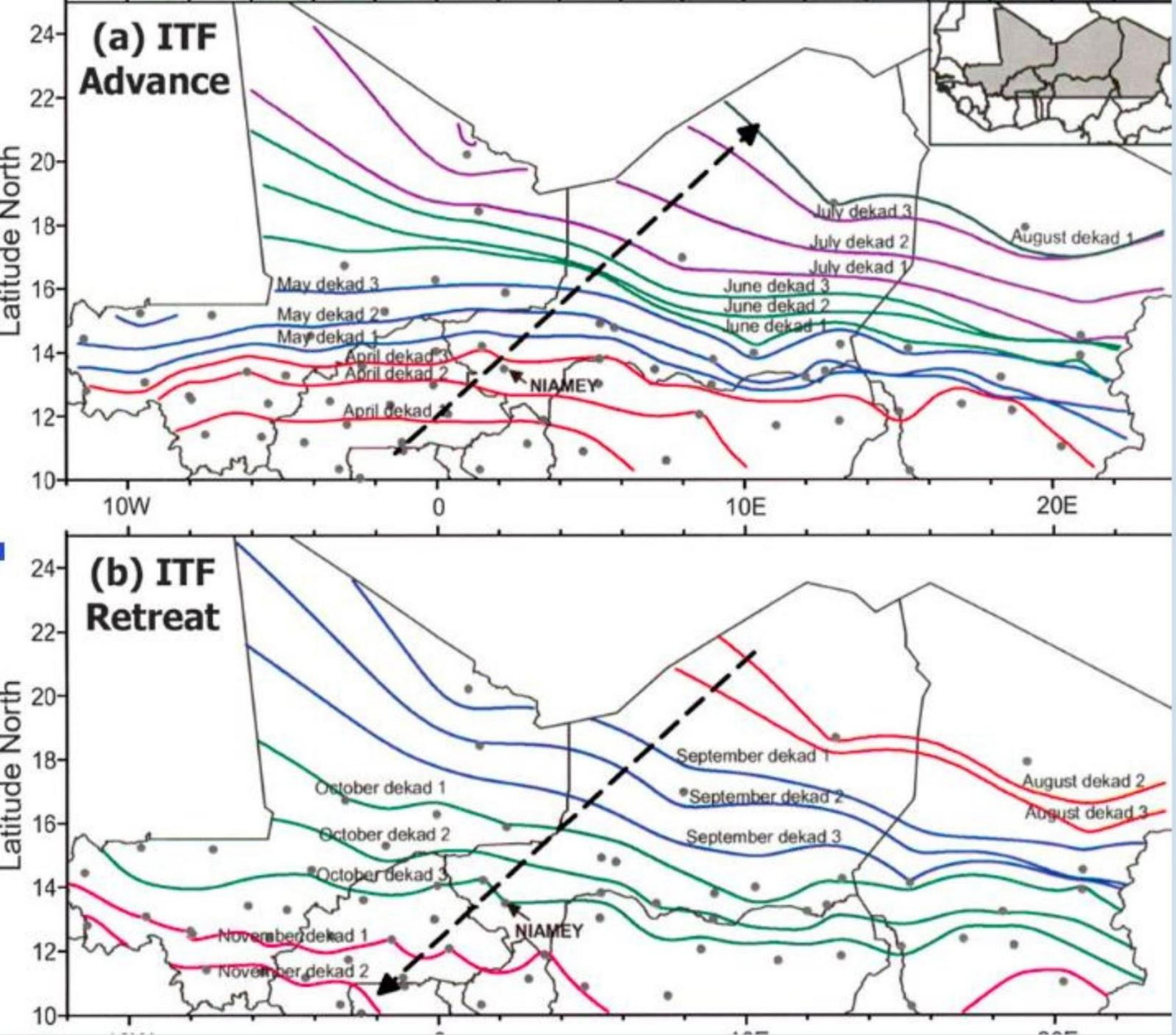
Climate and Precipitation

Sahel as mentioned before is located between the desert region of Sahara and the Savannas in the South. So naturally it has aN arid climate



ITF

The rainy season coincides with the arrival of the Intertropical Front (ITF), which is the boundary between dry continental air and moist sea air. This collision creates turbulence, leading to intense convective storms that often occur in the late afternoon. Prior to the rain, there are violent sandstorms, and sometimes the rain doesn't reach the ground. As the ITF moves north, the 'monsoon' arrives, bringing humid winds from the southwest. Conversely, when the ITF retreats southward, it brings the dry harmattan, a northeast wind. Rainfall is closely linked to the unpredictable movement of the ITF. Early advances, temporary retreats, and late returns of the ITF can result in uneven rainfall distribution, negatively impacting vegetation.



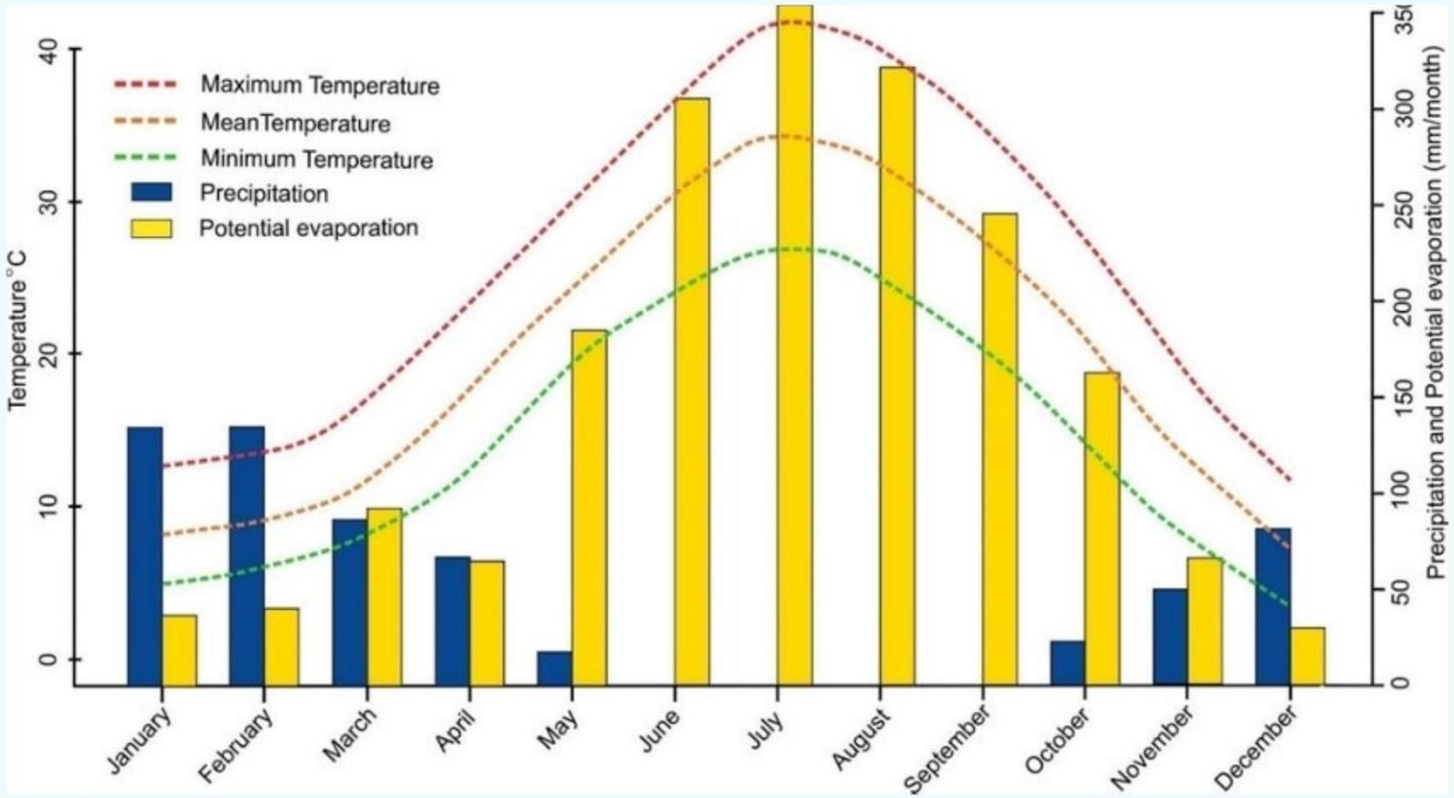
ROUTE FOLLOWED BY ITF IN SAHEL REGION

EVAPORATION AND TEMPERATURE

Evaporation is a crucial factor in the life of the North Sahel region as it leads to the drying of plants and pools. The rates of evaporation reach their peak during the scorching dry months of March to May, decline in the subsequent months, and then rise again starting from November.

Evaporation levels are influenced by both wind and temperature, with temperature being the primary factor. The months with the highest temperatures, typically from March to June, experience the greatest evaporation rates.

Moreover the presence of great heat and evaporation can be hard on people who often have heavy work to do at this time.



Precipitation occurs when water falls back to earth. This can happen in the form of rain, hail, sleet and snow.

PRECIPITATION

Rainfall plays a central role in arid regions as it directly influences vegetation, surface water, and shallow groundwater. Rainfall in Sahel can be best classified as irregular.

Irregularities are of 2 types

- Irregular distributed within one cycle
- Variation in rainfall from one year to other

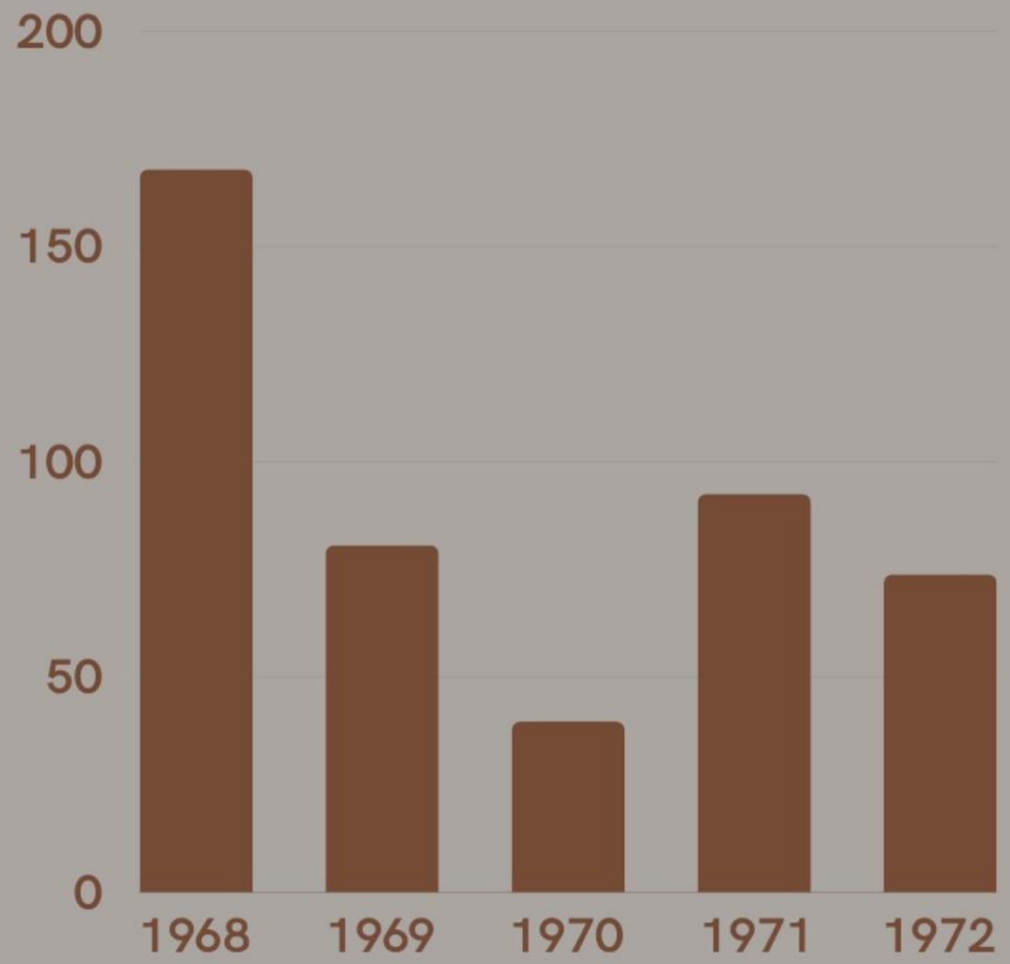
IRREGULARITIES WITHIN ONE CYCLE

- Useful rainfall is the % of rain that helps in vegetation development by triggering germination

- Abnormal rainfall timing can eliminate many annual species, making perennial plants more dominant. However, persistent irregularity depletes the reserves of perennial plants as well.

- For example, there was lesser than average rainfall in 1967 but it was evenly spread throughout the monsoon season and there was no drought.

- 1968 had above average rainfall but majority of the rainfall was in the first few days, which triggered germination but these plants were left without subsequent rainfall causing their death.



INTERANNUAL IRREGULARITY IN RAINFALL

The interannuailrregularitycan often producerainfall shortagesover a seriesof successiveyearsas was the casefrom1969 to 1972.The cumulativeeffectof these years caused droughts of catastrophic proportions.

Population and Demographics

Why is it important to learn about Population and Demographics?

- Population growth and demographic factors intimately linked to desertification
- Sahel’s fragile ecosystems degraded due to unsustainable land-usage and exacerbated water stress due to soaring population
- This analysis provides valuable information to enable us in developing effective strategies to combat desertification

Population Growth Trends

In West Africa

COUNTRY	FERTILITY RATE	LIFE EXPECTANCY	INFANT MORTALITY	HDI RANKING	AVERAGE AN POPULATI GROWTH IN L YEARS
Niger	6.95	61.8	102	189	3.23%
Burkina Faso	5.23	60.9	84	183	2.84%
Senegal	4.65	67.5	45	164	1.86%
Guinea-Bissau	4.51	57.8	82	177	3.02%

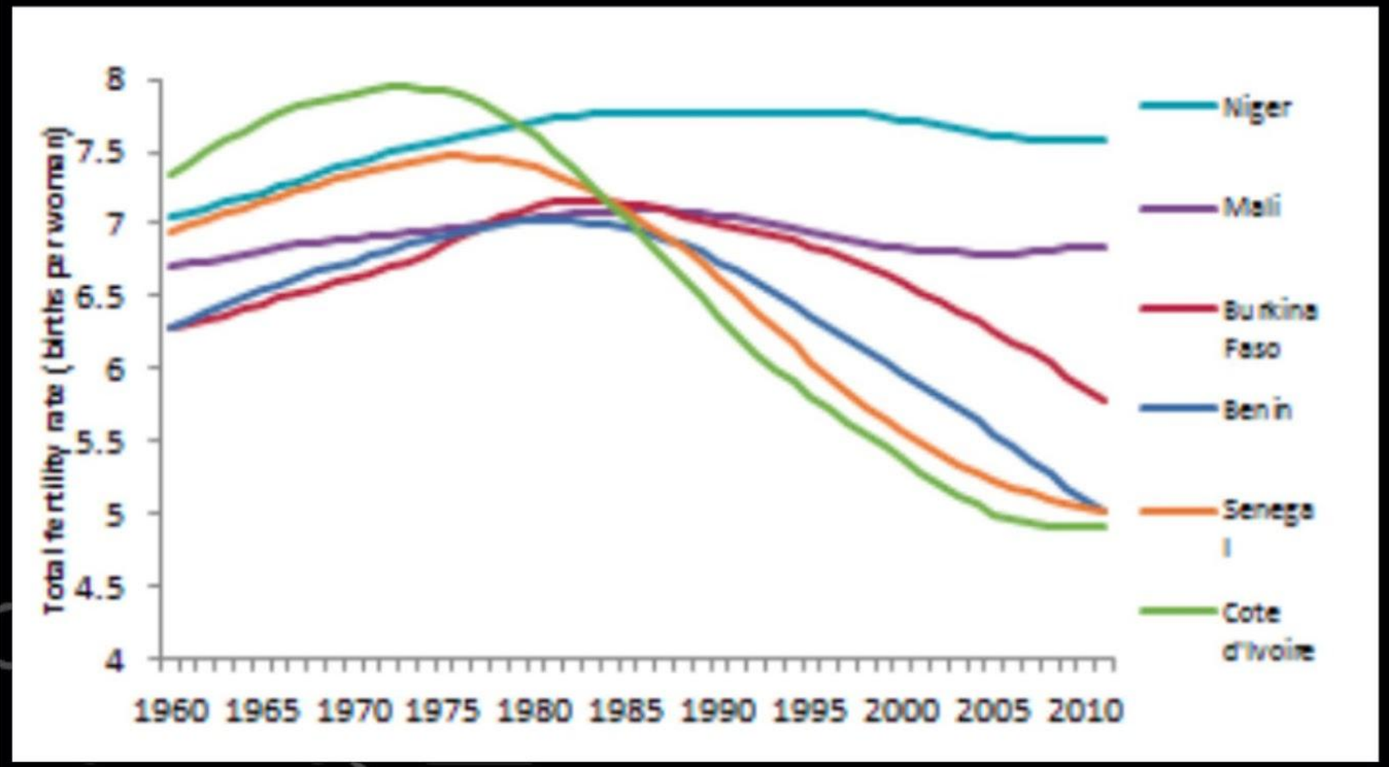
Resource Demands

What role did the resource demand play in causing desertification in the Sahel ?

- **A rapidly growing population requires more food, water, and shelter.**
- **To meet these needs, people in the Sahel engage in agricultural activities, often employing unsustainable practices that lead to land degradation.**
- **Overgrazing, excessive land cultivation, and inadequate irrigation methods are some of the consequences of population pressure.**

SAHEL REGION

HIGH FERTILITY RATES



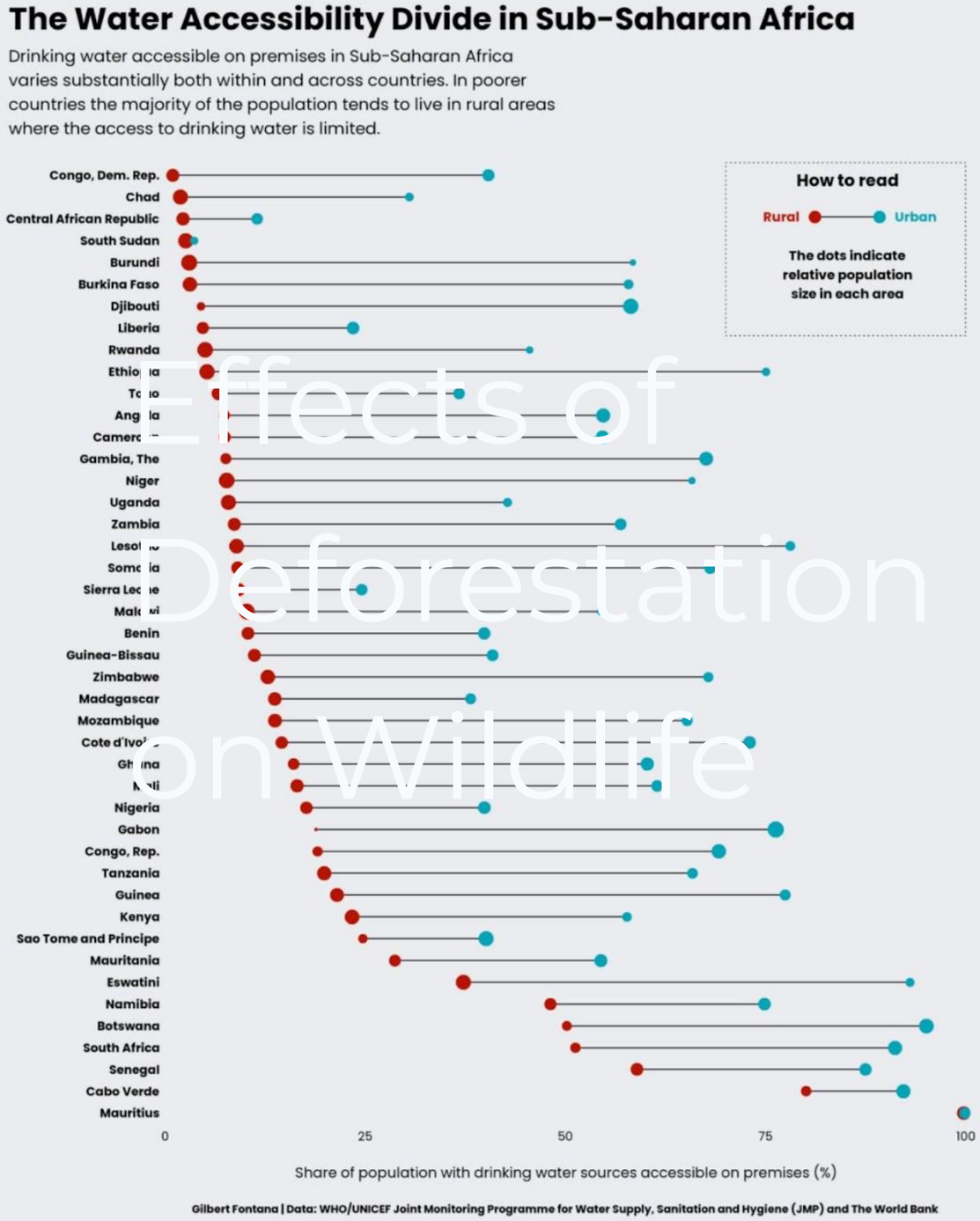
Land Fragmentation

High fertility rates in Sahelian communities lead to subdivided, smal land plots, often shared among multip heirs.

Impact on Sustainability

Land fragmentation complicates sustainable practices like crop rotatio and conservation, making the land mo prone to soil erosion and desertificatio

FERTILITY RATES ACROSS THE WORLD



Effects of Deforestation on Wildlife

DESERTIFICATION IN SAHEL REGION

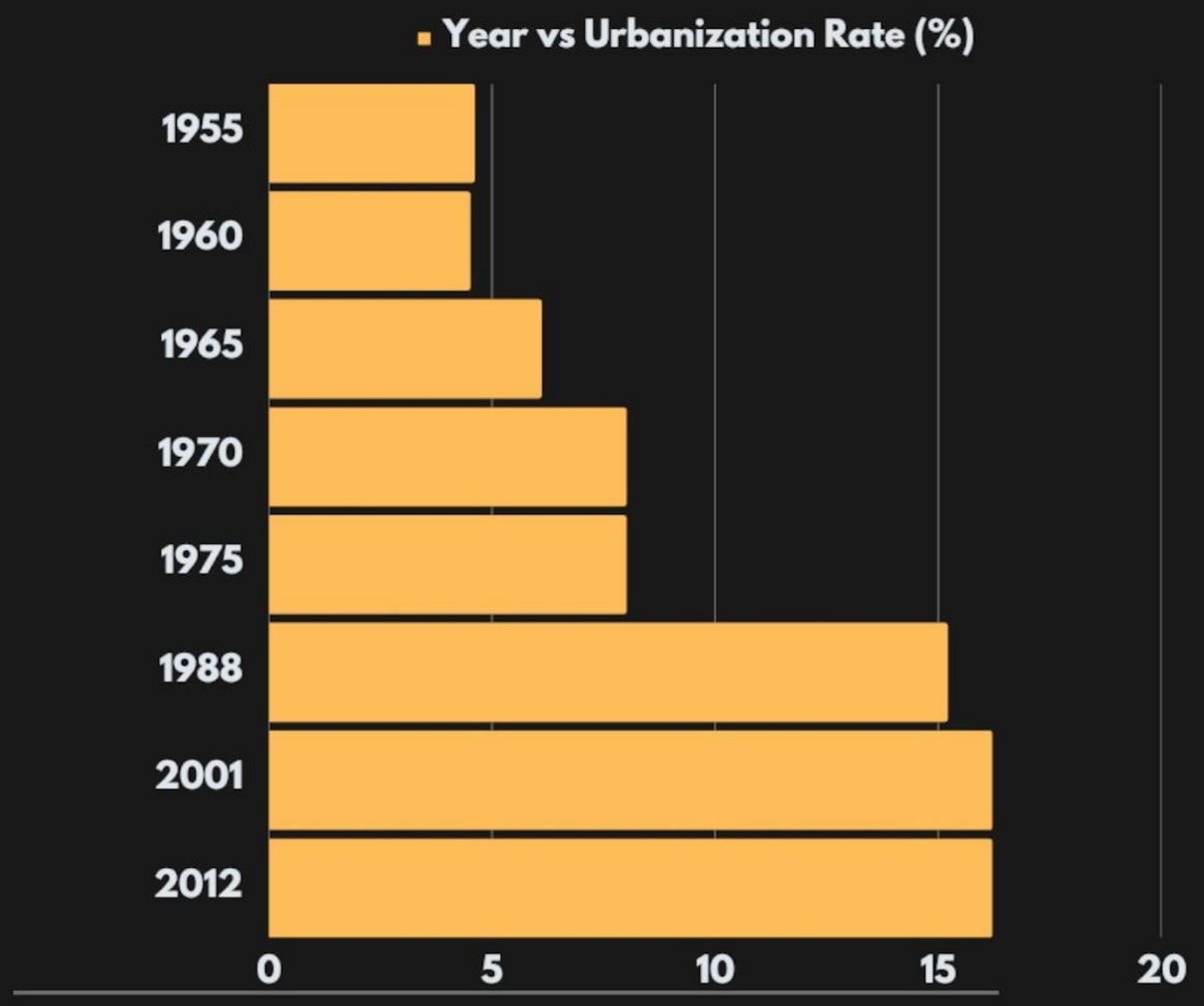
WATER STRESS

Rising population density exacerbates water scarcity, as more people draw from already limited water sources. This contributes to the overuse and depletion of aquifers and surface water bodies, negatively impacting the region's ecosystem and accelerating desertification.

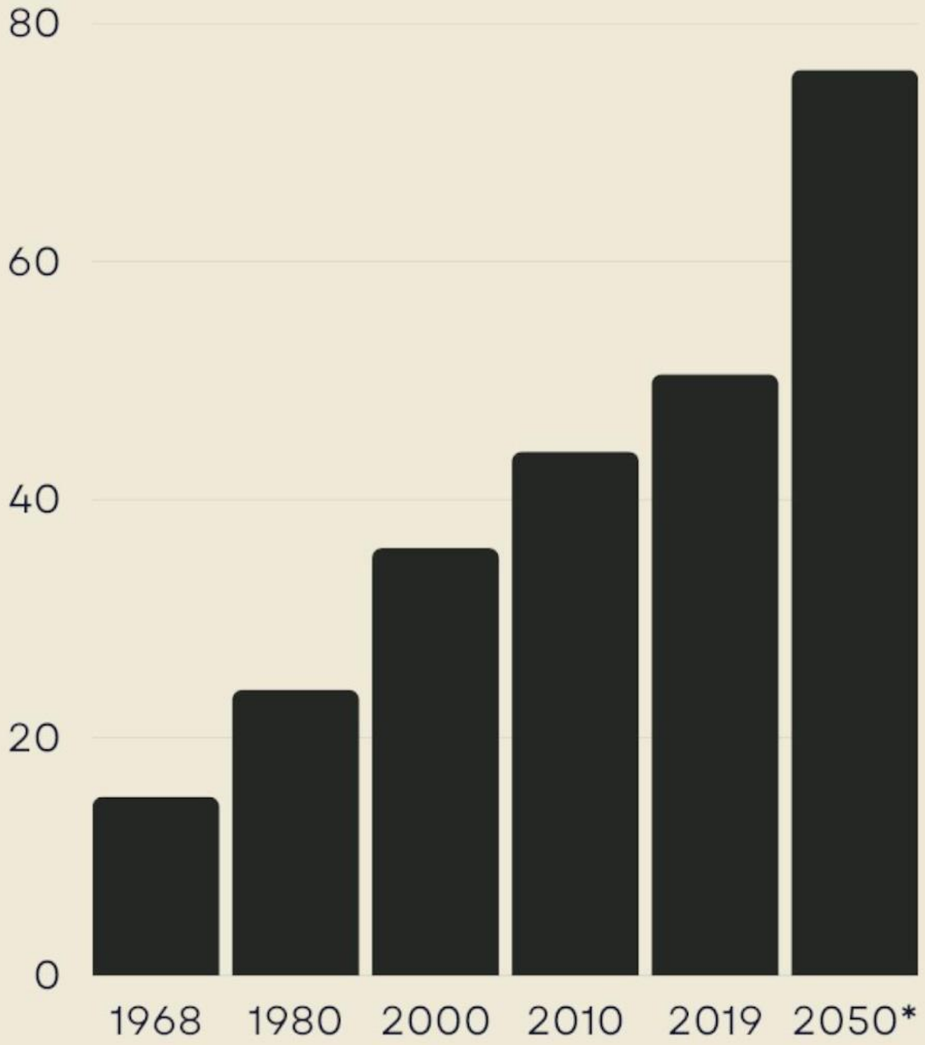
URBANIZATION

As rural populations in the Sahel grow, many individuals seek better economic opportunities in urban areas. This trend has led to significant urbanization. The demand for housing and infrastructure in peri-urban areas often resulted in the clearance of vegetation and topsoil, which made these areas more susceptible to desertification.

The graph reveals a consistent upward trend in urbanization rates across years in the Sahel region. This urban expansion impacts land use and can exacerbate desertification.



RURAL POPULATION



LAND CLEARANCE

Sahelian rural communities heavily depend on subsistence farming, necessitating expanded cultivation that often leads to deforestation and soil degradation.

TRANSHUMANCE

Nomadic pastoralism/Transhumance is common in the Sahel, but population growth has led to overgrazing, depleting vegetation and intensifying desertification.

YOUTH POPULATION AND EMPLOYMENT

DEMOGRAPHIC STRESS

Growing youth populatio strains land resources, stemming from rapid population growth, drives intensifying desertificatio challenges in the Sahel region.

UNEMPLOYMENT IMPACT

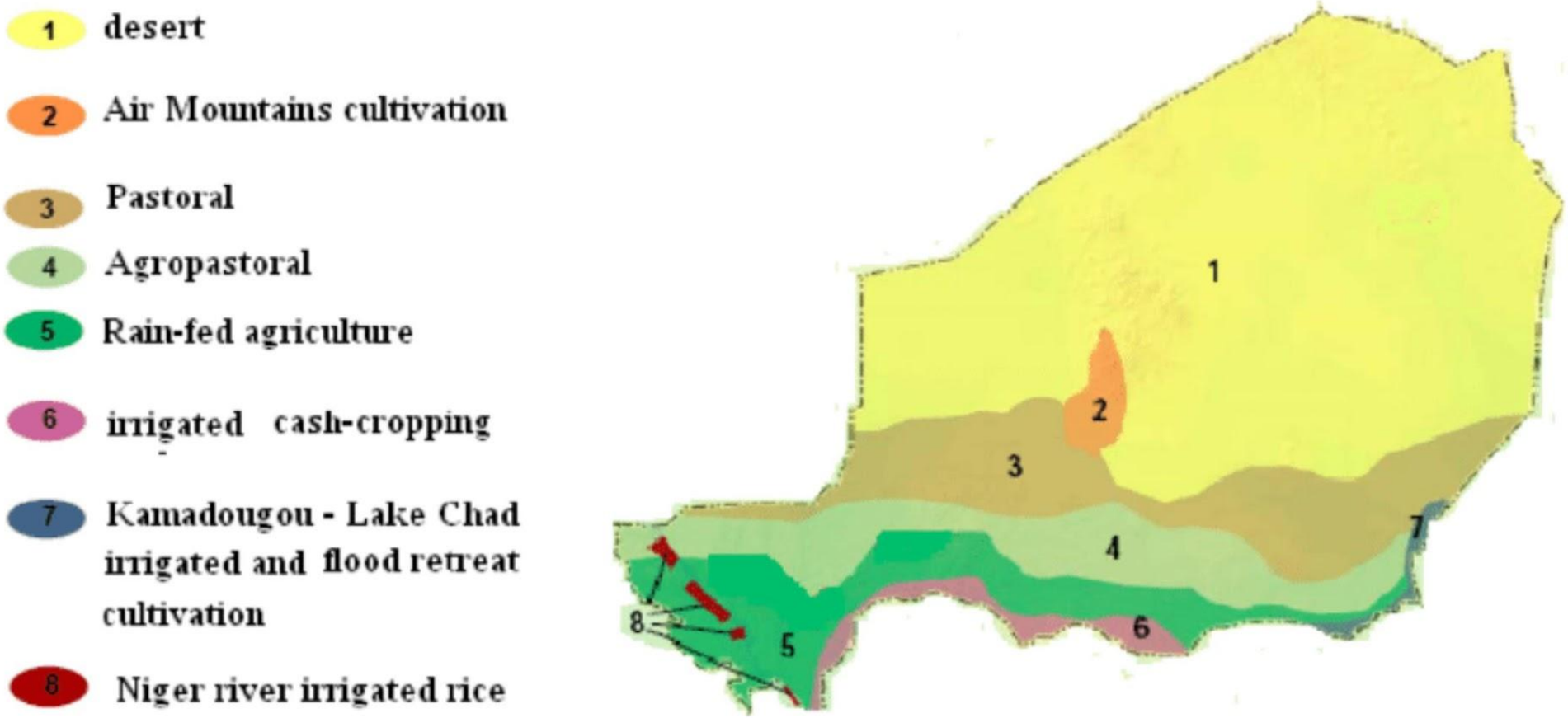
High youth unemployment intensifies land pressure, accelerating land unsustainable land-use degradation and practices, worsening desertification in the Sahel.

DEMOGRAPHIC SHIFT

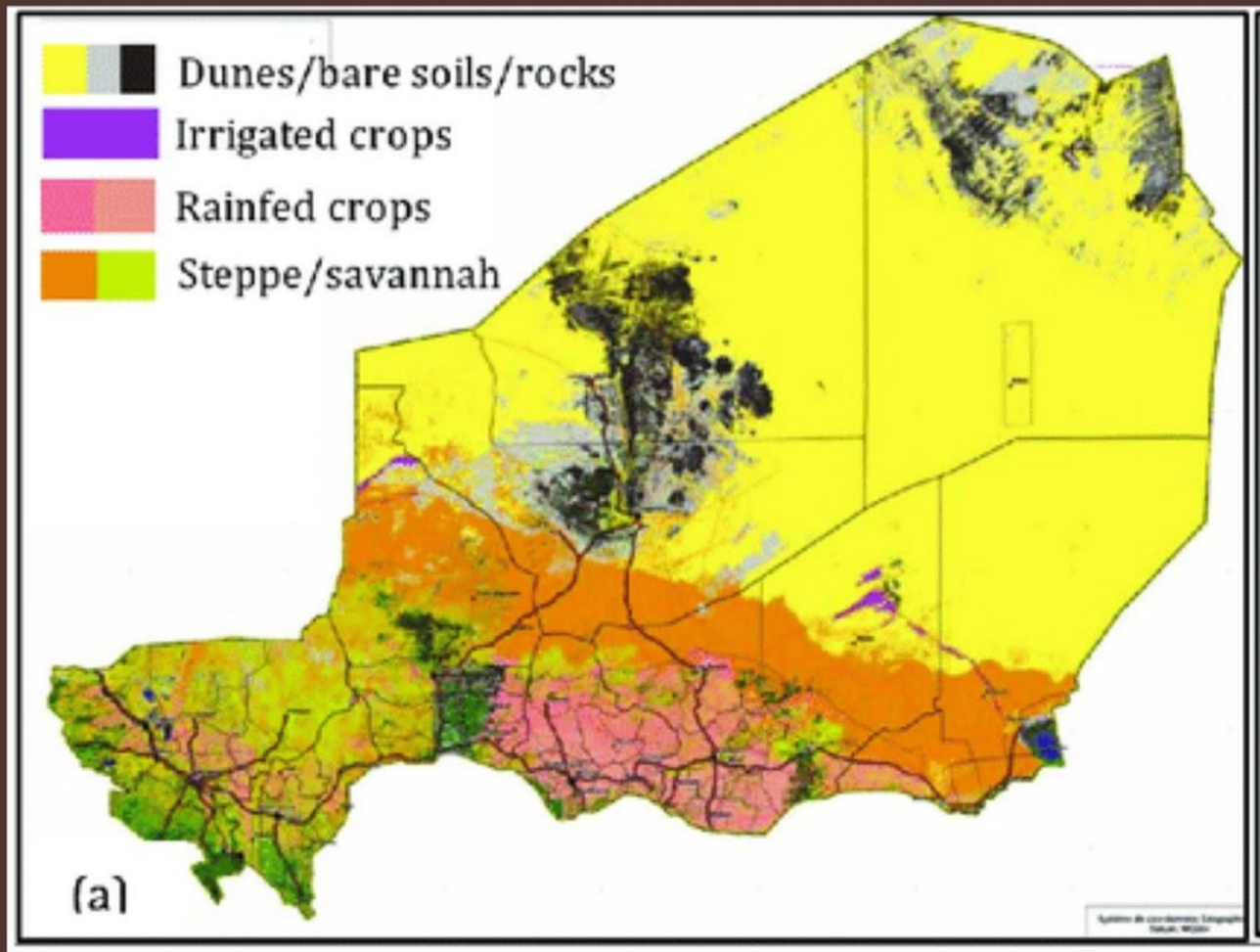
Rural-urban youth migrati desertification in the Sahe

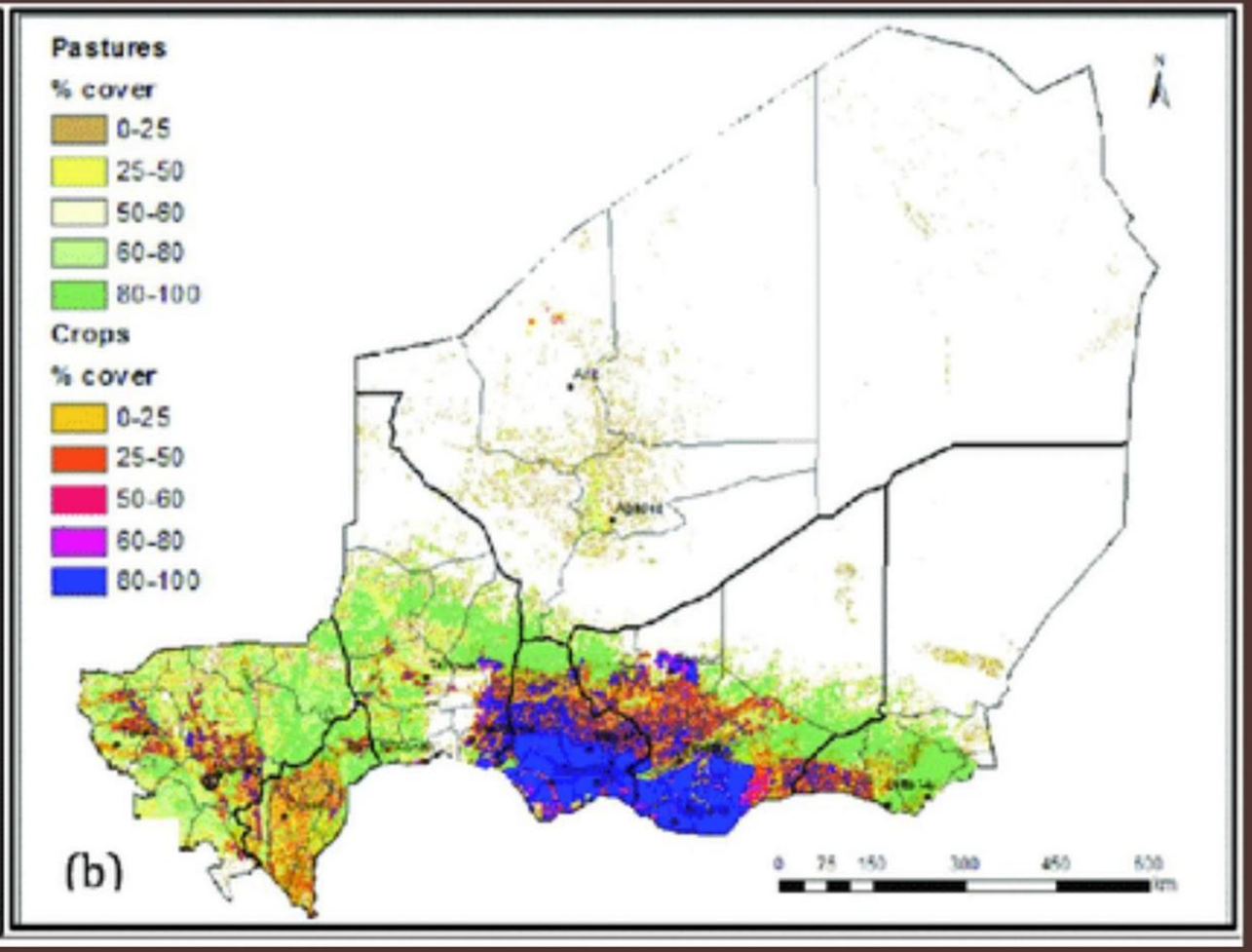
NIGER AGRICULTURE

NIGER AGRICULTURE



Most parts of Niger are deserted, but the southern parts flourish with vegetation, particularly in the region of the Niger River Delta, which is their main source of water.





Here, we can discern the geographical divisions:
Areas devoid of crops, Regions cultivating rainfed crops,
and Zones where crops are irrigated

MAIN CROPS GROWN

RICE

SORGHUM

MAIZE

MILLET

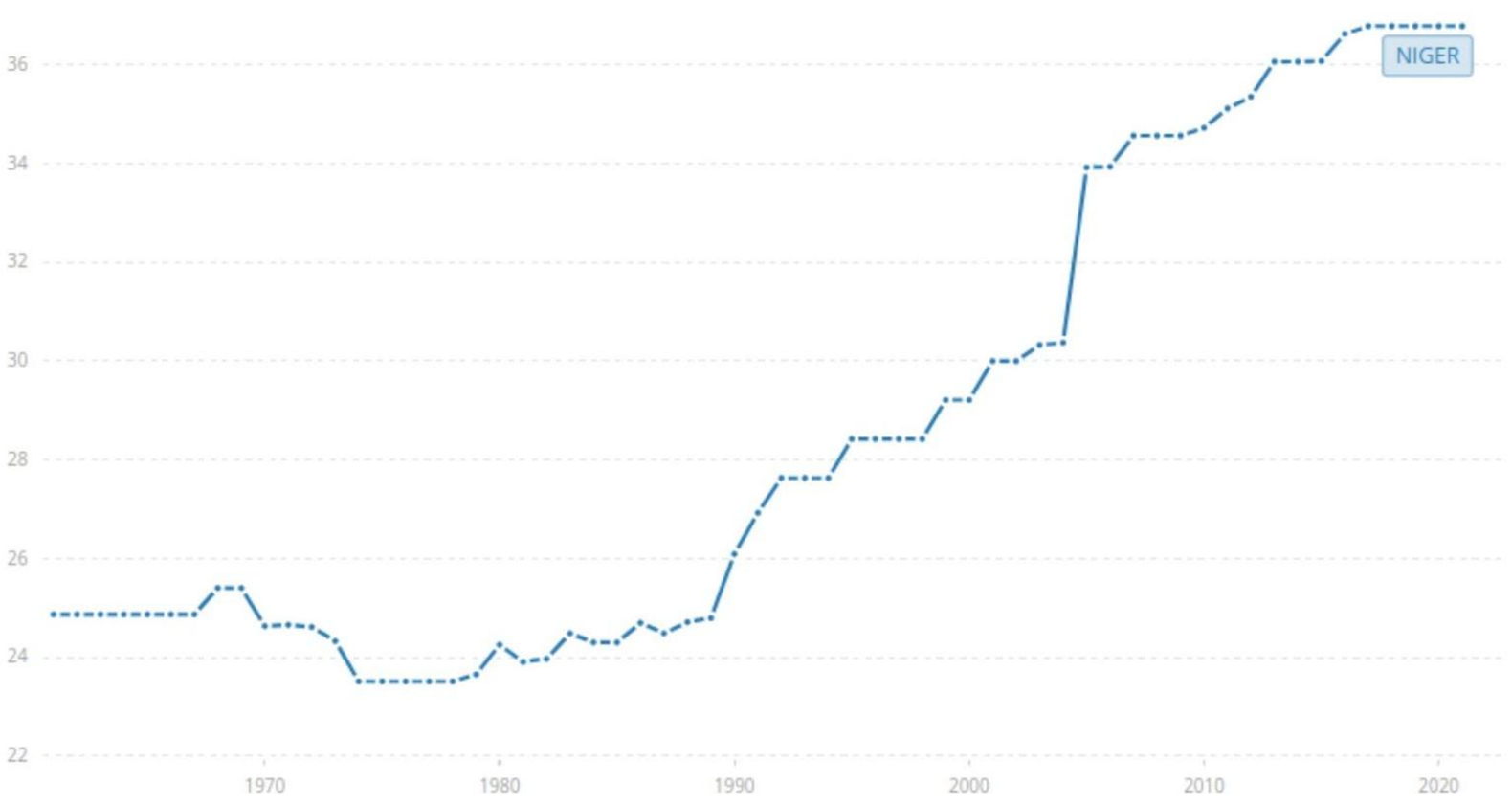
NIGER
AGRICULTUTRE

Why Did Agriculture, Once Vital, Experience a Shift?

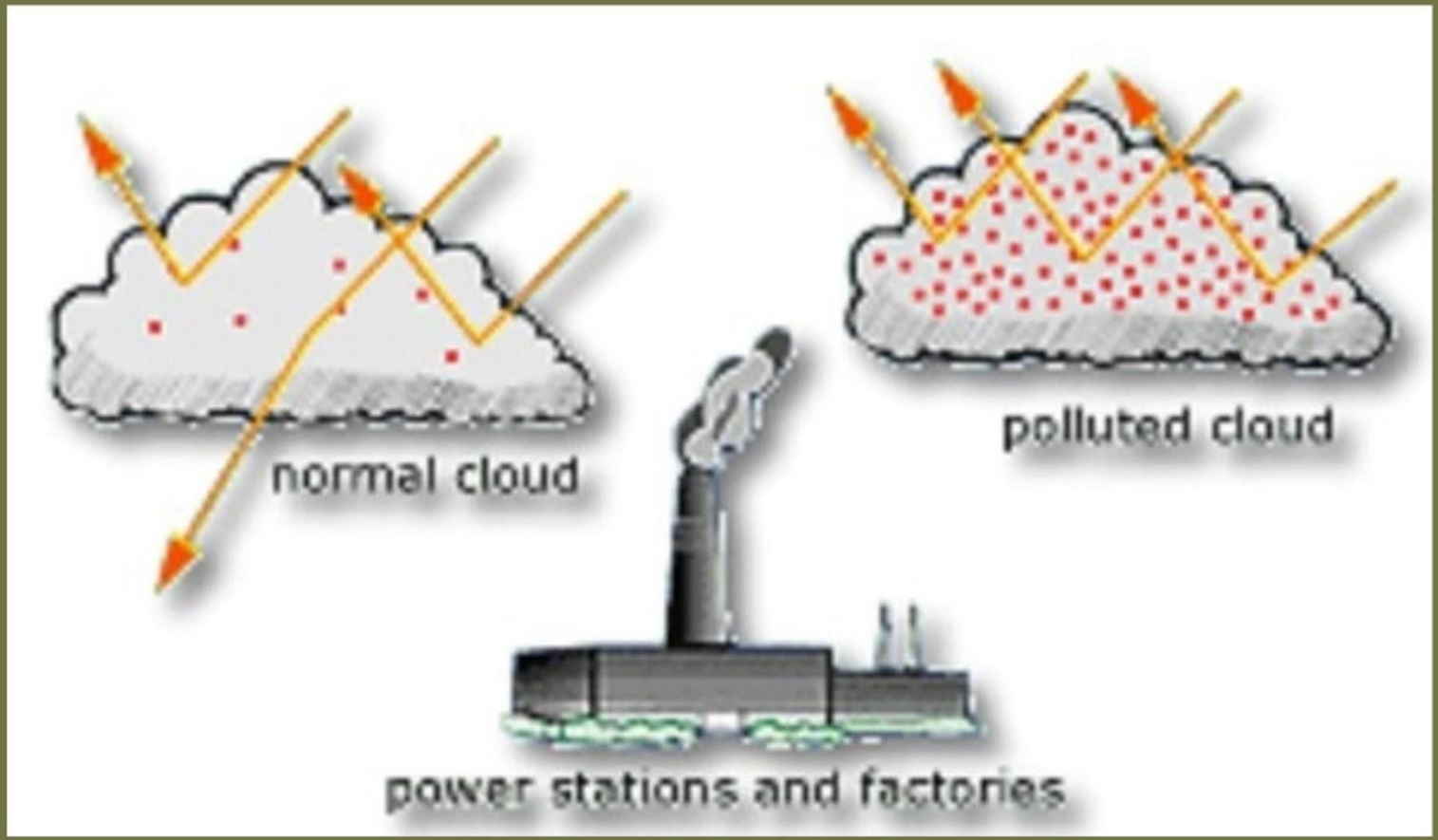
We can observe that the region boasts a robust river delta, ideally suited for cultivating water-intensive crops such as rice, indicating the pivotal role of agriculture in the local economy. Nevertheless, an intriguing question arises:

What transpired during the 1970s, resulting in a reduction of agricultural land?

What key factors precipitated this decline?

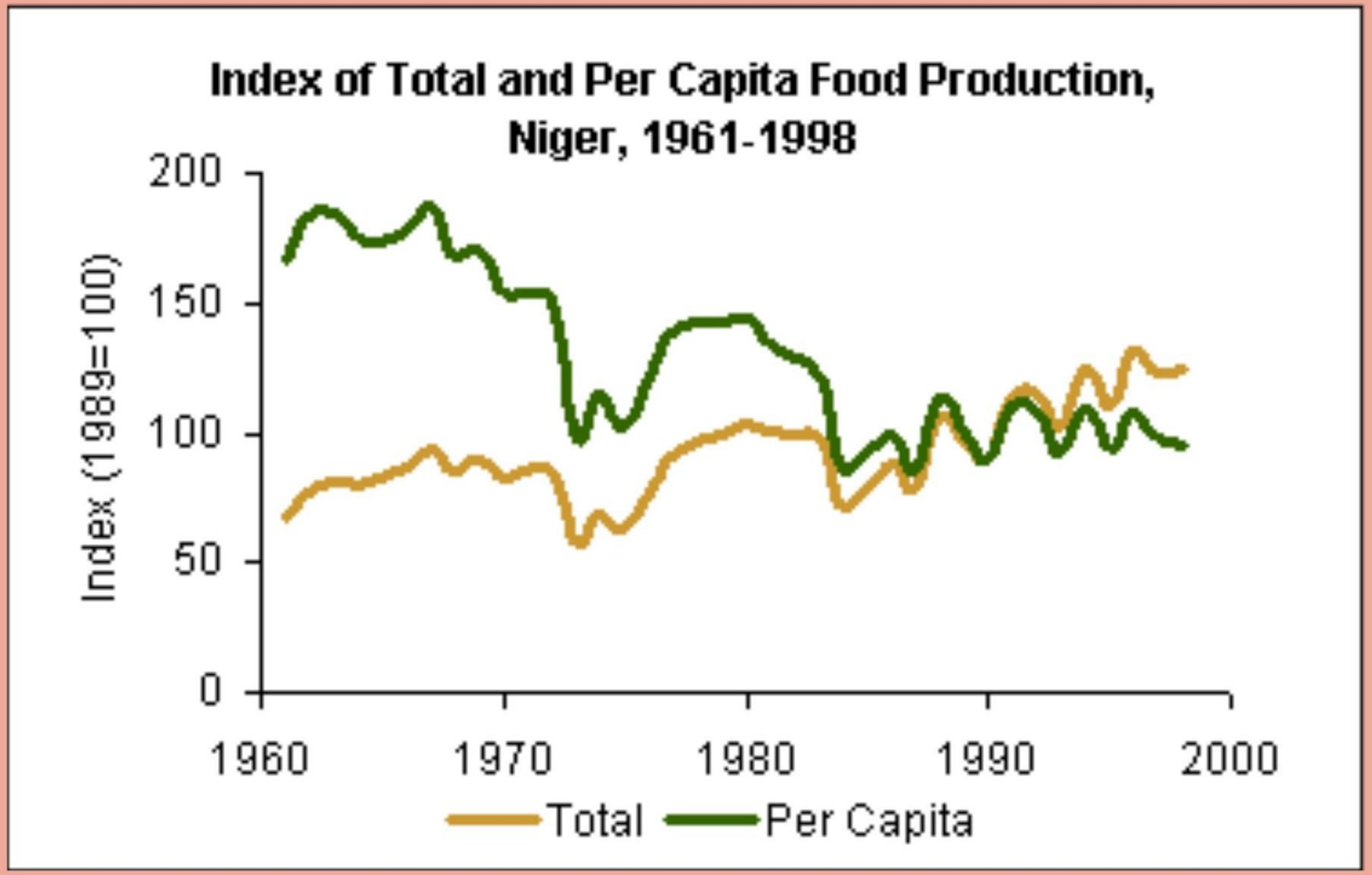


Global Dimming



Global dimming is a process by which less direct sunlight reaches Earth's surface due to aerosol particles, dust, and pollution in the atmosphere that reflect sunlight back into space. Global dimming was observed throughout the second half of the twentieth century.

After conducting some studies, it became evident that the primary reason for the decrease in agriculture and food availability was the decline in food crops, attributed to a lack of rainfall.This deficiency in rainfall was caused by reduced evaporation, a phenomenon linked to global dimming



In the graph presented above, we can discern both per capita and total effects

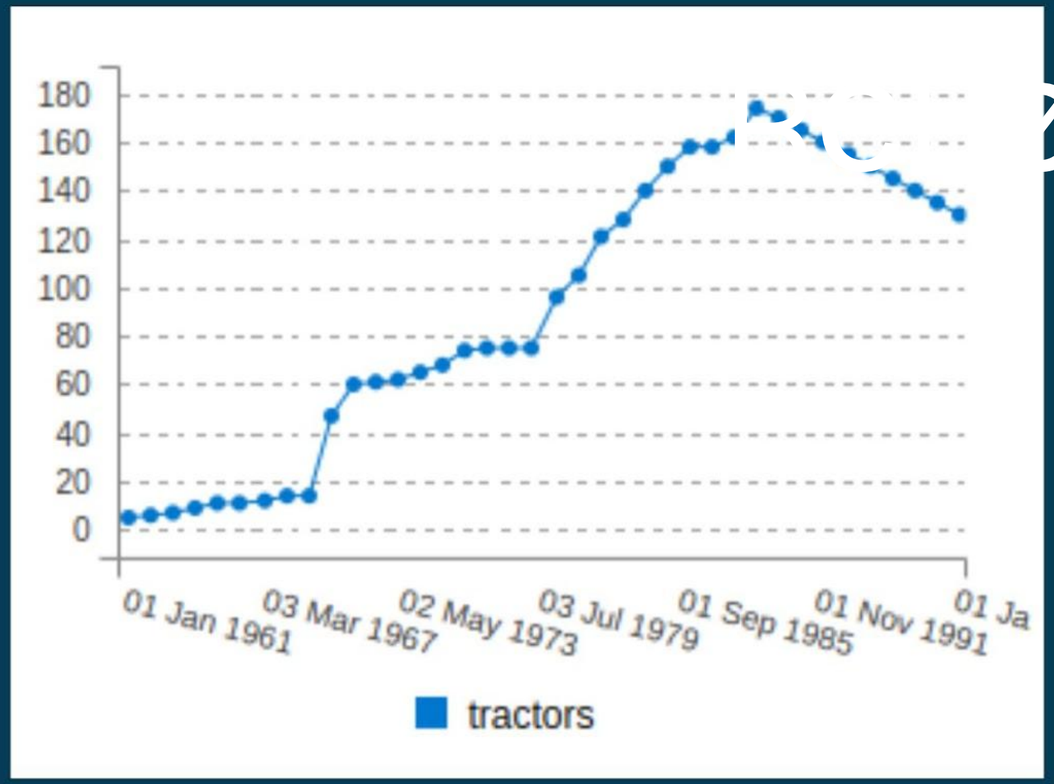
SUMMARY

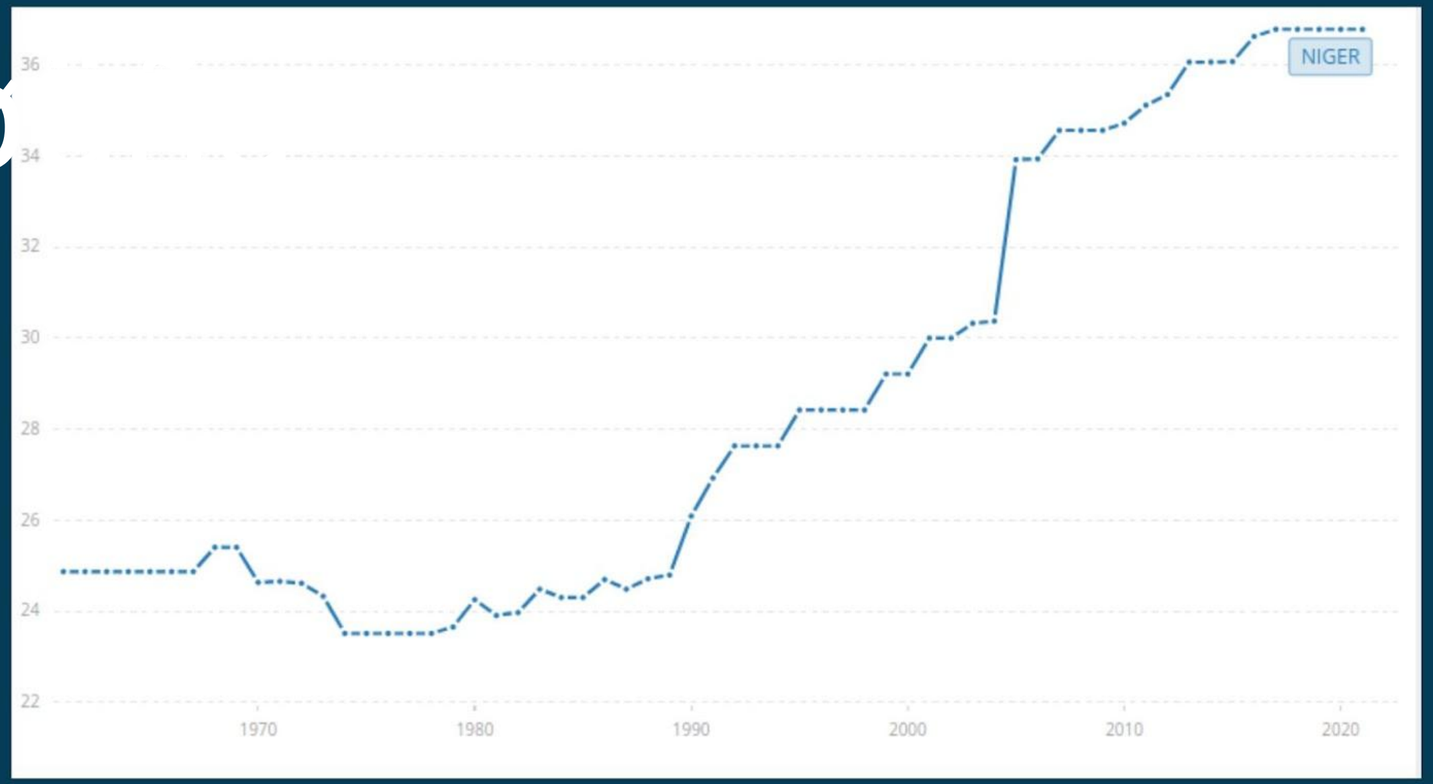
- *Global dimming reduced rainfall in Niger by an average of 20% between 1960 and 1990. This decline significantly impacted crops highly dependent on rainfall.*

- *This reduction of agricultural production caused Niger's GDP growth rate to slow down to 0.5% per year during the 1970s and 1980s, which caused an increase in poverty from 40% in 1970 to 60% in 1990.*

- *Factors such as population growth, land degradation, and climate change also contributed to the economic and agricultural challenges faced by Niger during this period.*

Agricultural





Agricultural Machinery, Tractors

% of Agricultural Land

Recovery is evident in the statistics, but what might be the primary contributing fac

USAID

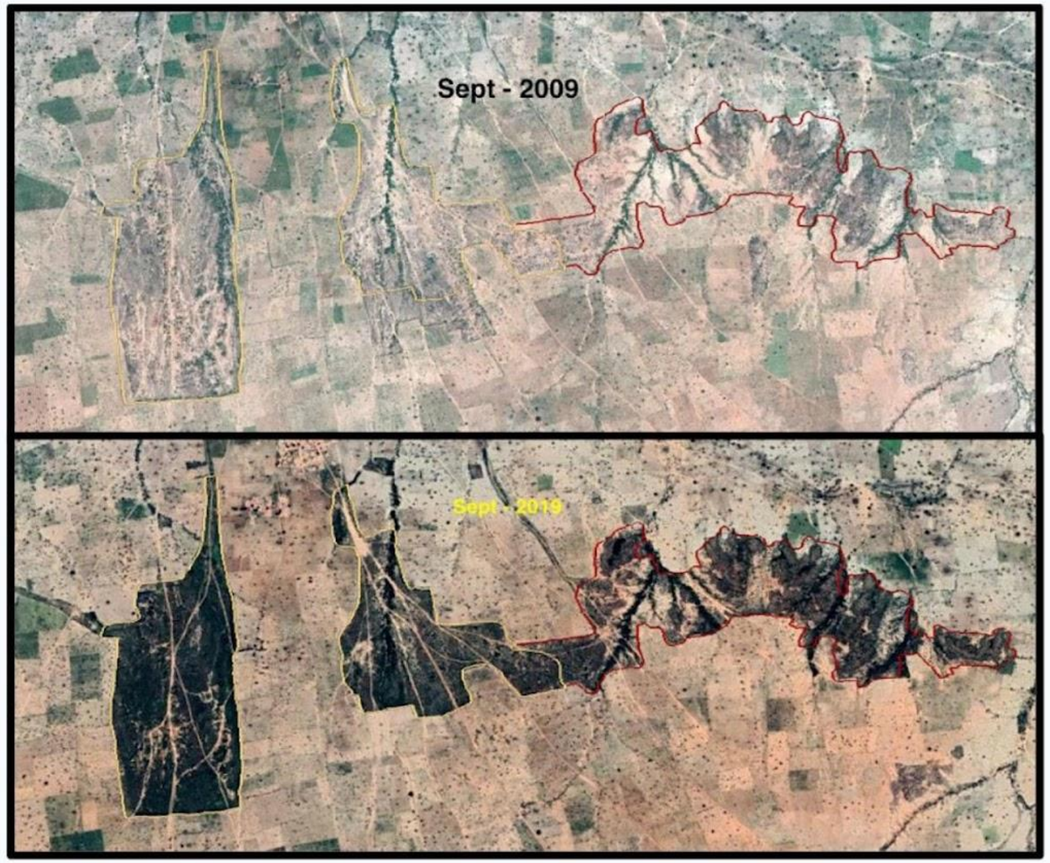
Efforts by USAID and Development Organizations:

- **Investments by USAID and development organizations aimed at enhancing resilience through land rehabilitation activities.**
- **Focus on restoring degraded lands and improving water conservation to support agriculture and food security.**

WFP

The World Food Programme (WFP) has played a significant role in helping the region of Niger by implementing various programs and initiatives aimed at addressing food security and humanitarian challenges

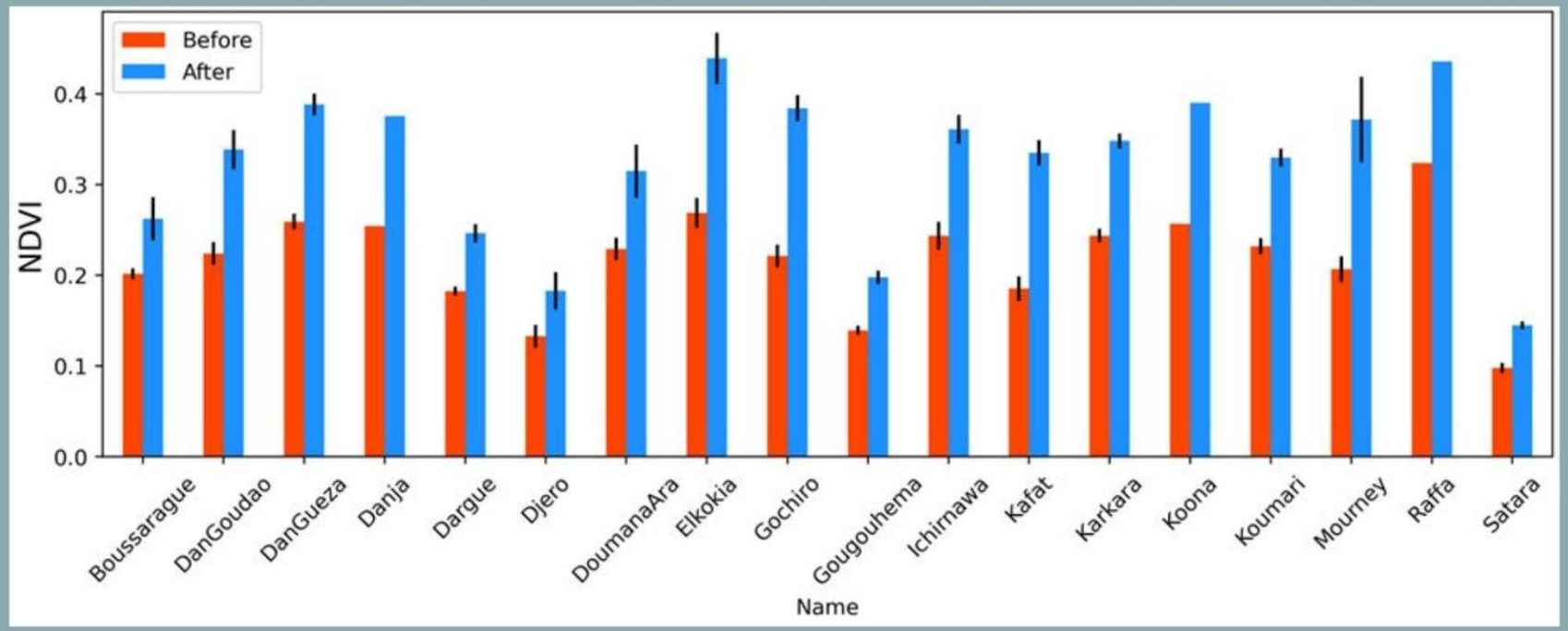
- Providing Food Assistance
- Nutrition Programs
- School Feeding Programs
- Emergency Response
- Cash and Voucher Assistance
- Agricultural and Resilience Programs
- Advocacy and Awareness
- Monitoring and Assessment
- Capacity Building



Half-Moon Technology

The use of half moons as a technology for water harvesting in Niger is a significant initiative that has been supported by USAID and other development organizations. The practice involves creating half-moon-shaped ditches in the ground to capture and retain rainwater, effectively improving water management and enhancing agricultural productivity.

WHAT IS IT ?



- Half moons are a water harvesting technique in which small, crescent-shaped ditches are dug into the earth, forming a series of low barriers that slow the flow of rainwater and encourage its infiltration into the ground.

- This method effectively stores rainwater in the root zone of crops and helps recharge groundwater aquifers. Half moons are typically constructed in parallel rows across fields to maximize water capture. The barriers reduce soil erosion and help conserve precious water resources in a region where water scarcity is a persistent challenge.

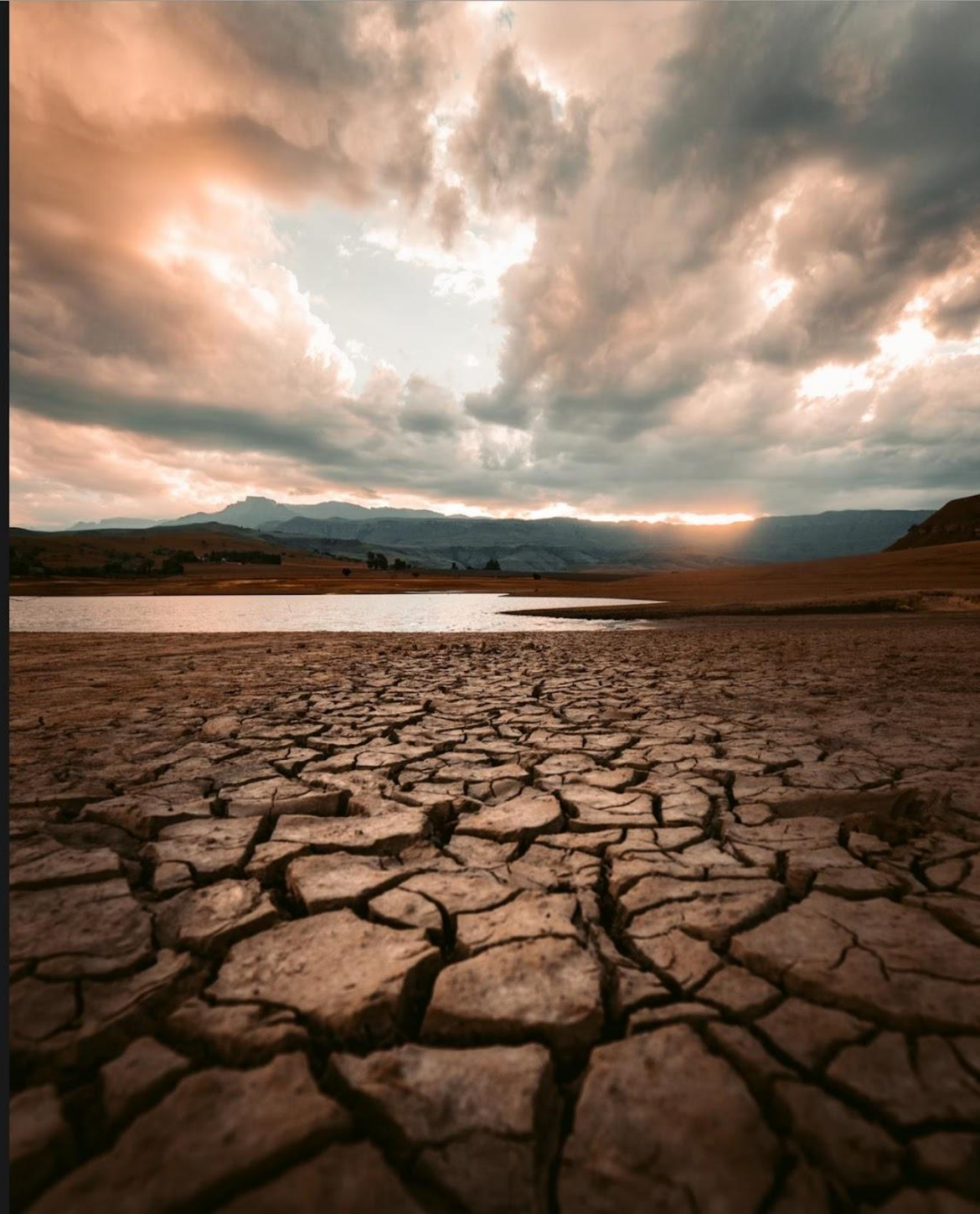
USAID

The adoption of half moons has had a profound impact on the people of Niger. By enhancing water availability for agriculture, it has increased crop production, reduced food shortages, and improved the overall standard of living for rural communities. Furthermore, the technology has empowered farmers to mitigate the effects of drought and adapt to the challenges posed by a changing climate. In addition to improved food security, half moons have also contributed to better income prospects and reduced vulnerability to drought-related crises, ultimately supporting the resilience of Niger's population. The promotion of half moons for water harvesting in Niger, supported by USAID and other organizations, has proven to be a sustainable and effective solution to combat water scarcity and enhance agricultural productivity, thereby positively impacting the lives of the people in this region.

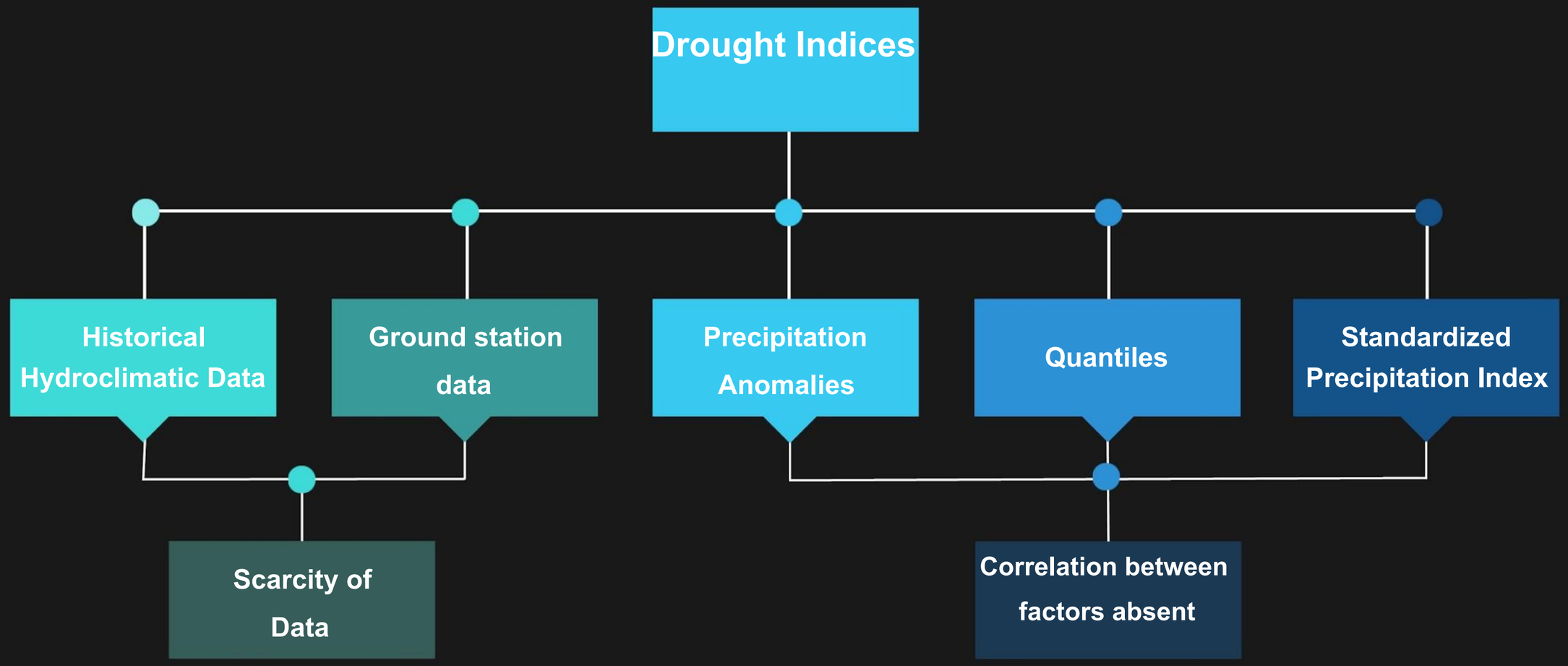
COMPOSITE DROUGHT INDEX - CDI

Drought

- Difficult to accurately identify onset and end as they start and end gradually
- 1.1 Billion people affected by droughts between 1994 and 2013 with Africa being the most affected continent
- Droughts in the Sahelian region in the 1970s and 80s severely impacted livestock and crop productivity
- They also caused land degradation, and hence, ultimately, desertification
- Effective strategies needed to predict droughts along with the susceptibility of regions



ISSUES WITH TRADITIONAL ESTIMATORS



COMPOSITE DROUGHT INDEX (CDI)

- **CDI-3 - CDI values computed over 3 months instead of 1 month**
- **MODIS - MODerate resolution Imaging Spectroradiometer**
- **CHIRPS - Climate Hazards group InfraRed Precipitation with Stations**

VEGETATION

NDVI(**N**ormalized**D**ifference **V**egetation**I**ndex) is used to obatain vegetation info.

Collected from MODIS

TEMPERATURE

LST(**L**and**S**urface **T**emperature) is used to analyse land temperatu

Collected from MODIS

PRECIPITATION

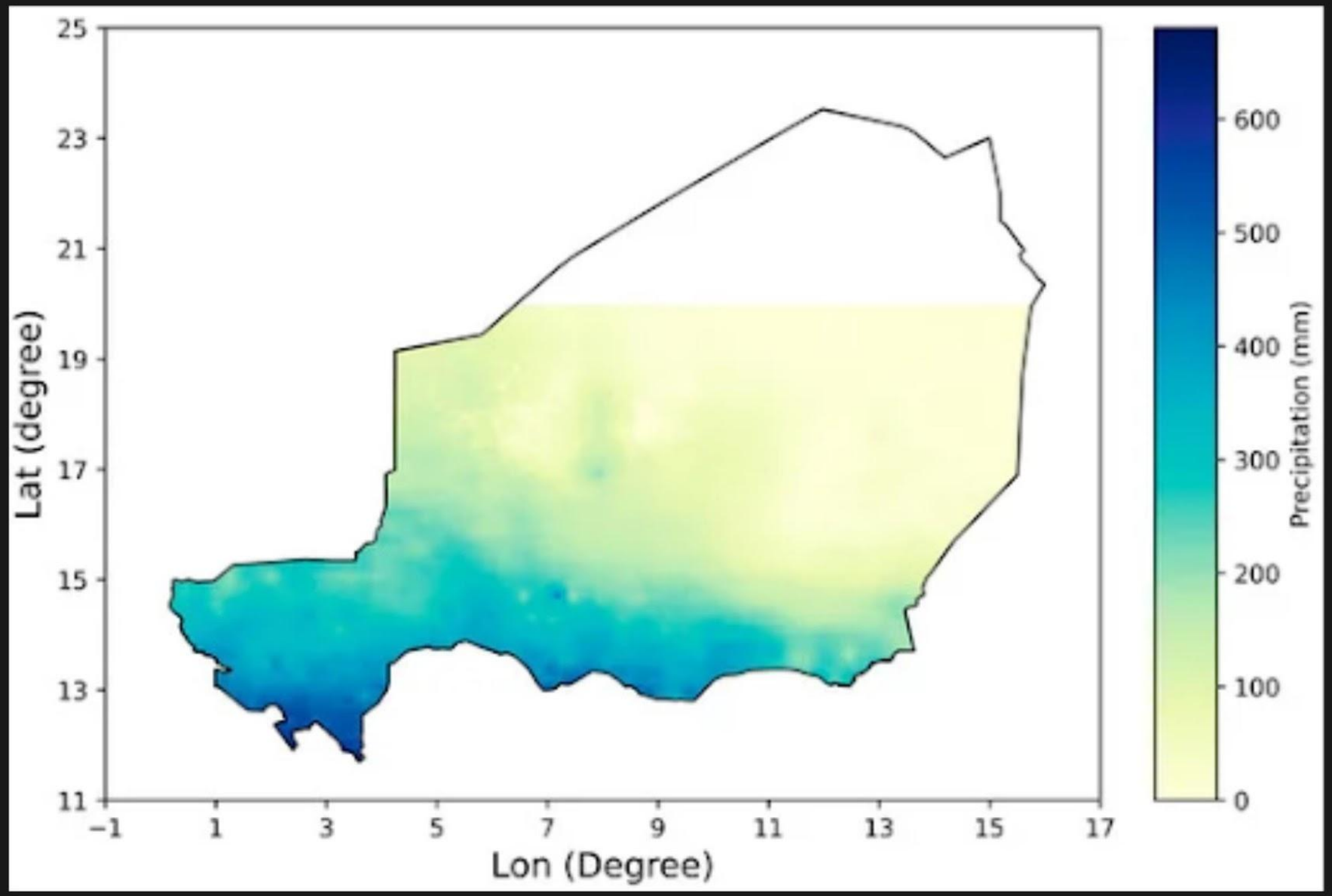
Precipitationdata is used to measure the average rainfall across areas.

Collected from CHIRPS

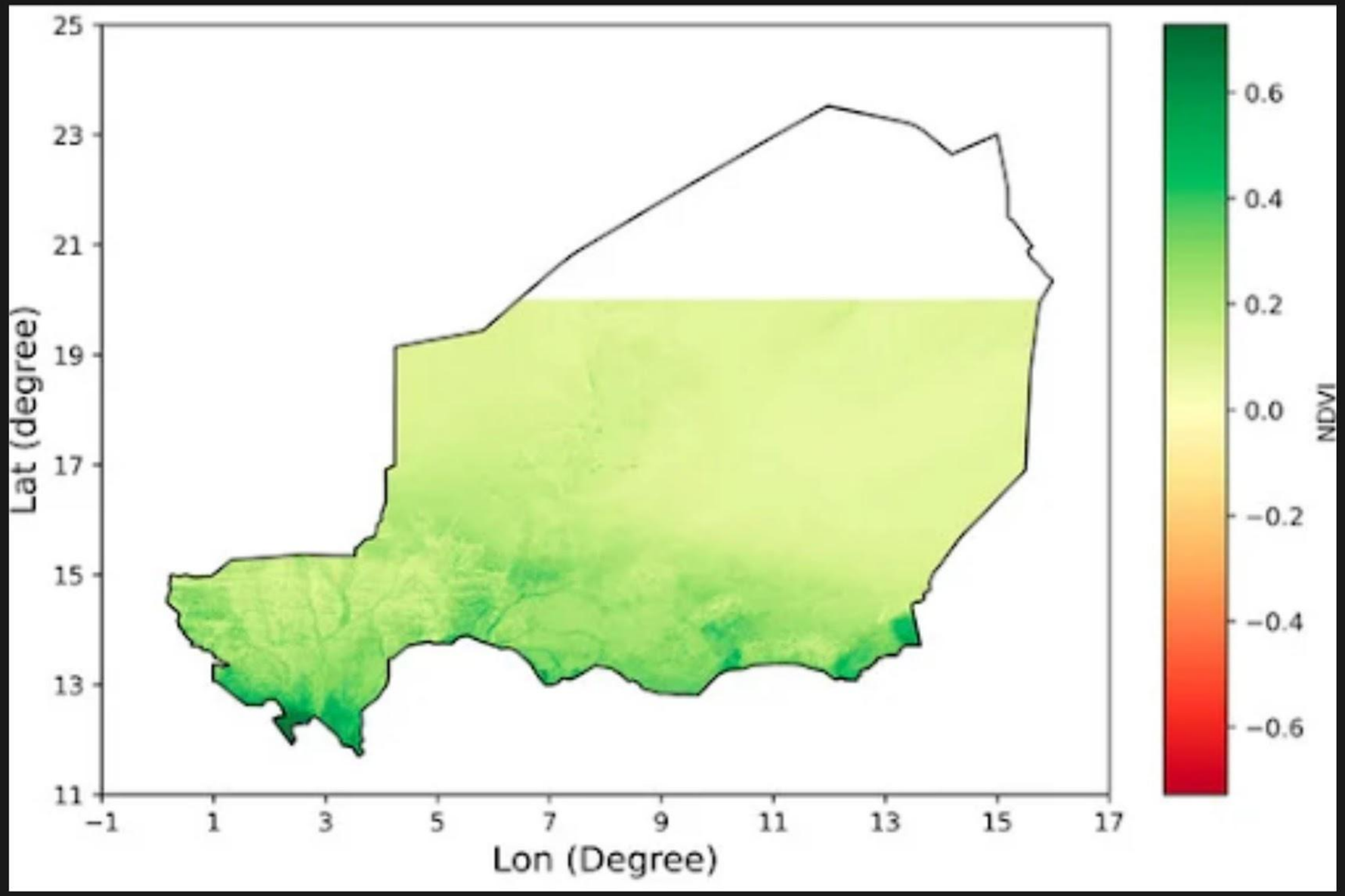
REMOTE SENSING DATA

All data is collected thro remote sensing unlike traditional methods tha on ground stations

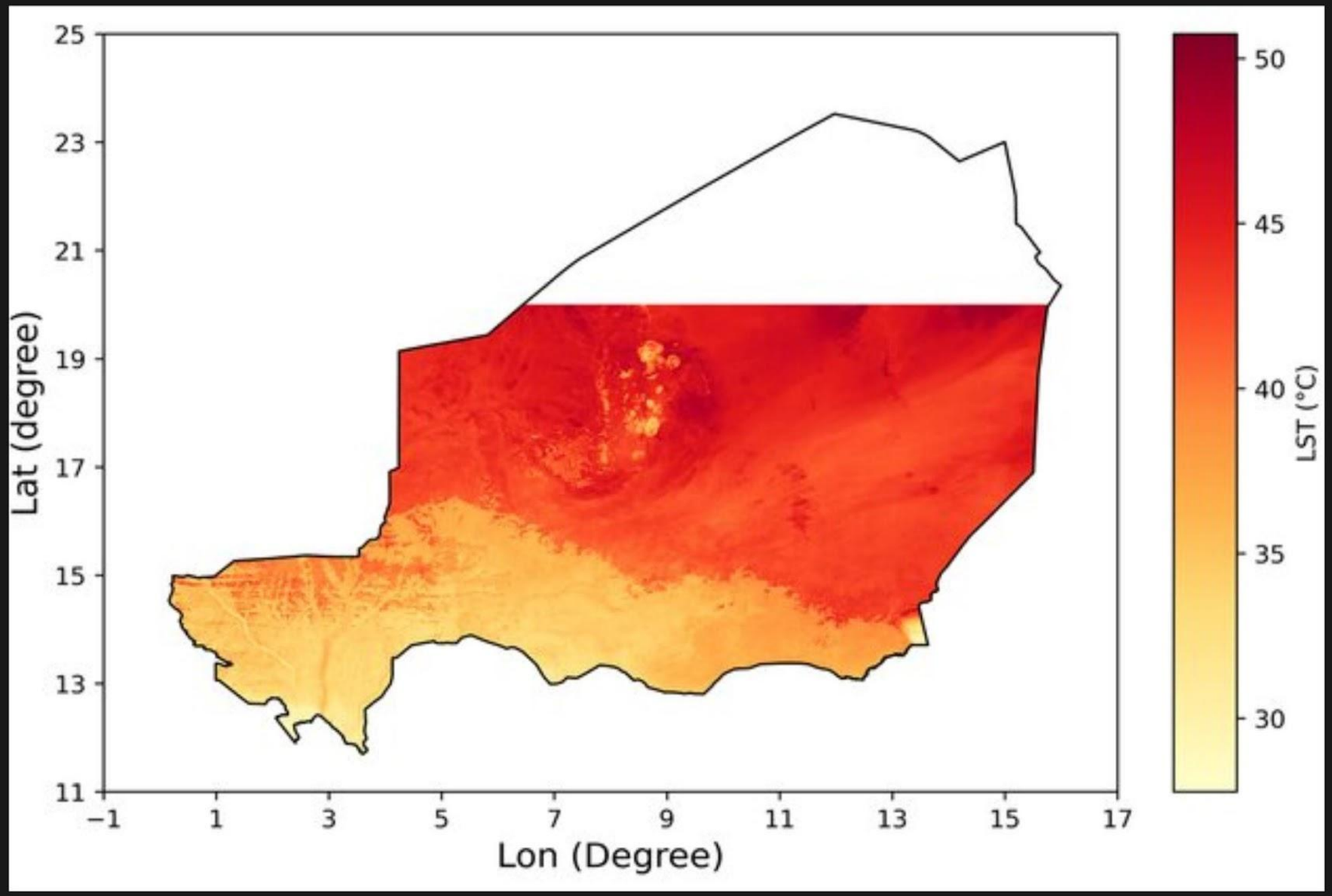
Mean seasonal rainfall (2000-2020)



Mean seasonal NDVI (2000-2020)



Mean seasonal daytime LST (2000-2020)



VARIABLE PREPOROCESSING AND VALIDITY ESTIMATION FOR CDI CALCULATION

PRECIPITATION

CHIRPS precipitation data has to be bias-corrected using ground observation data and resample to it to 1km x 1km resolution

NDVI

The MODIS NDVI measurements are impacted by aerosol content in the atmosphere but found to have an overall accuracy within ±0.025 units across the Sahel region

LST

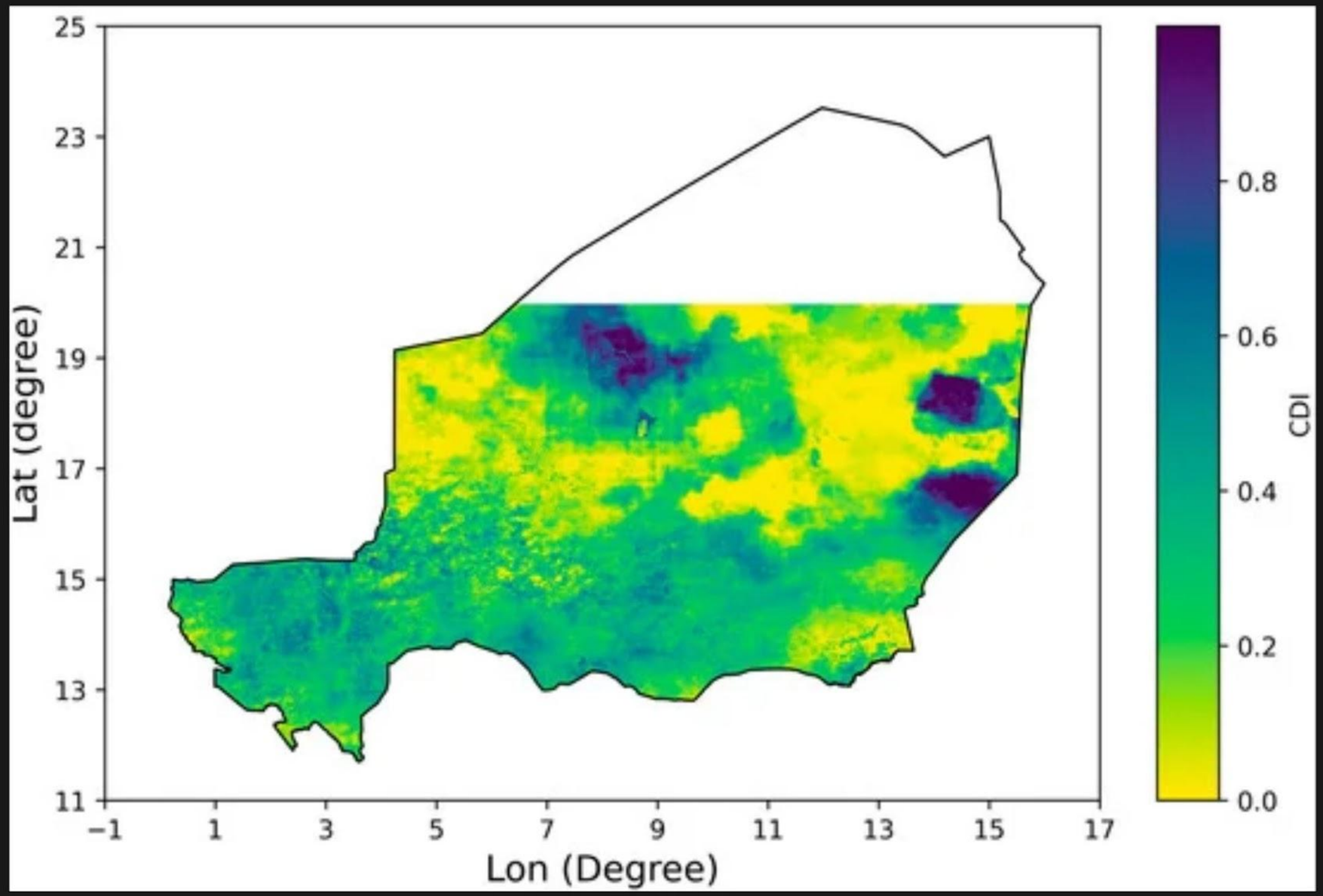
The MODIS LST has b shown to be valid acr various land cover types various studies irrespectiv the atmospheric condit

CDI CALCULATION

5-Step Process with 3 variables - Precipitation, NDVI, LST

1	2	3	4	5
Variable Categorisation & Normalisation	**Entropy Measure & Degree of Diversification**	**Entropy Weights**	**Maximum Driest Condition, MDC & Maximum Wettest Condition, MWC**	**CDI from Present Condition (PC & MWC, MDC**

Drought map of 2000 based on CDI-3

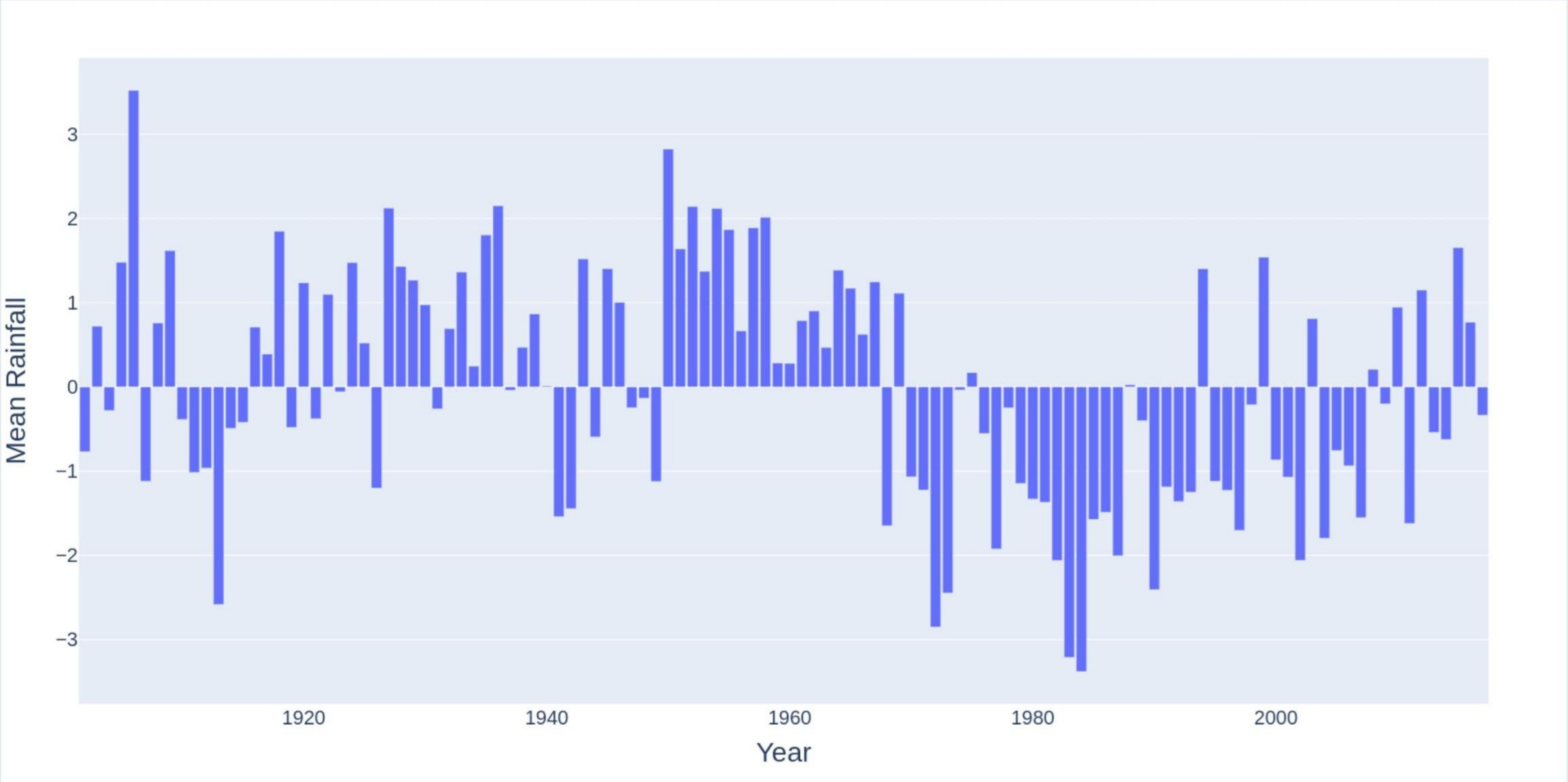


DROUGHT CLASSES

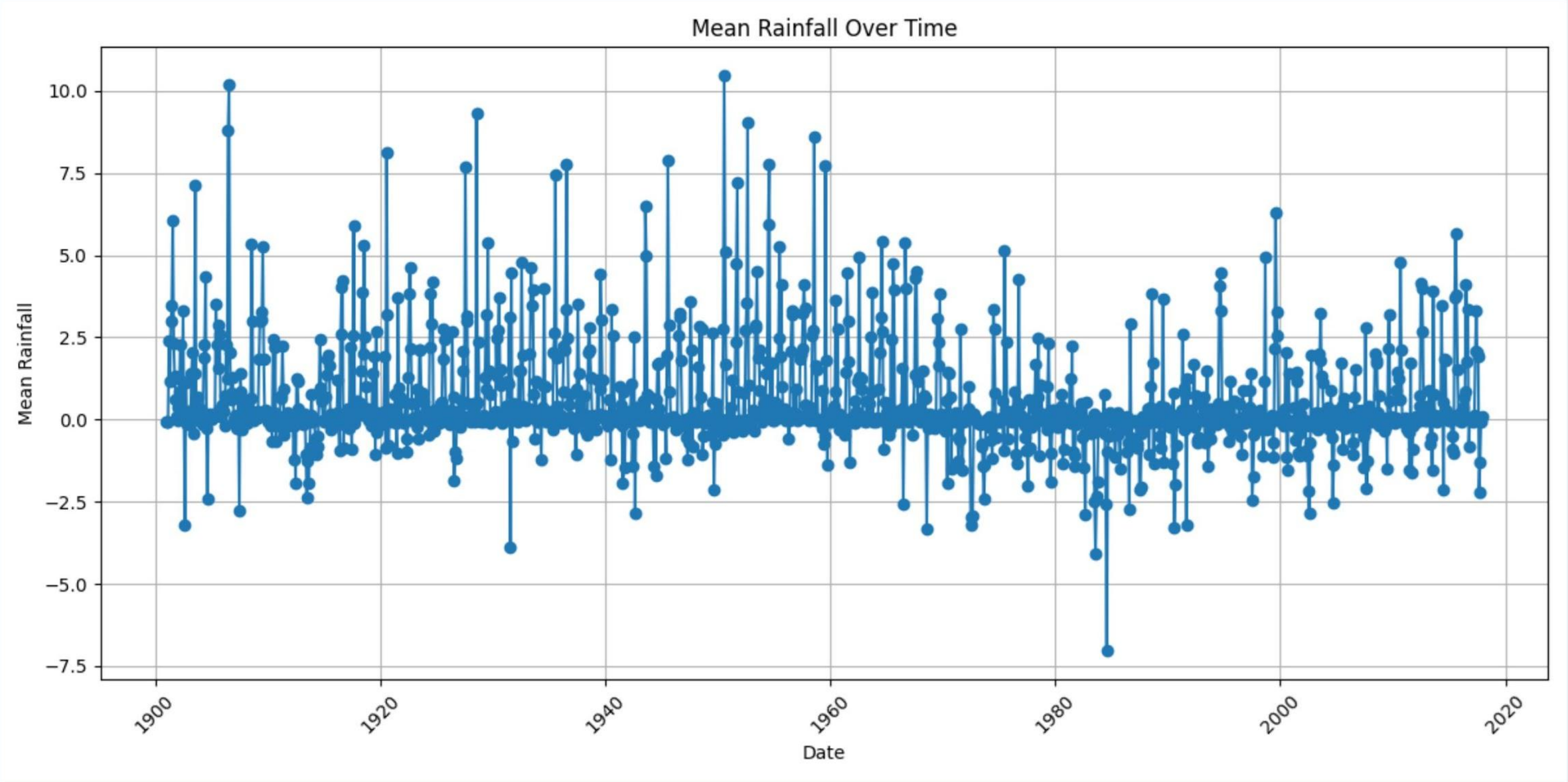
BASED ON CDI VALUES

CDI Interval	Classification
<0.1	Extreme Drought
0.1-0.2	Severe Drought
0.2-0.3	Moderate Drought
0.3-0.4	Mild Drought
0.4-0.5	Near Normal
>0.5	Above Normal

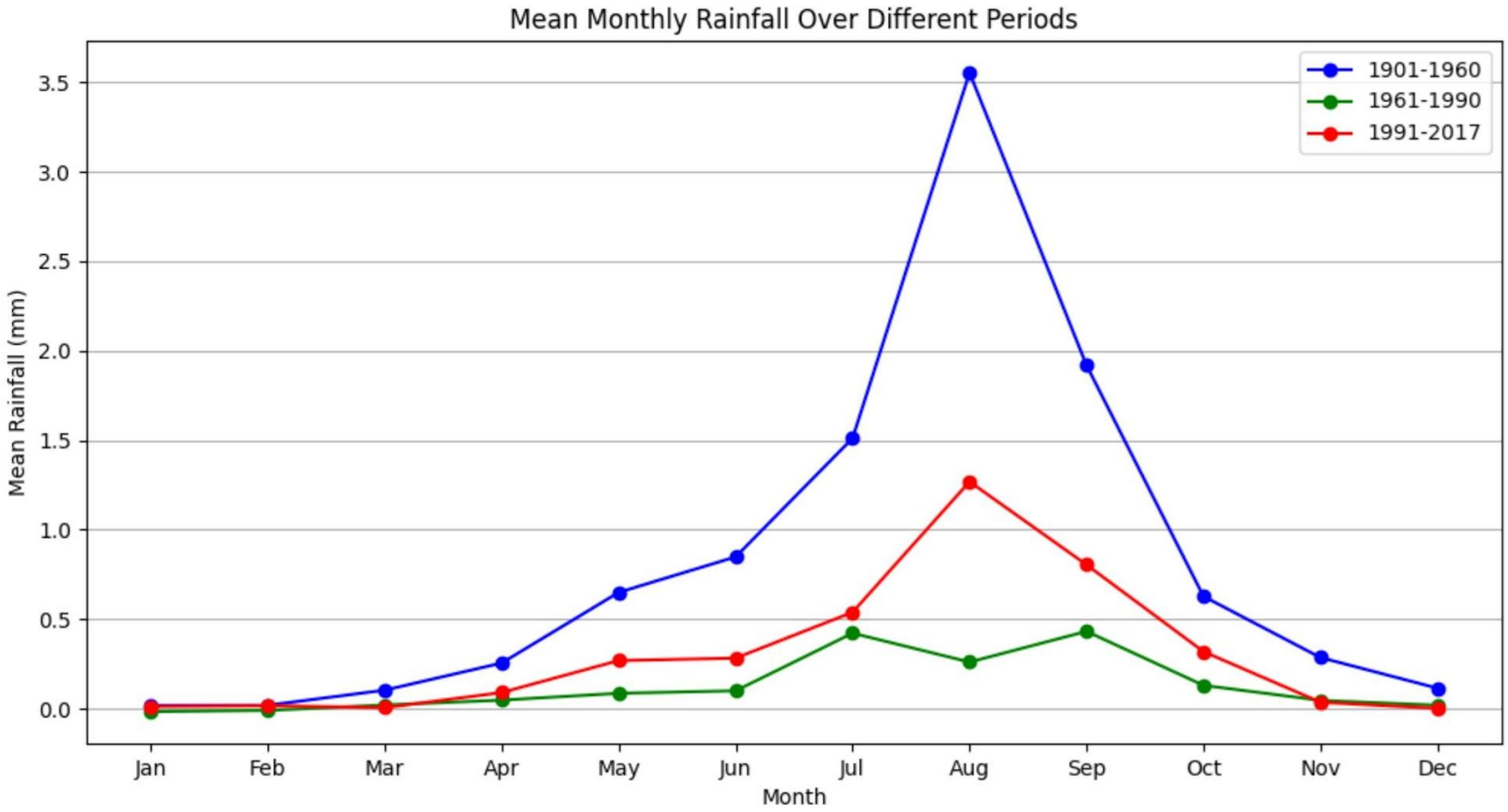
Mean Annual Rainfall



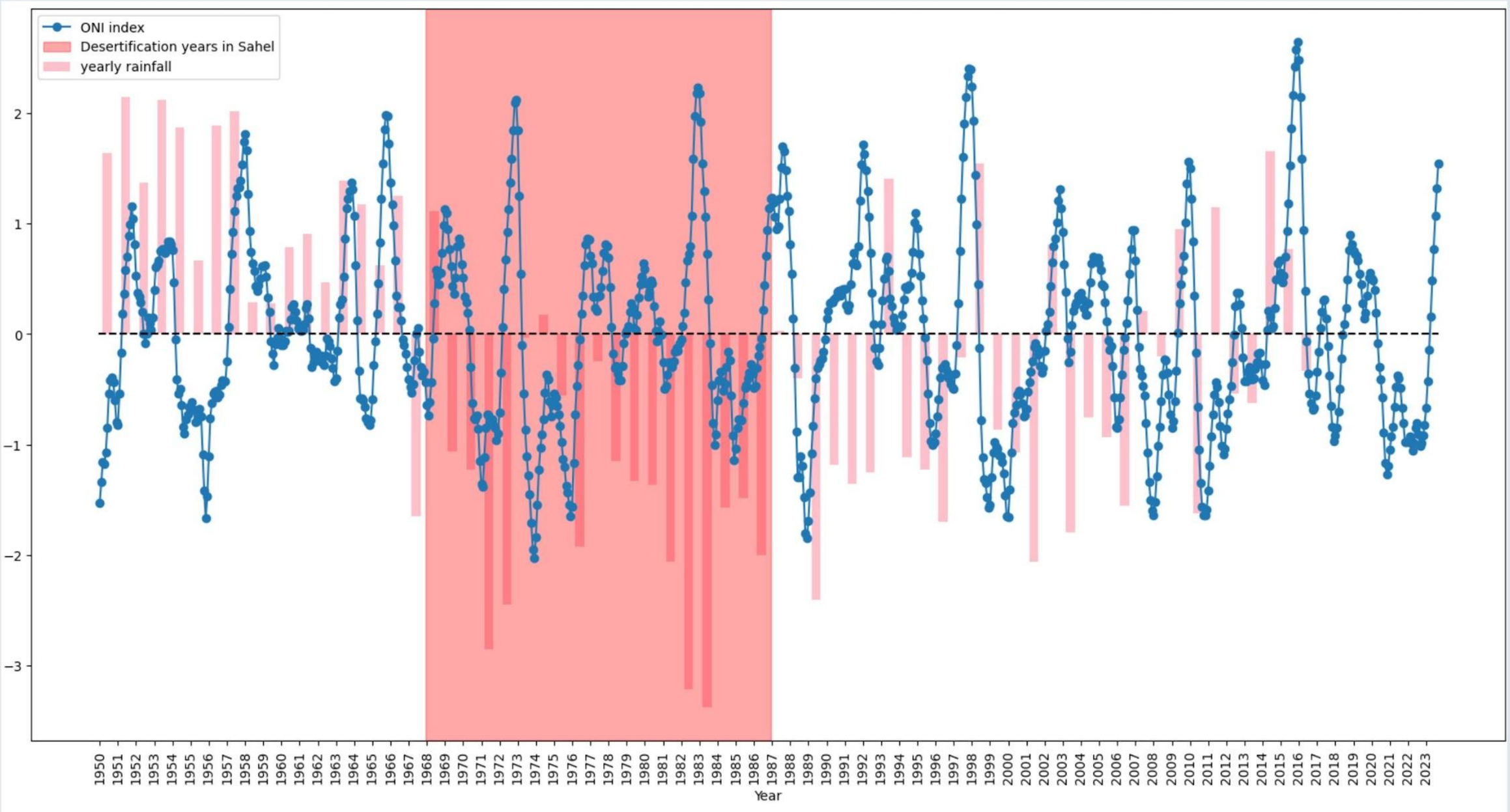
Average Monthly Rainfall



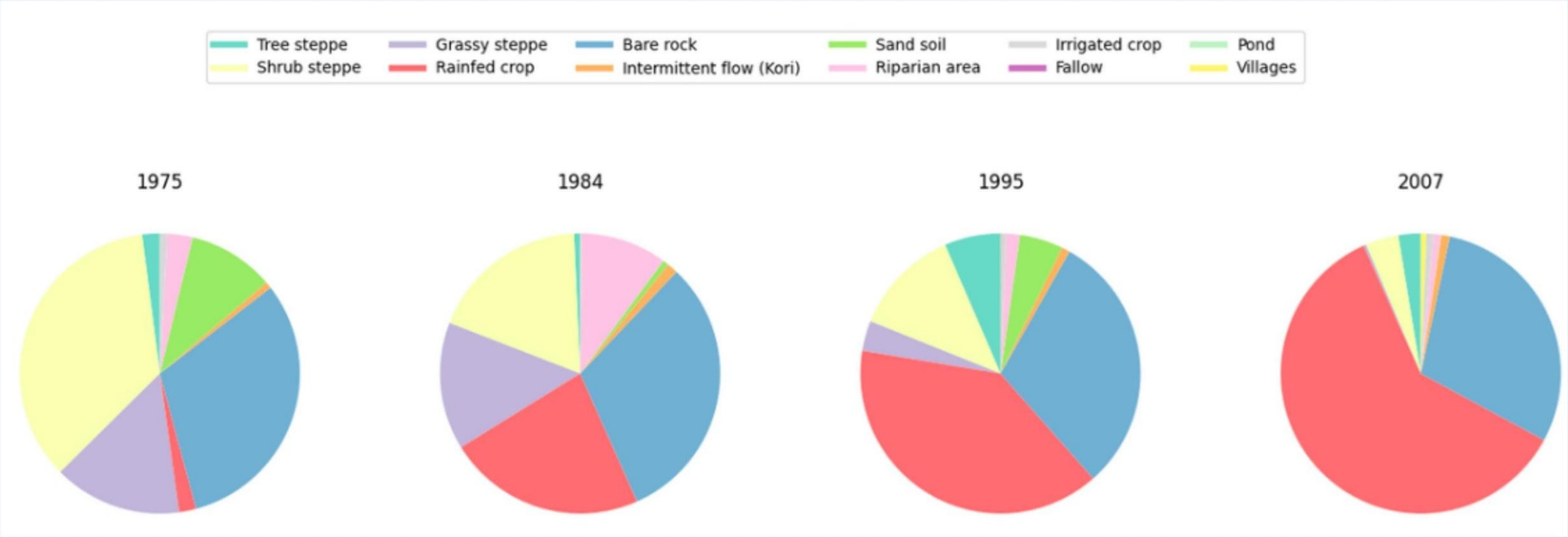
Monthly Rainfall Across Desertification Phases



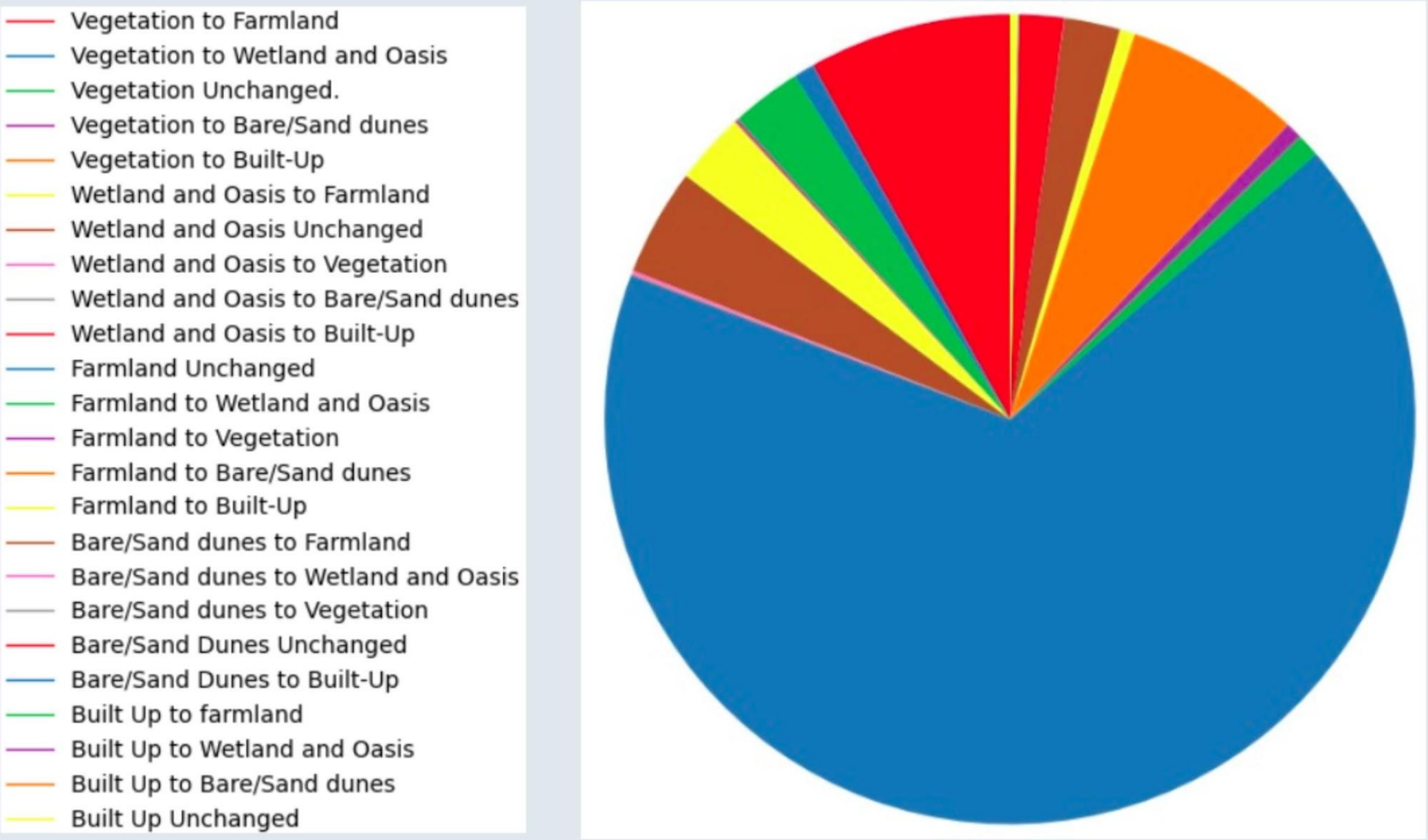
Effect of El-Nino on Precipitation in Sahel



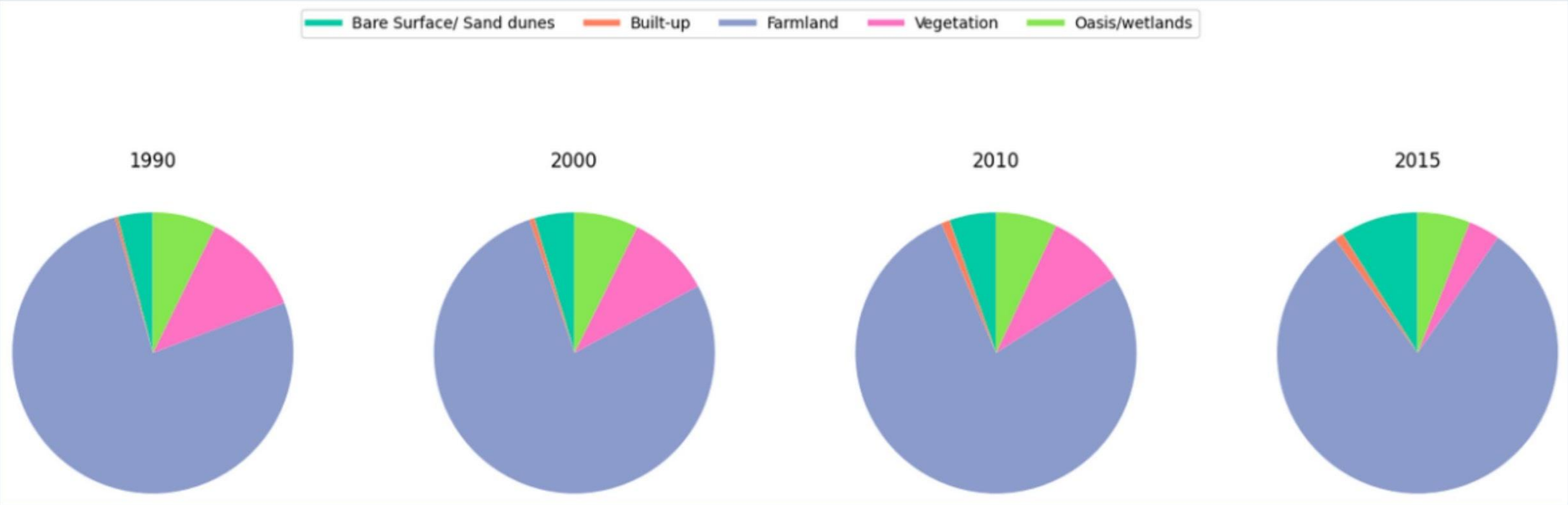
DISTRIBUTION OF LAND USAGE IN KEITA VALLEY



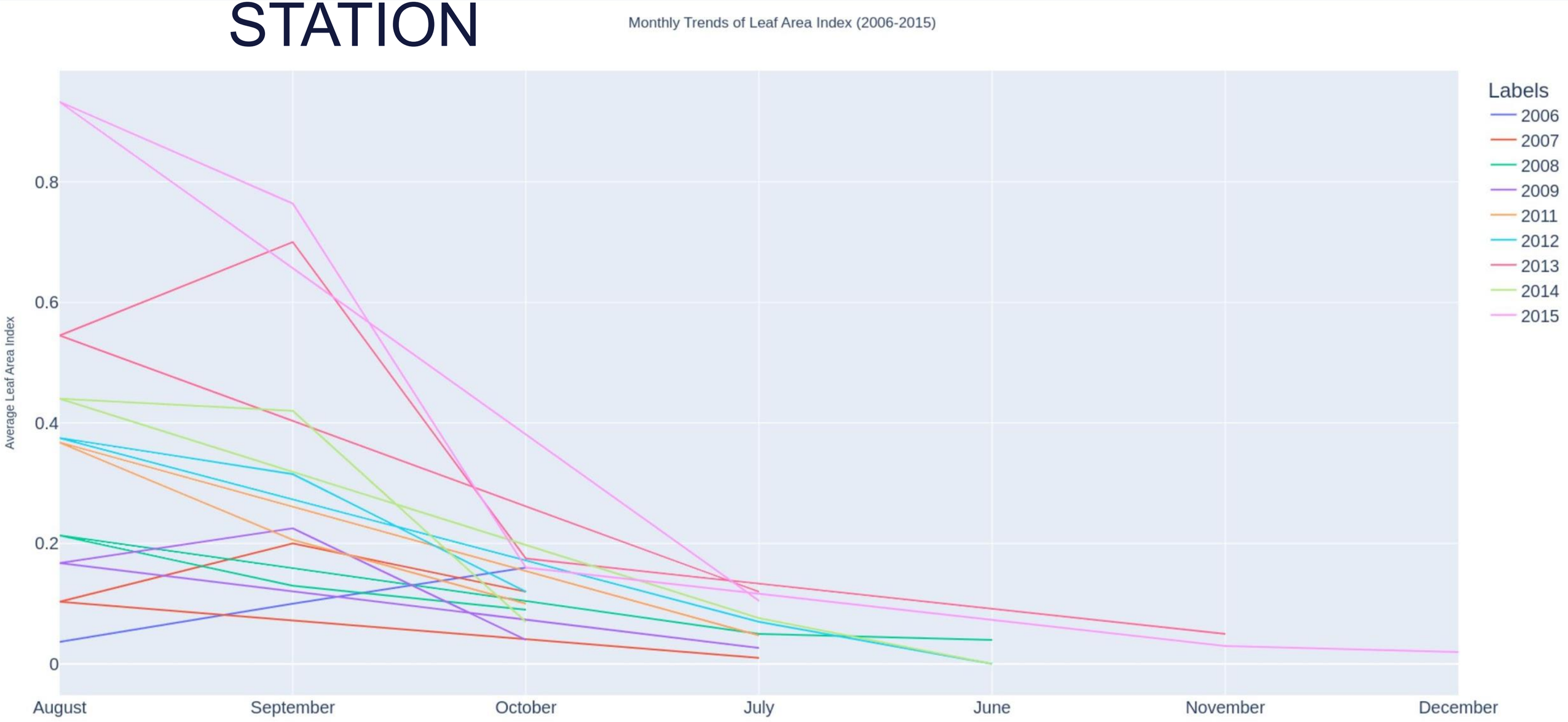
Land Cover Conversions from 1990 to 2015



Land Cover Changes from 1990 to 2015



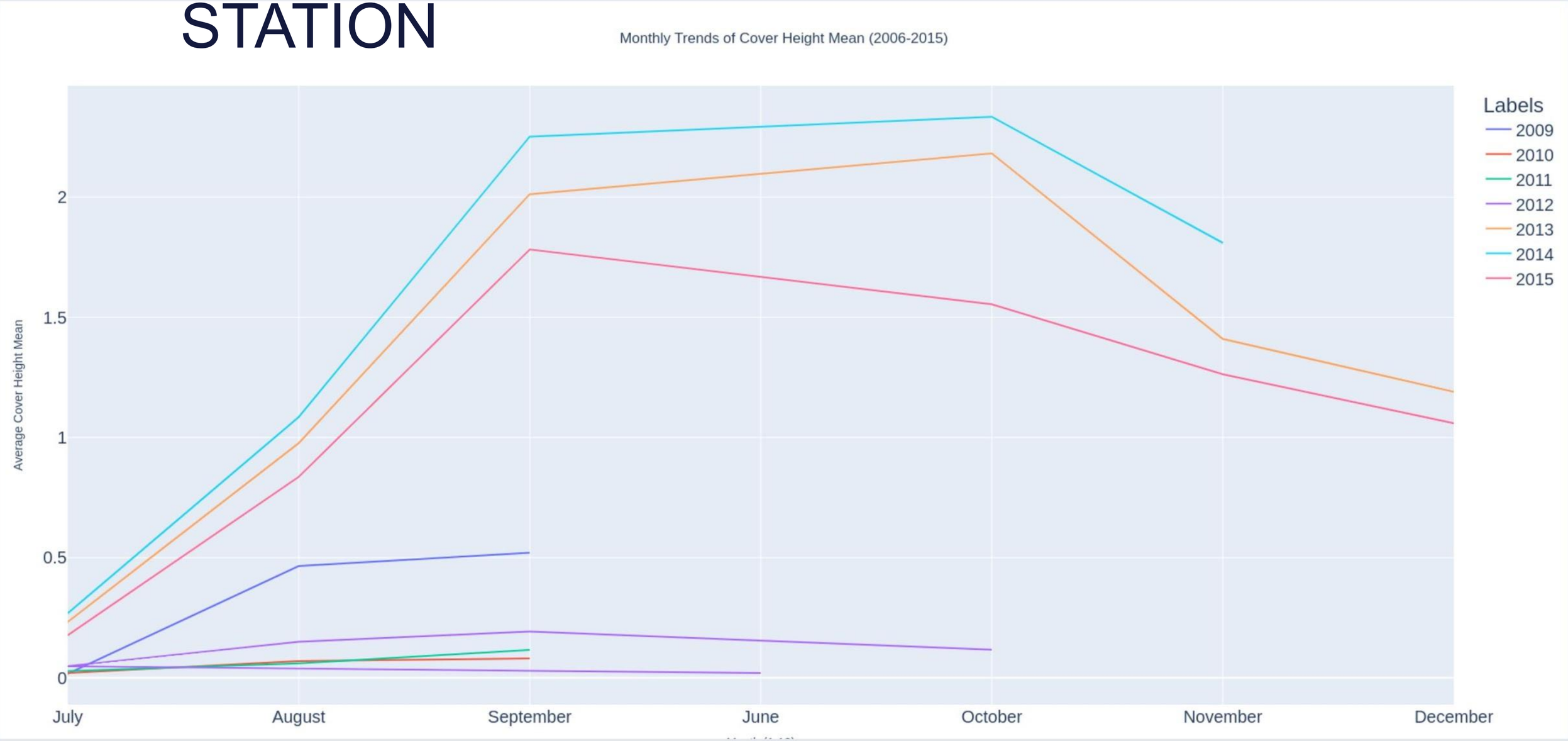
LEAF AREA INDEX - WAKANAMA_SUD STATION



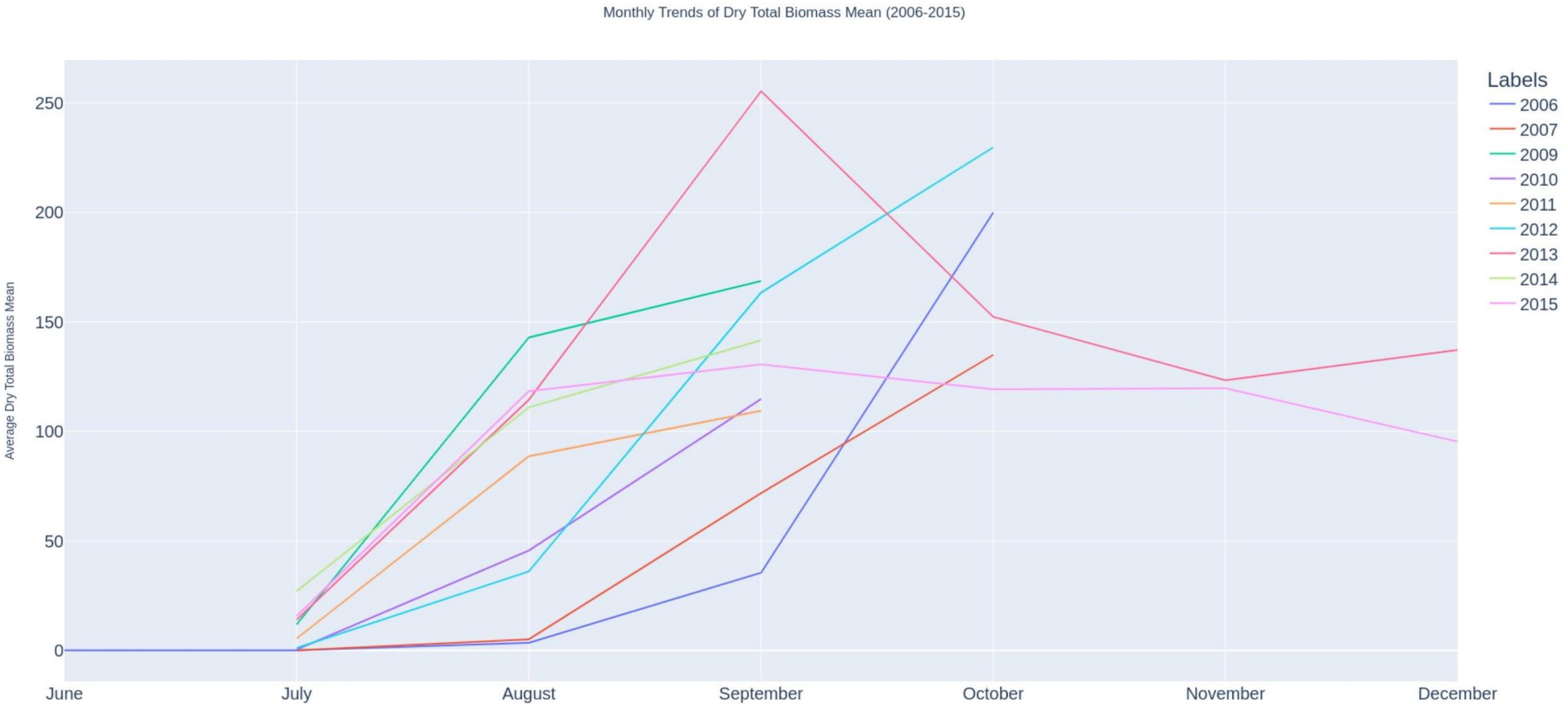
LEAF AREA INDEX - WAKANAMA_NORD STATION

Cover Height Mean - WAKANAMA_SUD STATION

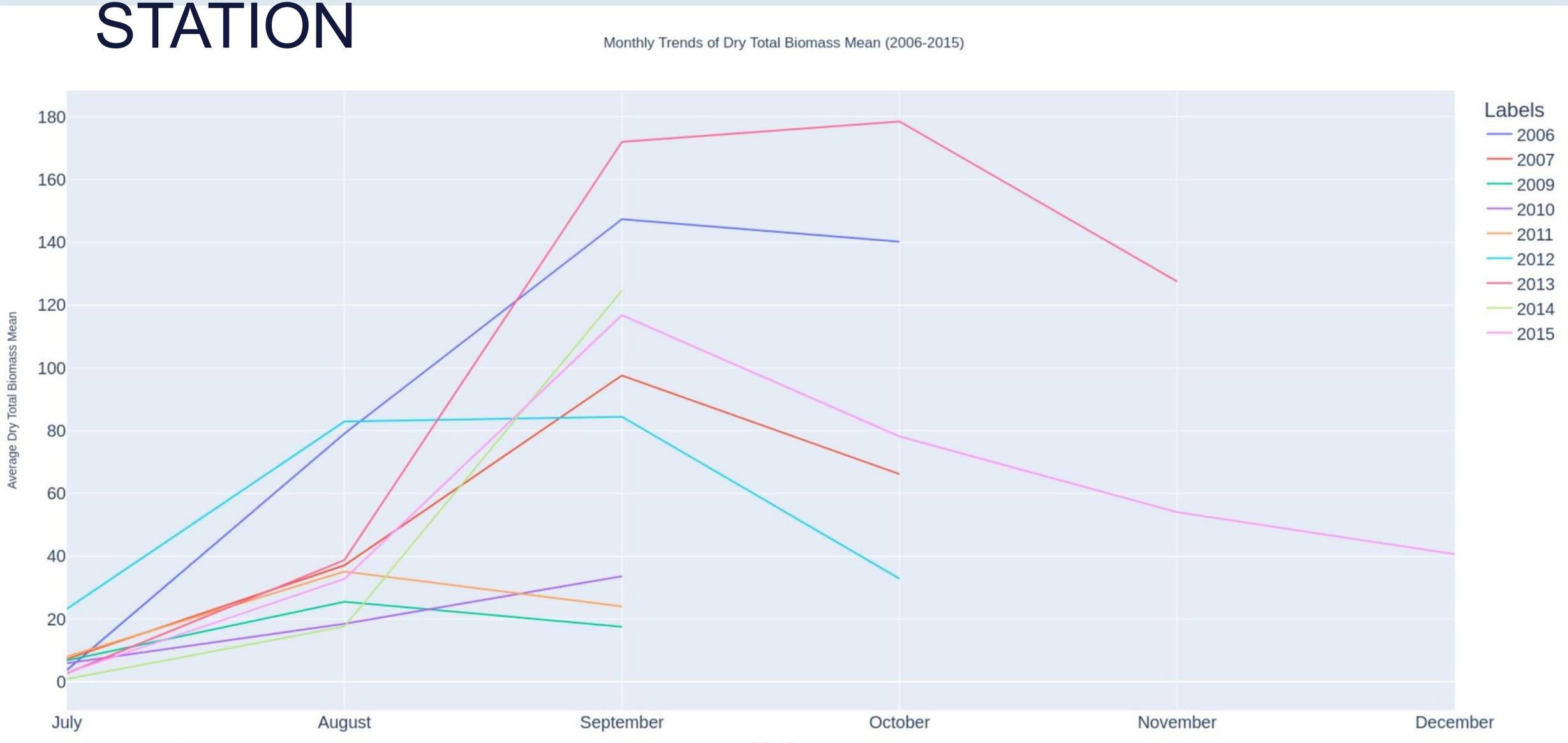
Cover Height Mean- WAKANAMA_NORD STATION



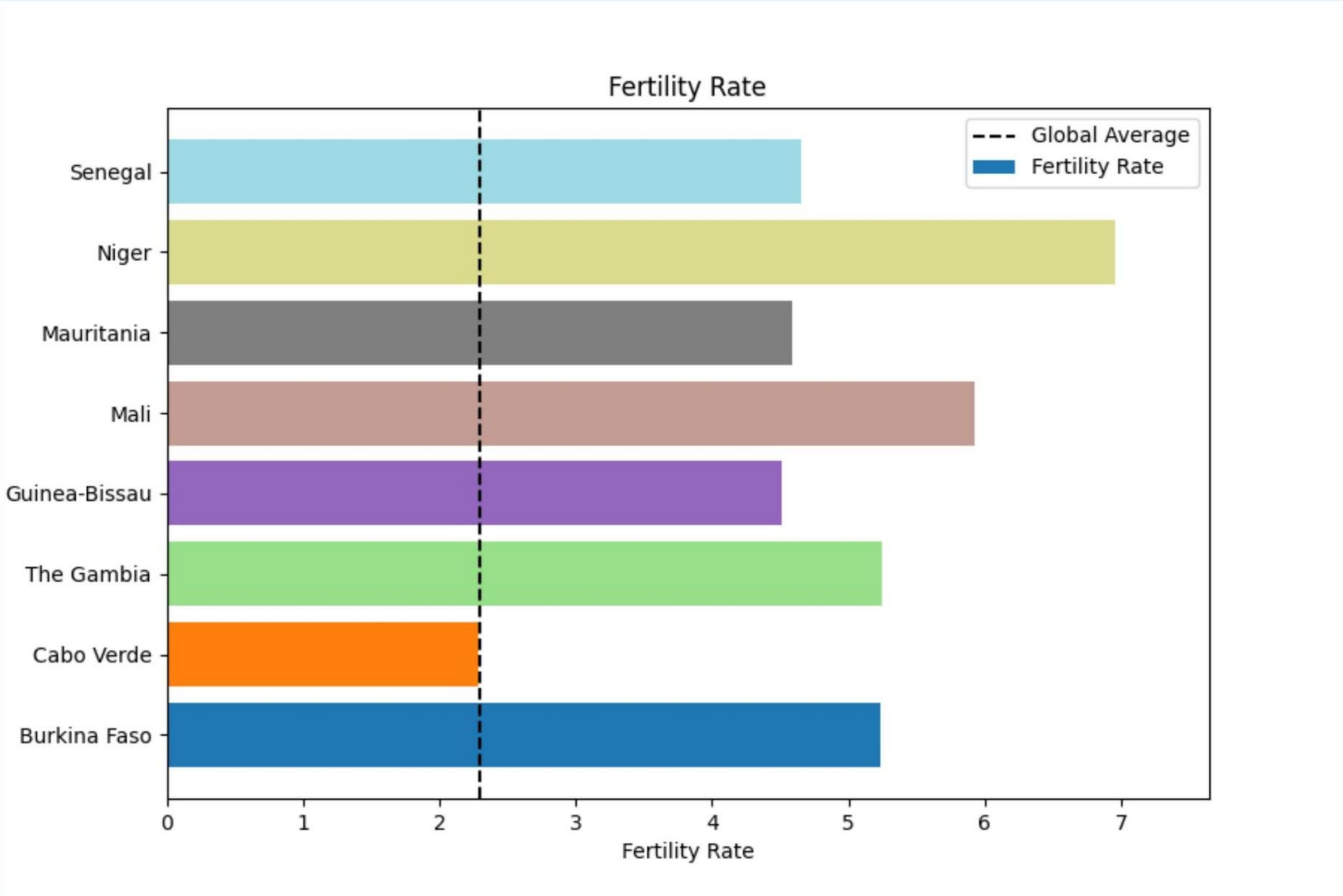
Dry Total Biomass Mean - WAKANAMA_SUD STATIO



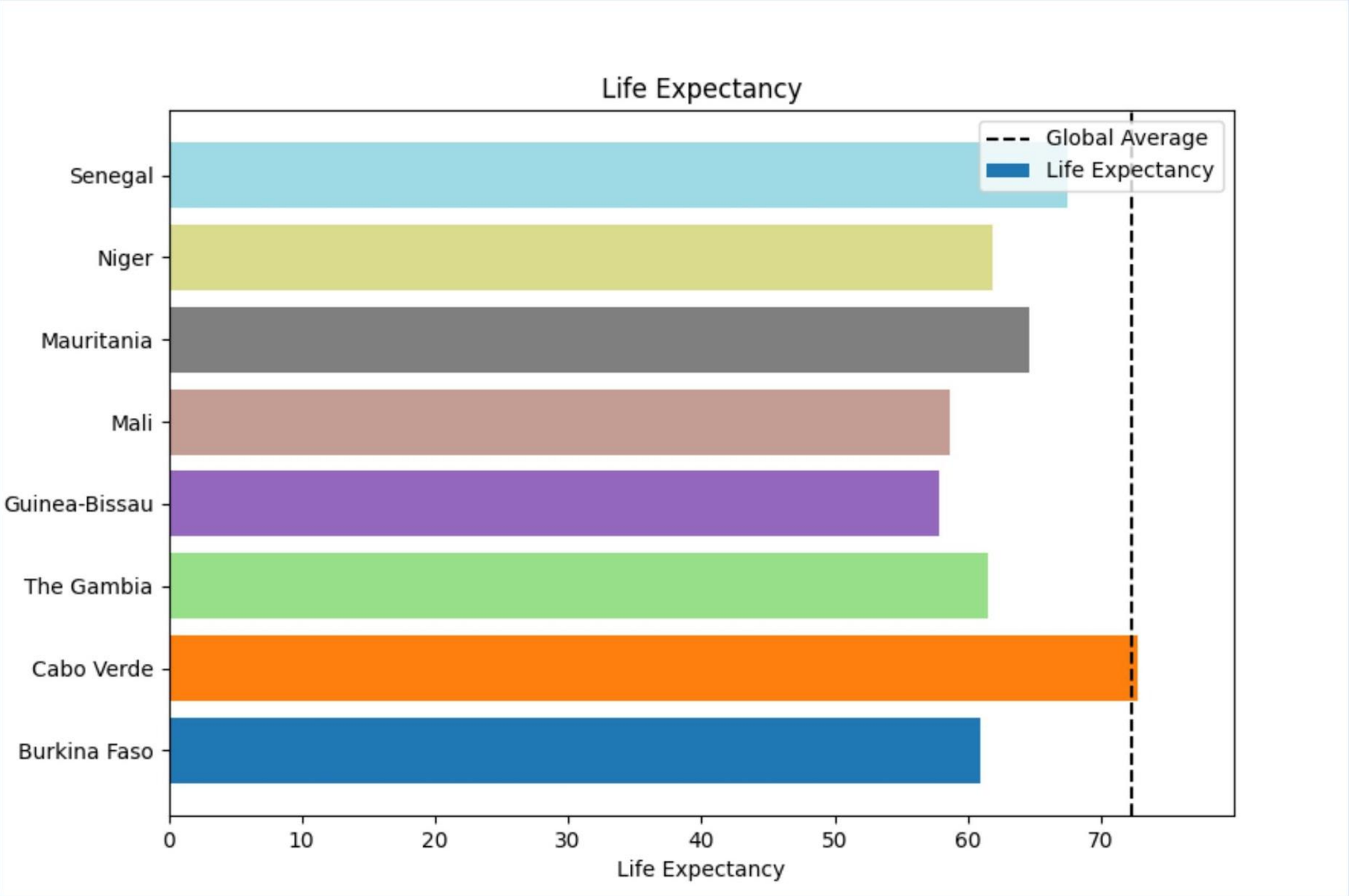
Dry Total Biomass Mean - WAKANAMA_NORD STATION



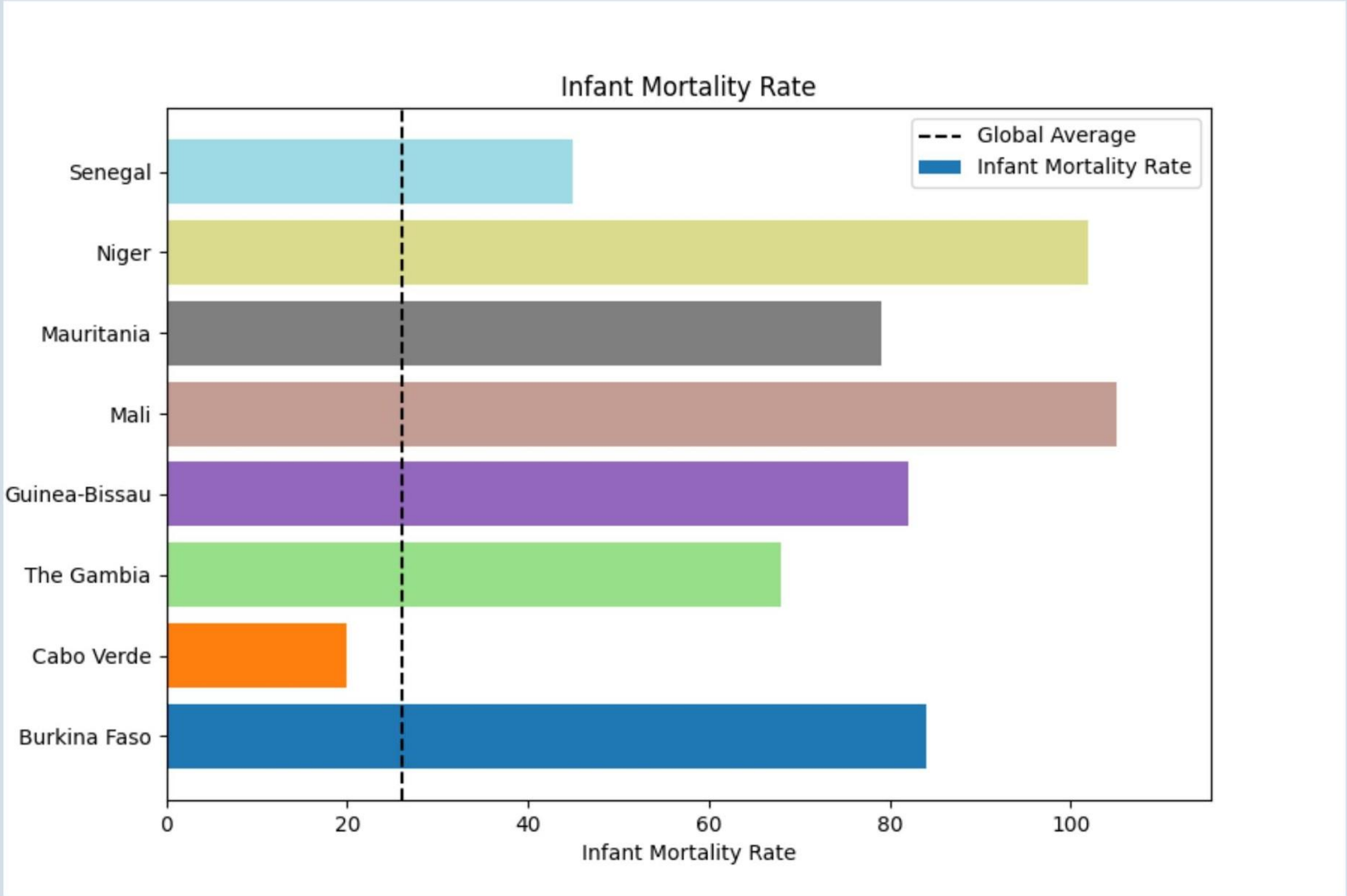
Fertility Rates in West Africa



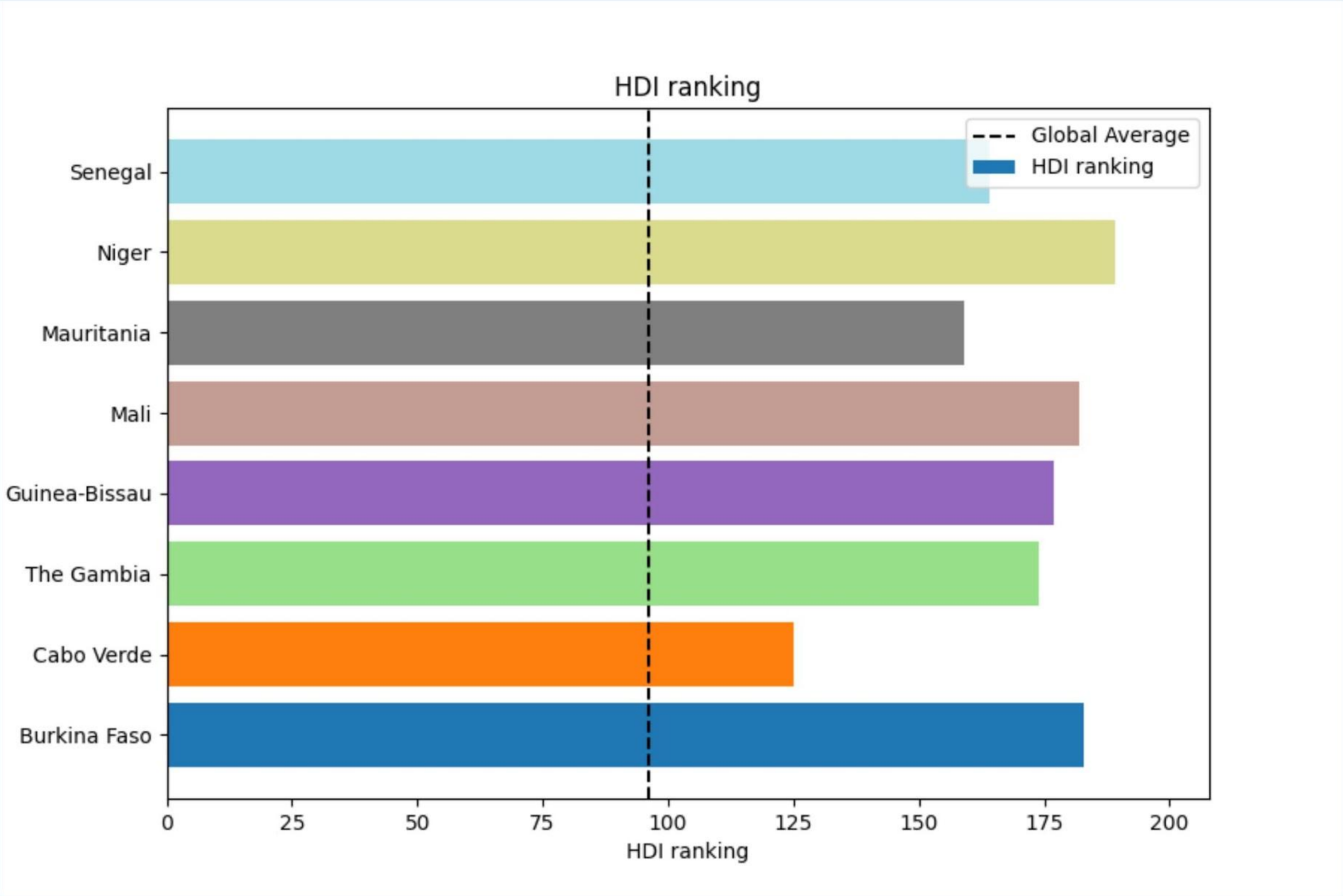
Life Expectancy across West Africa



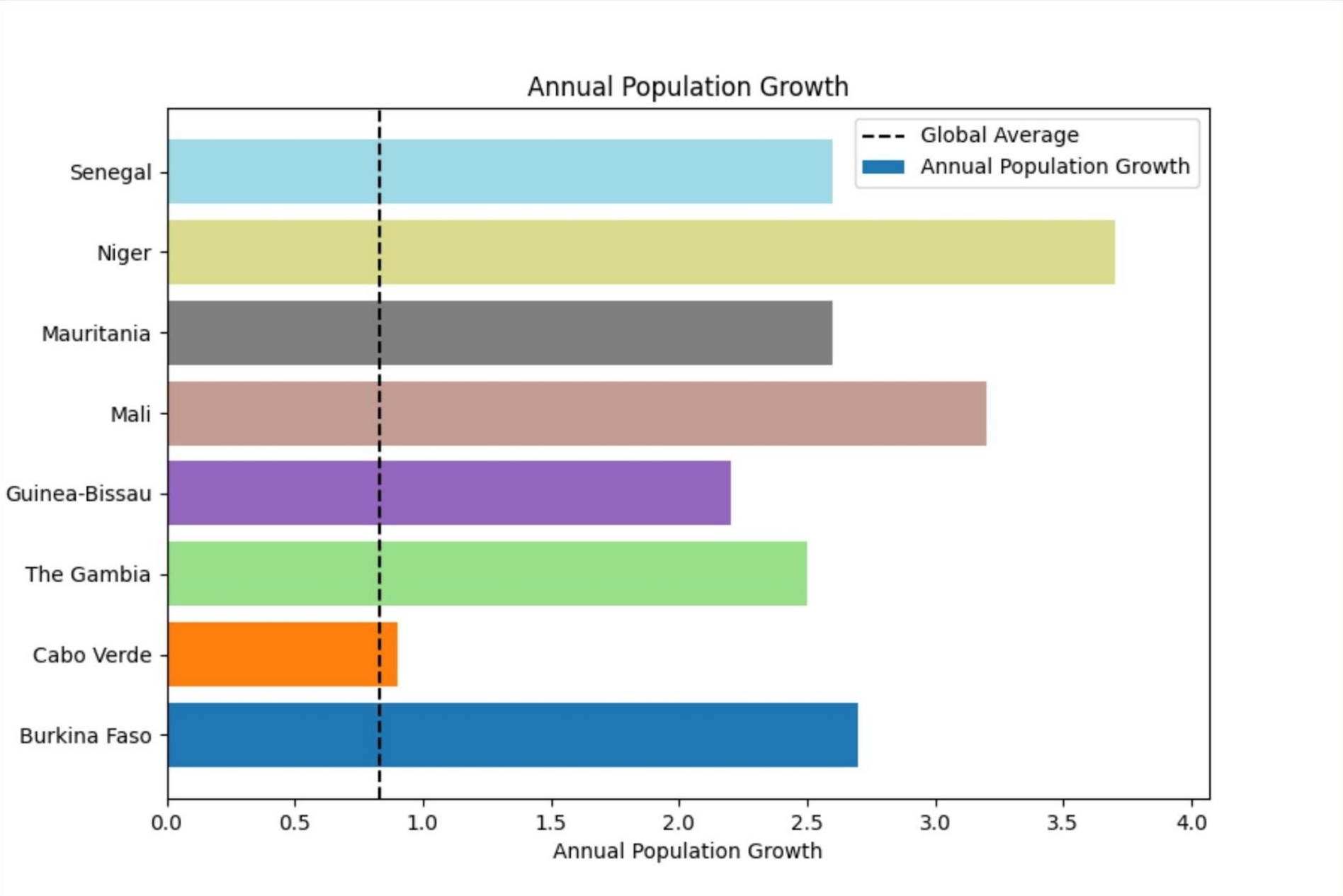
Infant Mortality Rates in West Africa



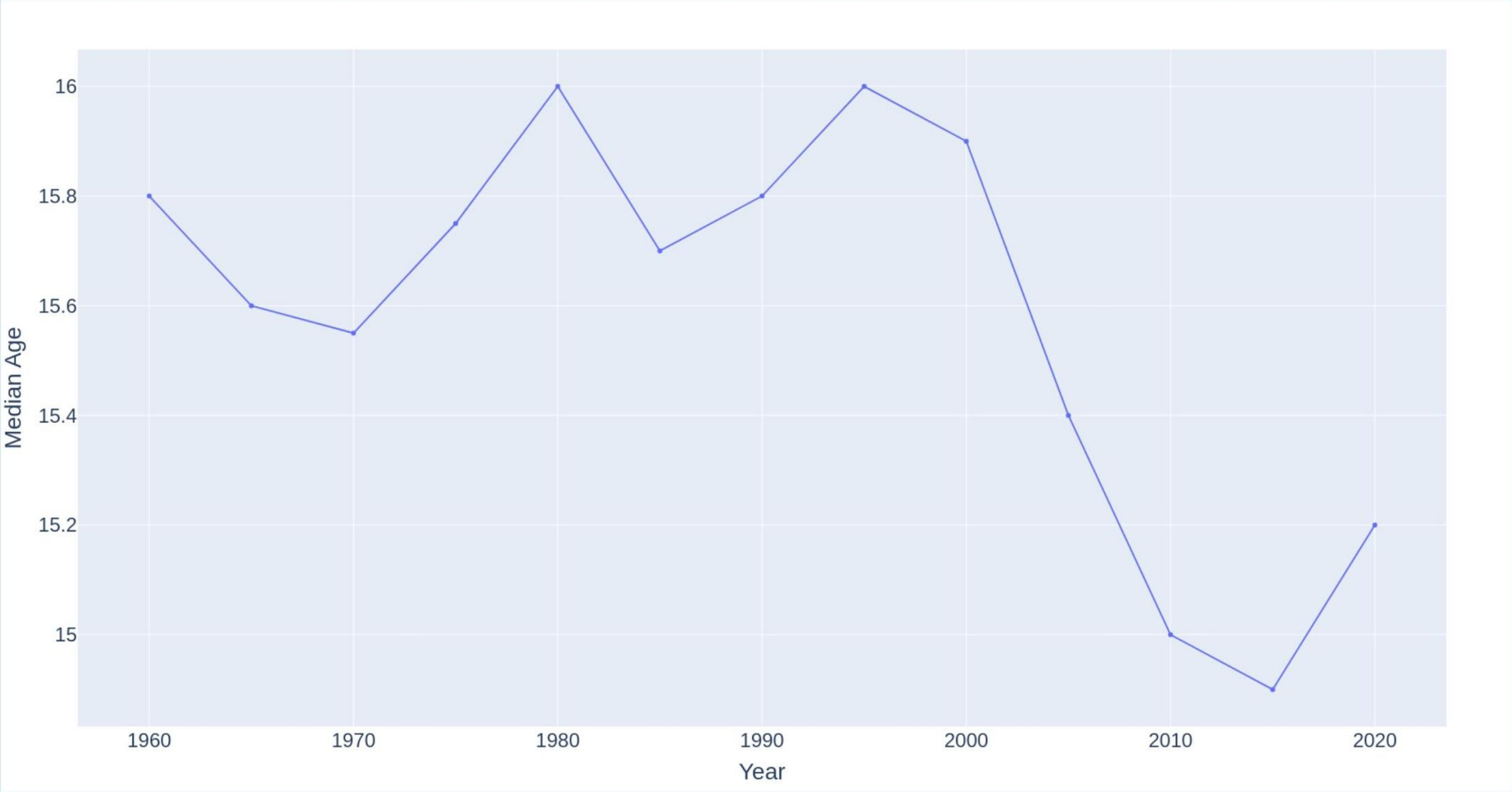
HDI Rankings of Countries in West Africa



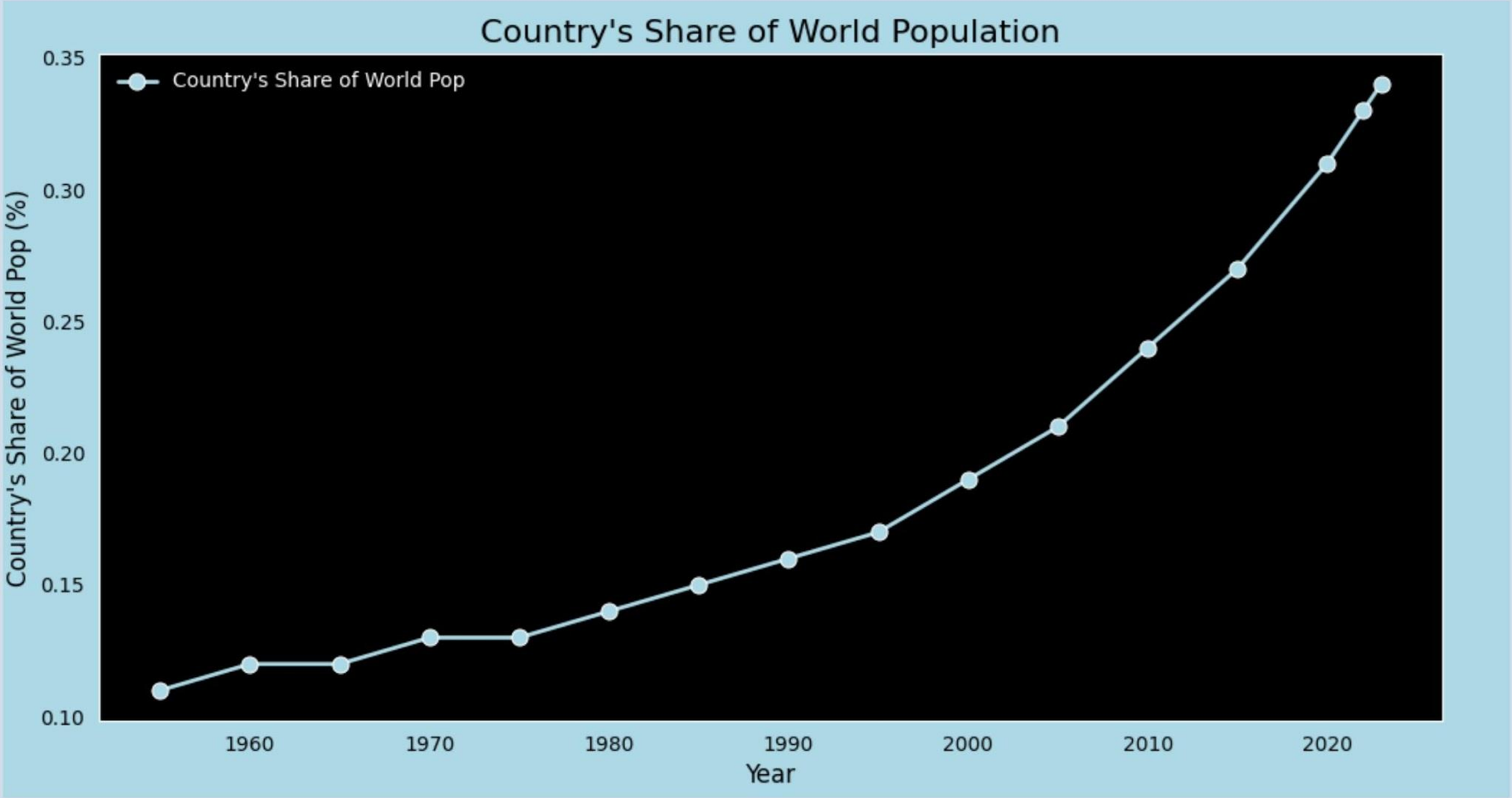
Annual Population Growth Rates in West Africa



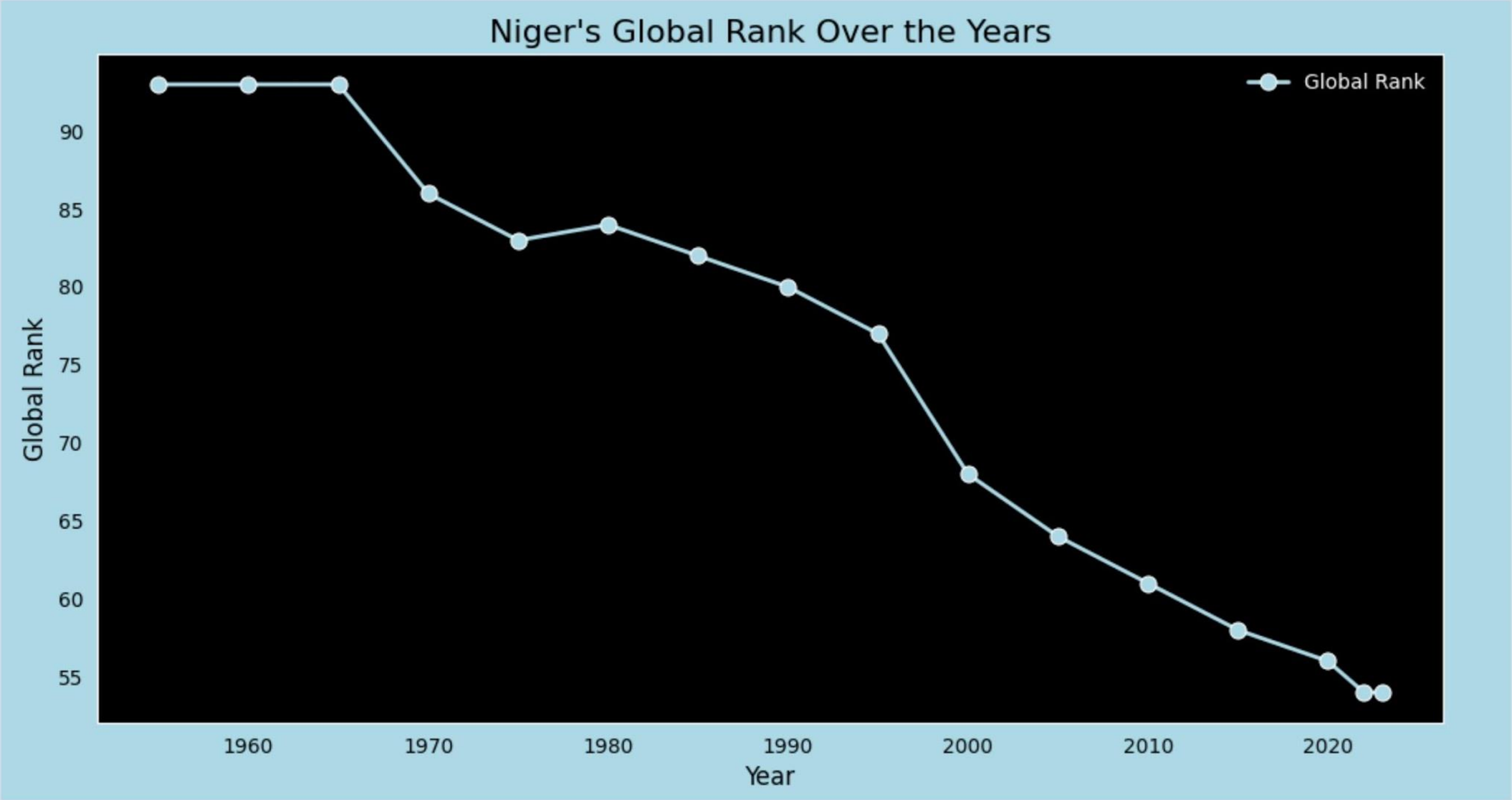
Population Age Median



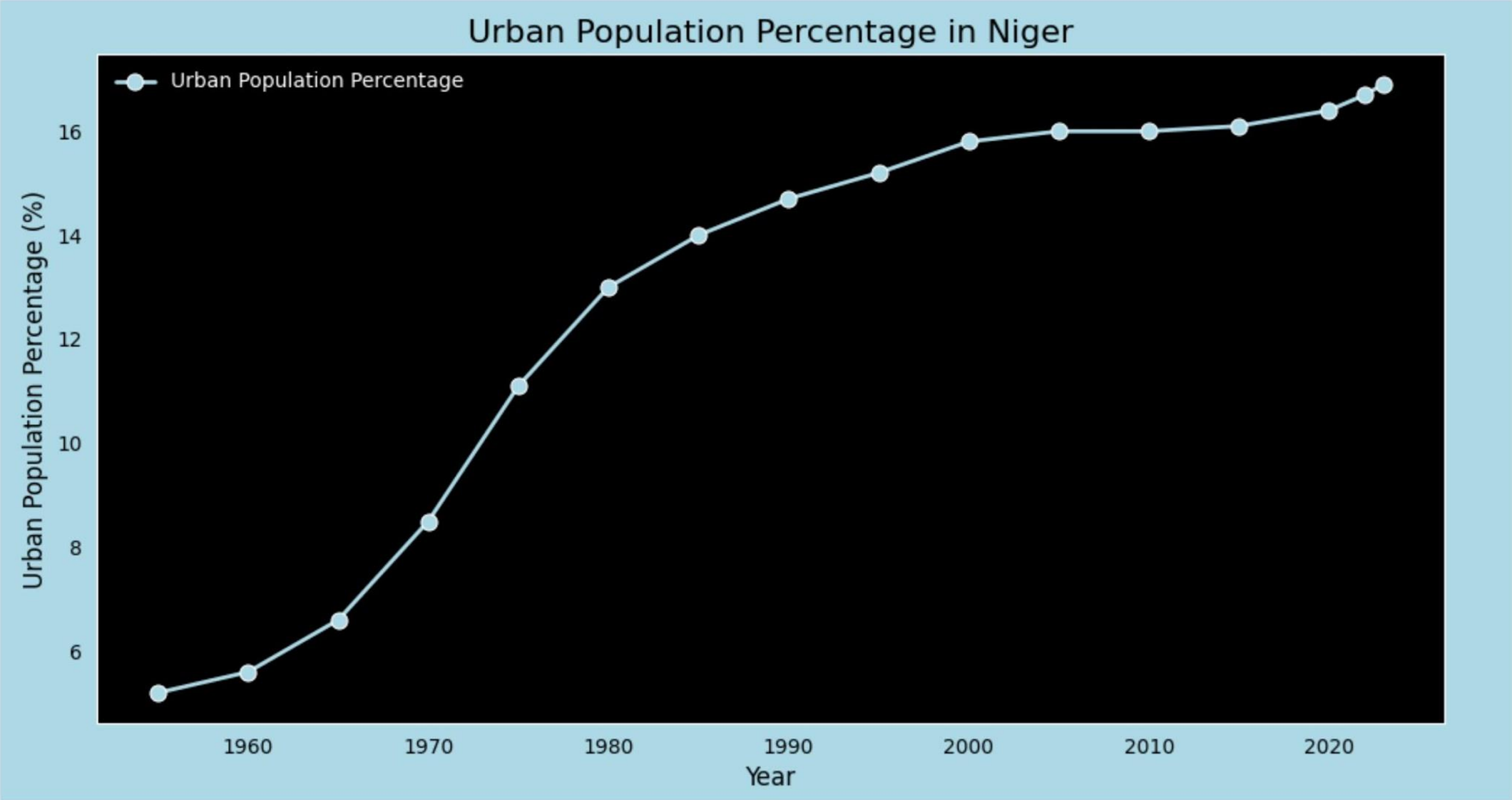
Niger’s share of World Population



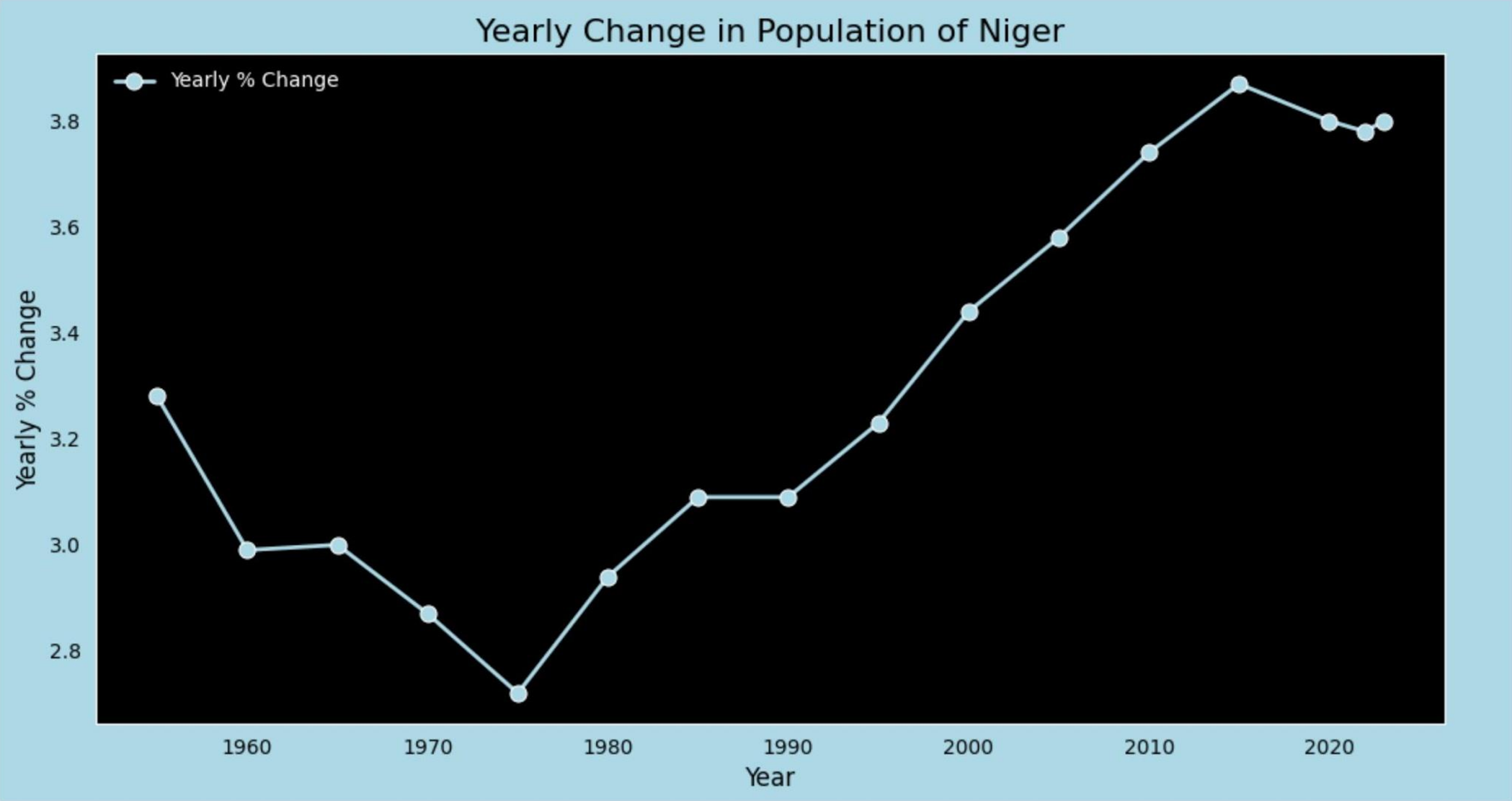
Niger's World Population Ranking



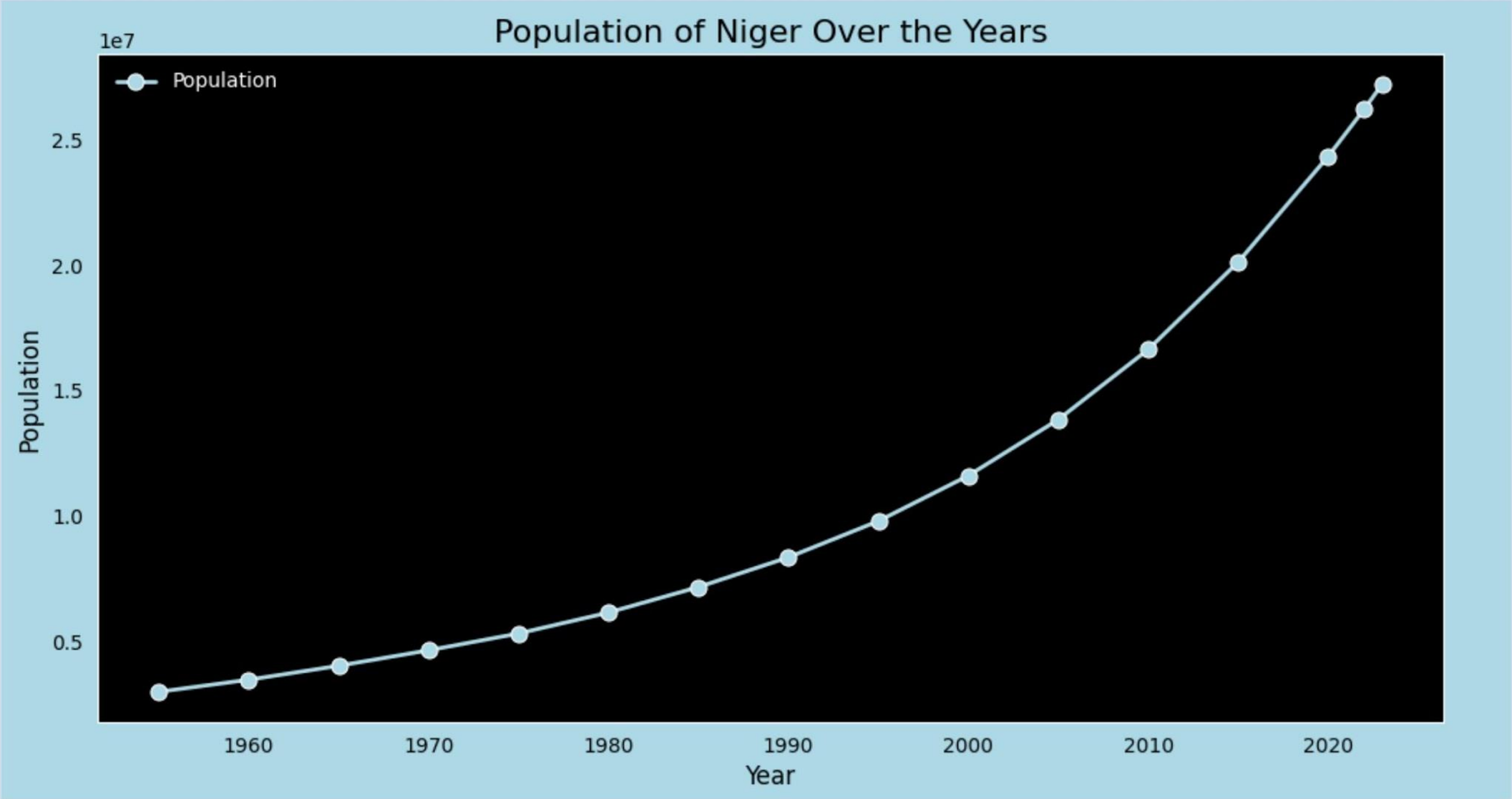
Niger's Urban Population %



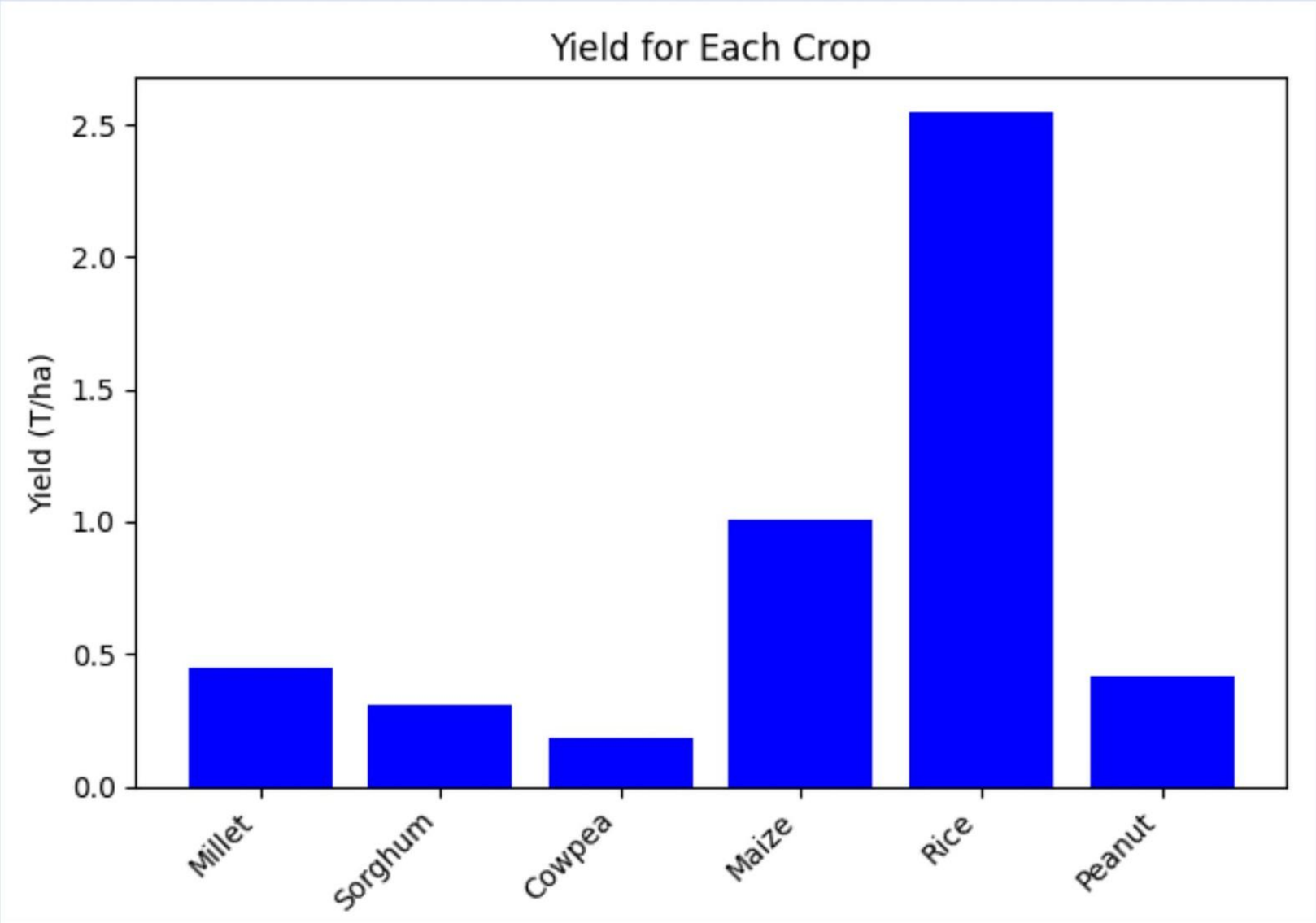
Yearly Change in Niger’s Population



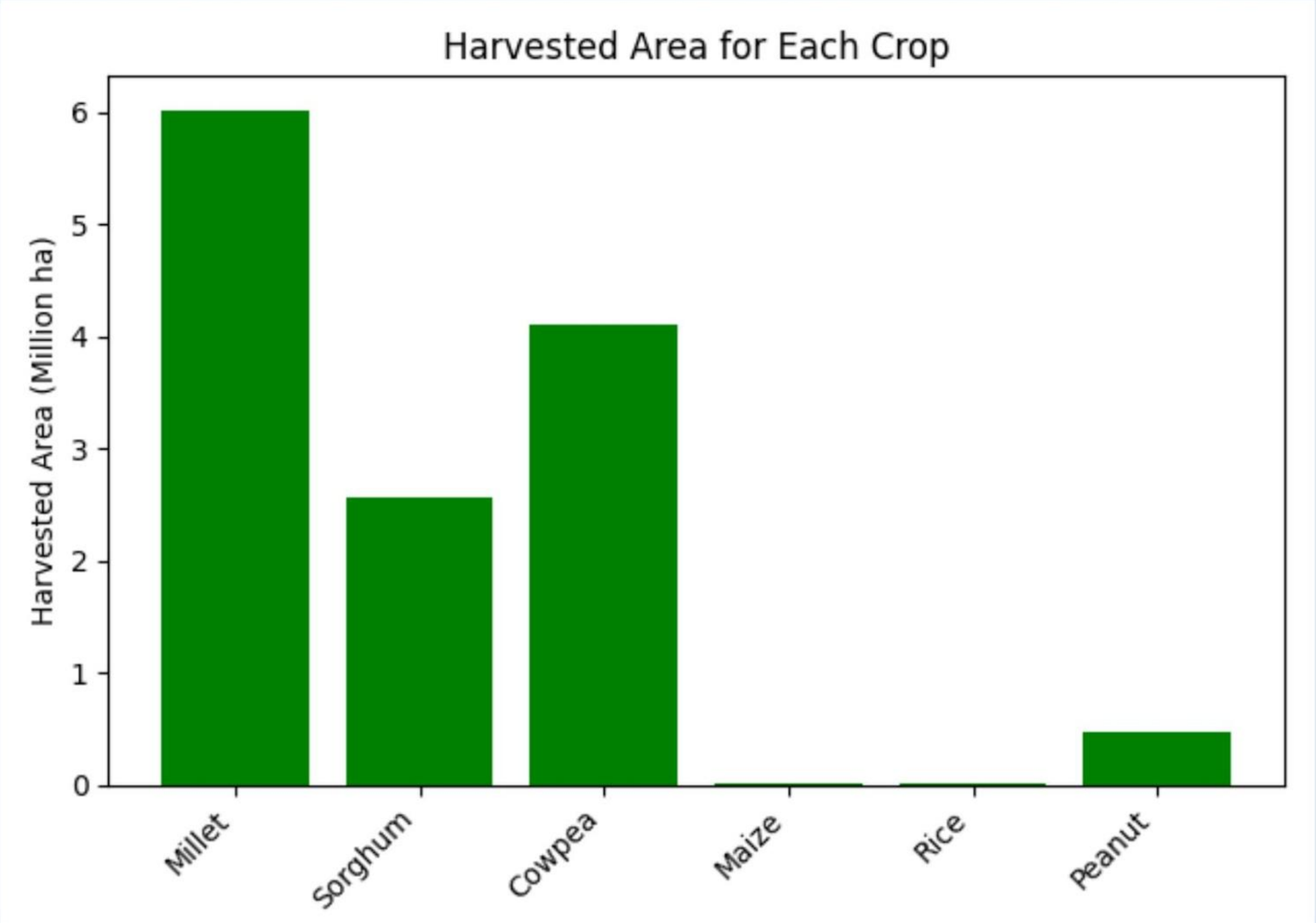
Total Population of Niger



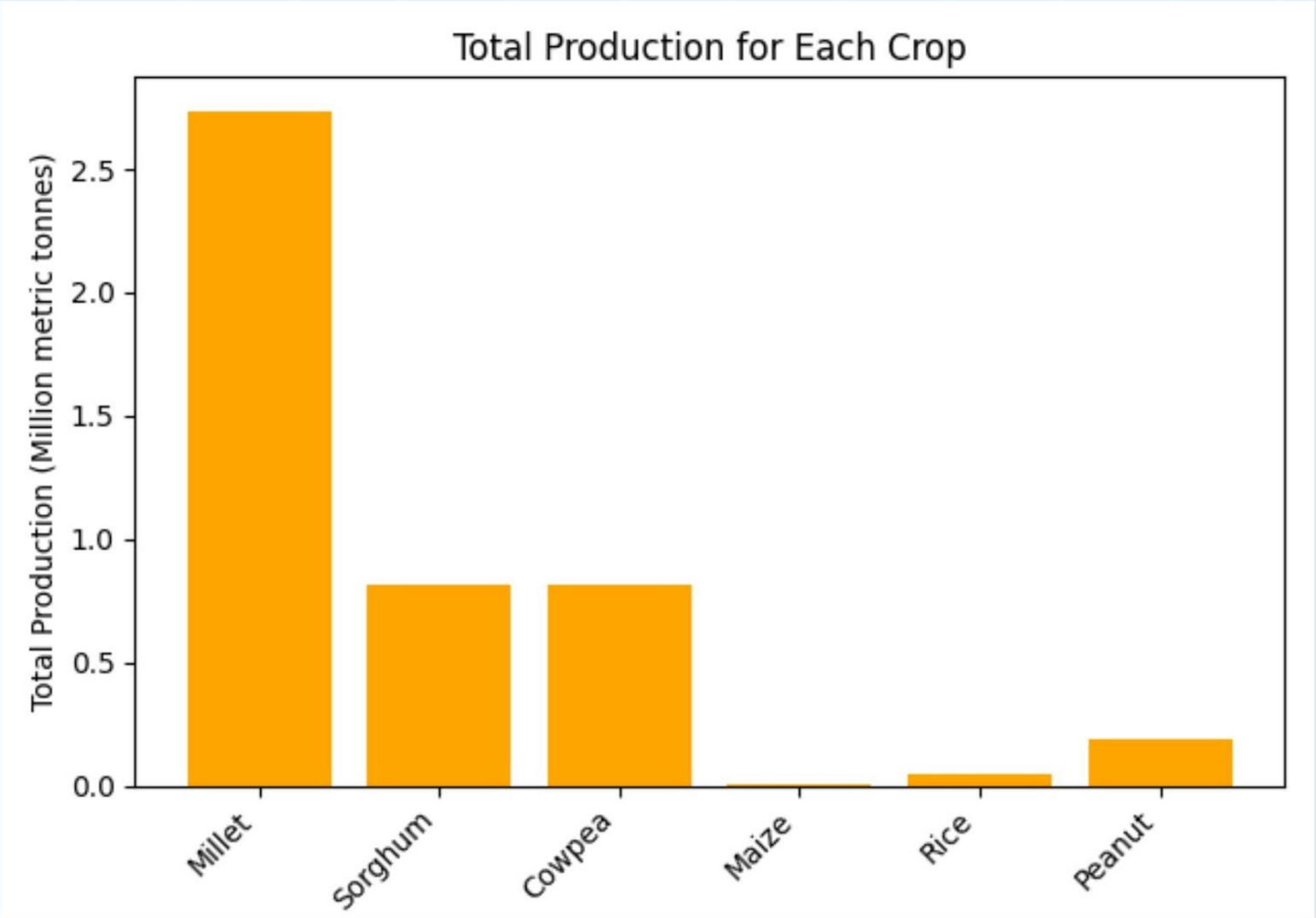
Cropwise Yield in Sahel Region



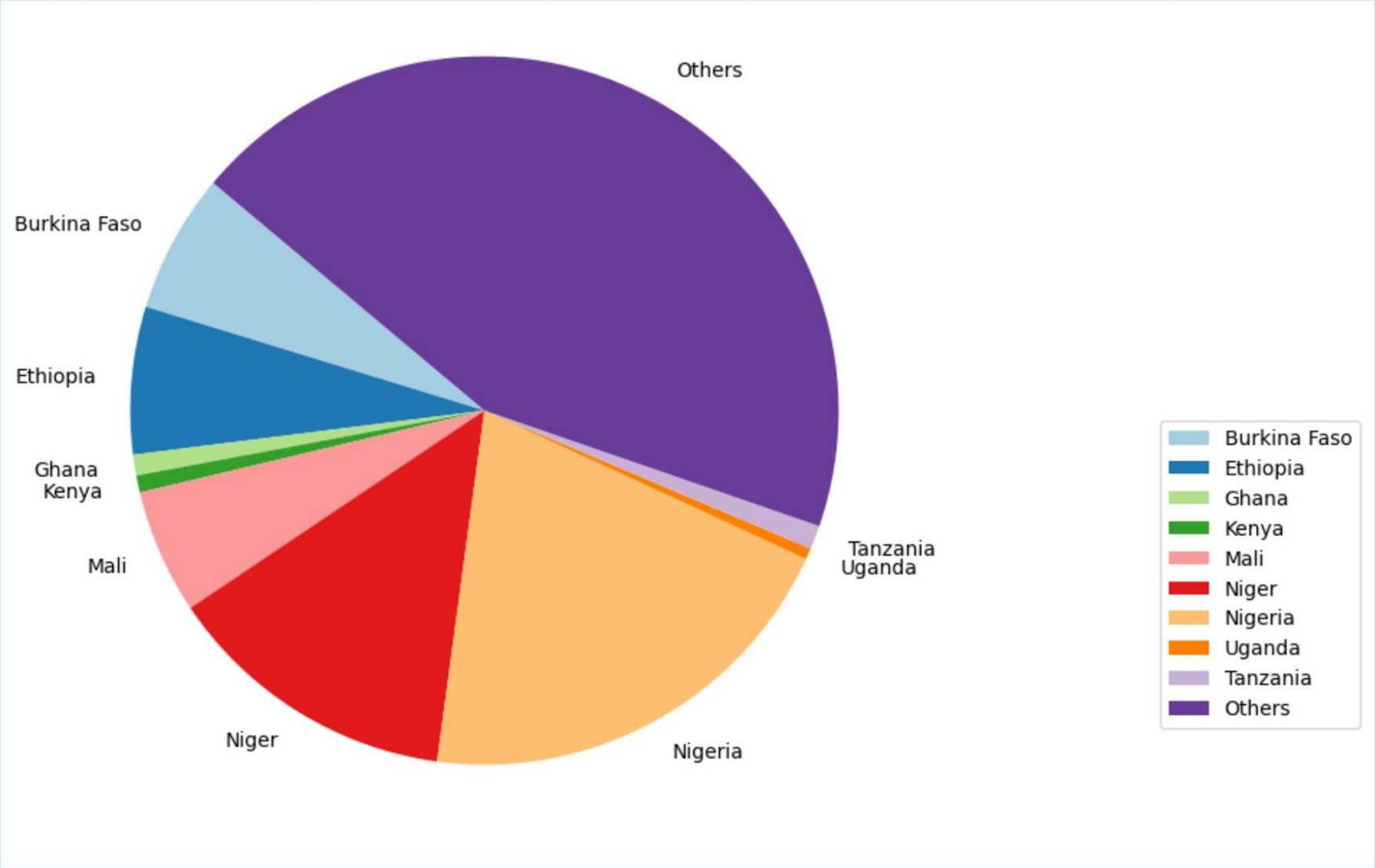
Cropwise Harvested Area in Sahel Region



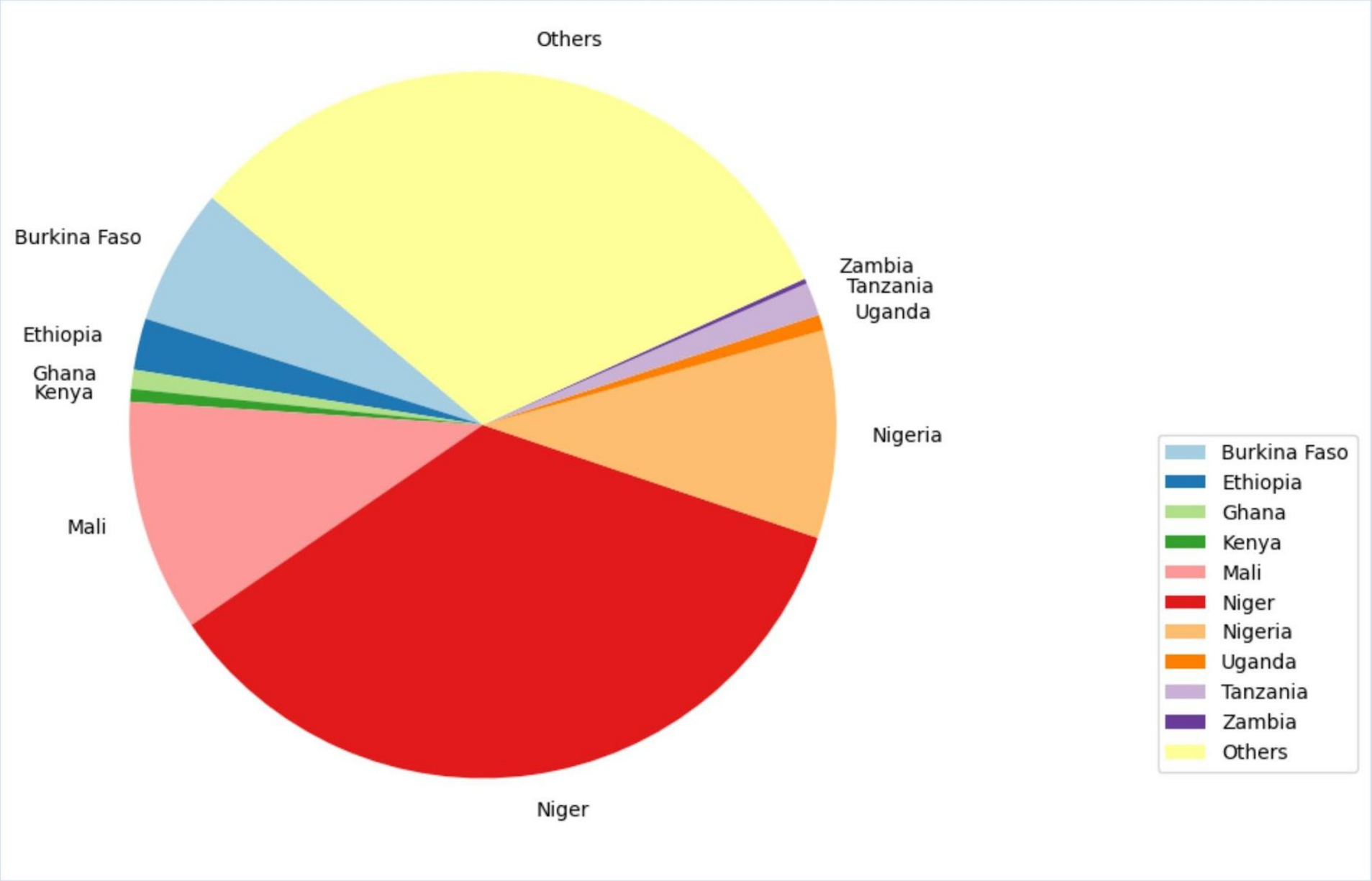
Cropwise Production in Sahel Region



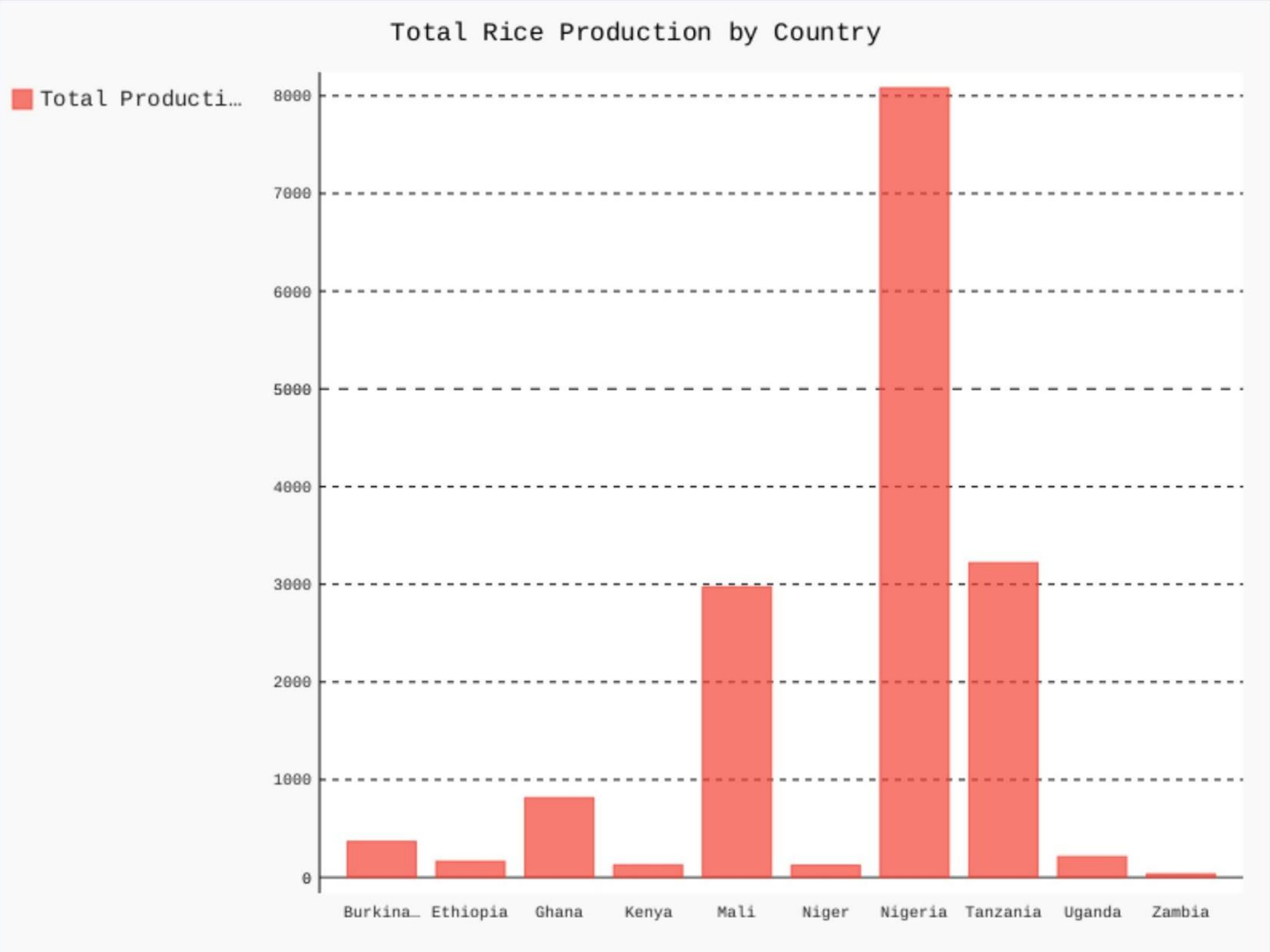
Sorghum Harvest Area in africa

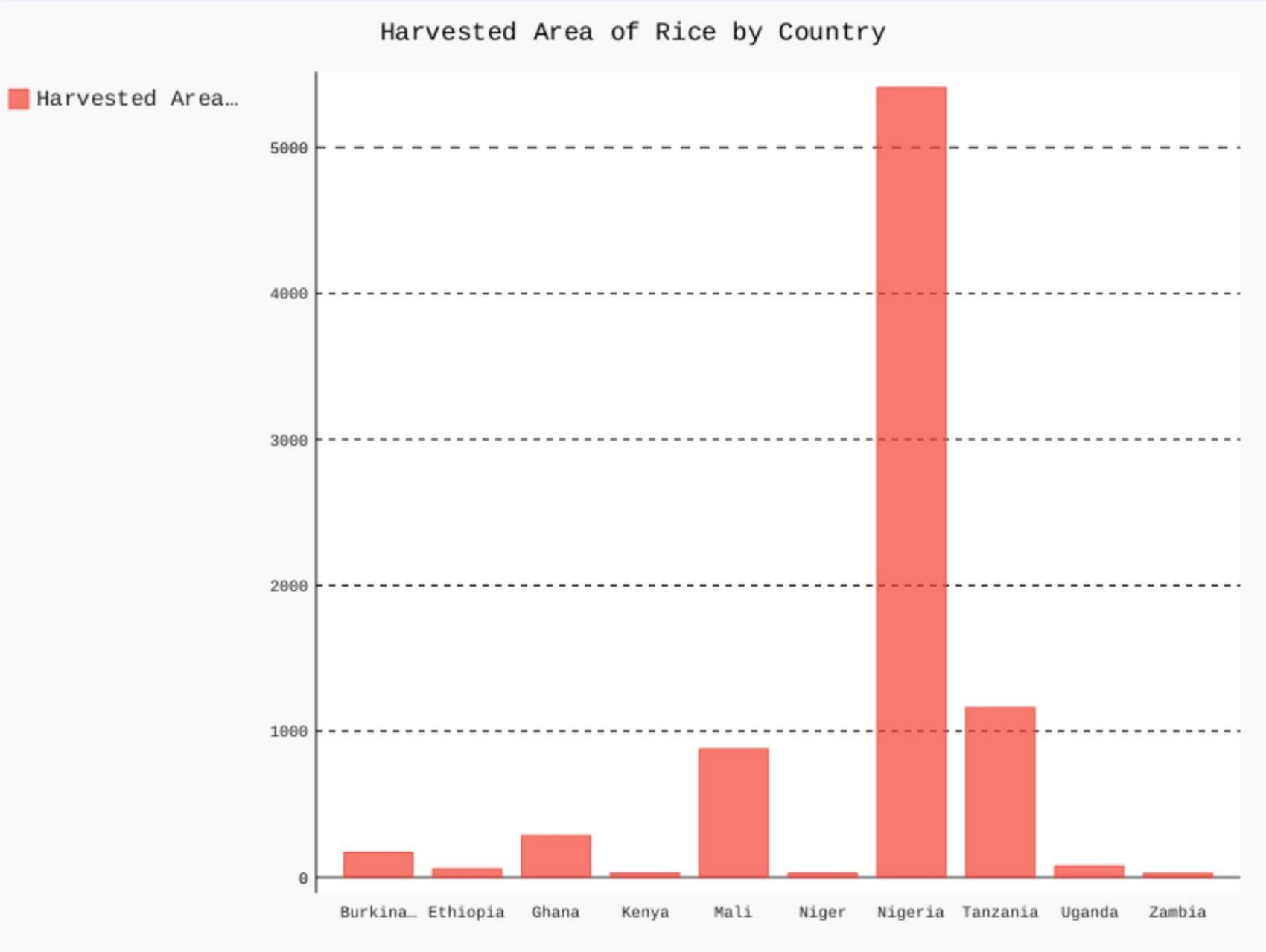


Millet Harvest Area in africa



Total Rice Production by Country




Harvested Area of Rice by Country
Harvested Area…
5000
4000
3000
2000
1000
0
Burkina…
Ethiopia
Ghana
Kenya
Mali
Niger
Nigeria
Tanzania
Uganda
Zambia

Website

ANALYSIS

Composite Drought Index

This contains analysis of Desertification using Composite Drought Index

See Graphs

Niger Agriculture

This contains the trends in Niger Agriculture

See Graphs

Population

This contains the trends in Population across Africa

See Graphs

Precipitation

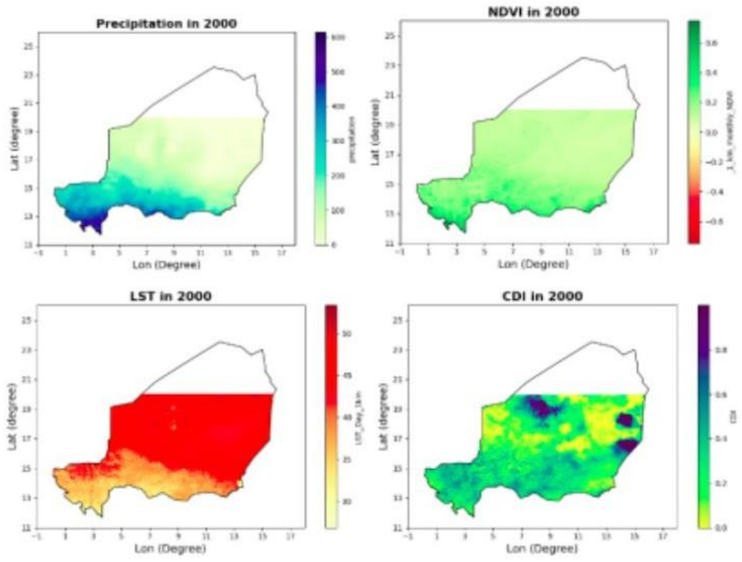
This contains the trends in Precipitation across Africa

See Graphs

GRAPHS

CDI Analysis - 2000

This graph depicts Precipitation , NDVI , LST and CDI for the year 2000.



Frameworks Used

Vanilla JS

jQuery

PARCEL

CHALLENGES FACED

- DATA COLLECTION
- DATA PREPROCESSING
- RETRIEVING EXISTING CASE STUDIES
- DATA ANALYSIS
- BUILDING STATIC WEBSITE
- Project REPORT

TIMELINE

SAHEL DESERTIFICATION

1

Brainstorming and Topic Selection

2

Define the scope and objectives

3

Develop and Analyze Data

4

Create a Case Study Document

5

Develop Data Visualizations

6

Build a website for Visualization display

7

Final Presentation

Atreides

THANK YOU

Sahel Desertification