Downscaled Climate Projections for Ghana Using the KAPy Framework

AfricaGIS 2025

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UNITED NATIONS GLOBAL GEOSPATIAL INFORMATION MANAGEMENT

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Harnessing Geospatial Intelligence for Africa's Sustainable and Resilient Future

Ghana Meteorological Agency

Danmarks Meteorologiske Institut

United Nations Economic Commission for Africa

EIS

FIG International Federation of Surveyors / Fédération Internationale des Géomètres / Internationale Vereinigung der Vermessungsingenieure

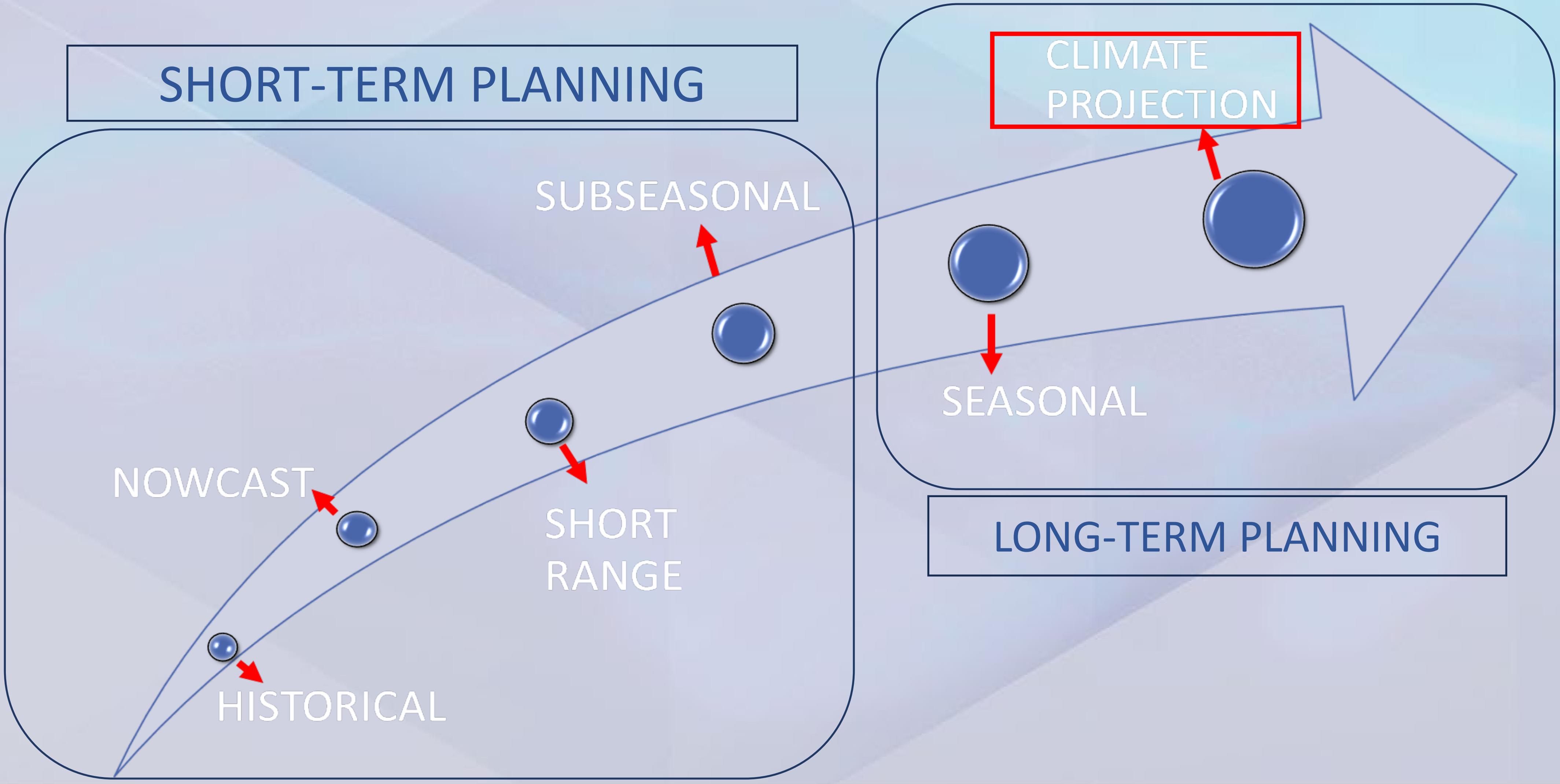
Lands Commission Ghana

University of Ghana

Presentation Outline

- Timescales of Climate Information Services
- Introduction
- Methodology
- Results & Discussions
- Summary
- Way Forward
- Visualization
- Acknowledgement
- References

Timescales of Climate Information Services



Introduction

- Climate change is causing rising temperatures, droughts, floods, and coastal erosion (IPCC, 2021; WMO, 2023; Nicholls & Cazenave, 2010).

- Coarse-resolution Global Climate Models (≈ 100 km) limit local planning in Ghana (IPCC, 2021; Jones & Lins, 2013).

- Ghana's high vulnerability, from drought-prone northern savannah to sea-level-rise threatened coastal zones, requires high-resolution climate data for effective planning (Antwi-Agyei *et al.,* 2012; Armah *et al.,* 2020; Boateng, 2012).

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Objective

Main objective: To generate and disseminate high-resolution, scientifically robust, and policy relevant climate information for Ghana, thereby enabling effective national planning, climate risk assessment, and evidence-based adaptation strategies.

Specific Objectives

1

To develop high-resolution, downscaled climate projections for Ghana utilizing state of the art climate modeling techniques.

2

To identify and calculate relevant climate indicators for comprehensive climate monitoring, trend analysis, and future climate scenario generation.

3

To co-produce, synthesize, and effectively communicate reliable, policy relevant climate information to support evidence based decision making and climate adaptation initiatives.

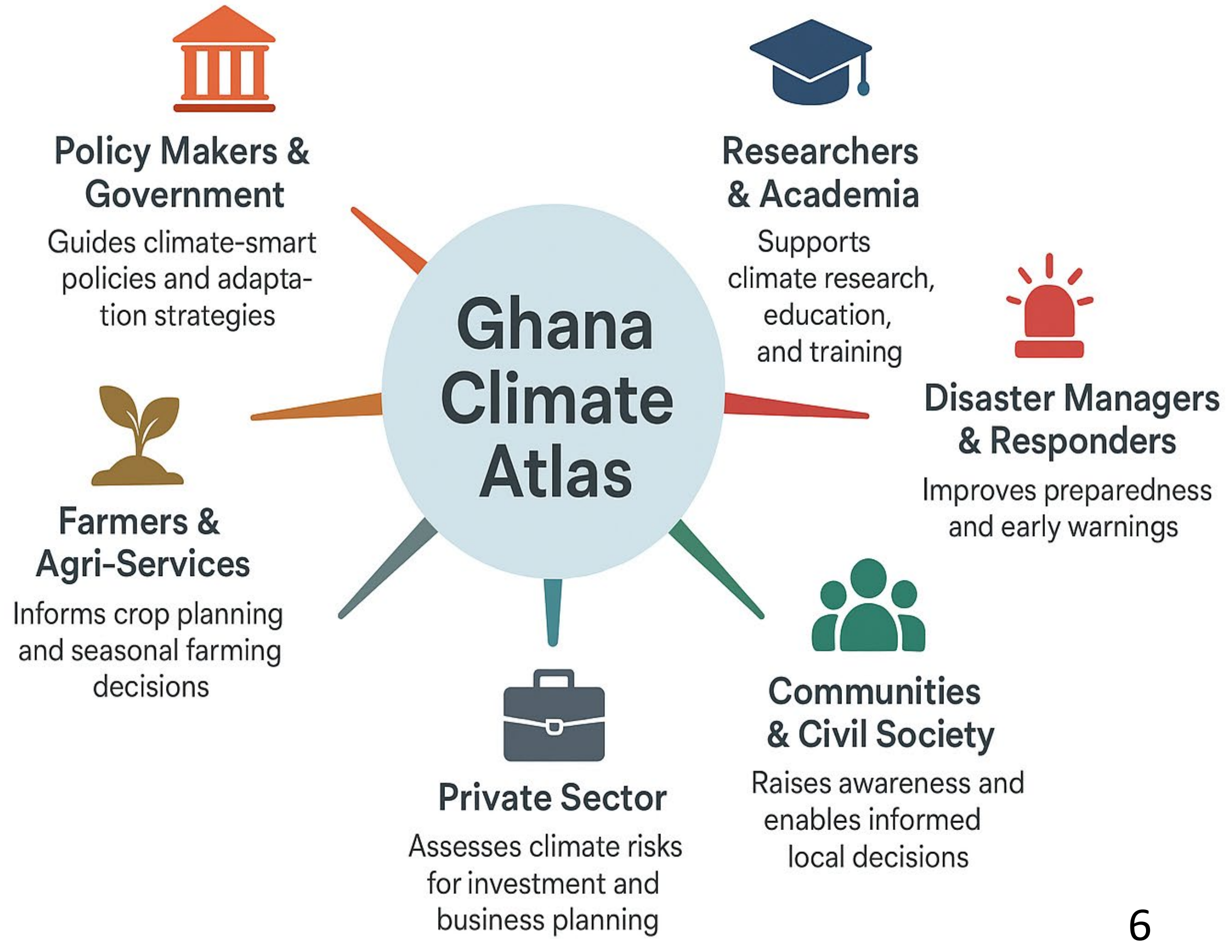
Stakeholders and Users of the Ghana Climate Atlas

The **Ghana Climate Atlas** is a user-friendly and interactive tool that illustrates how Ghana's climate is expected to change over the coming years, up to the end of century.

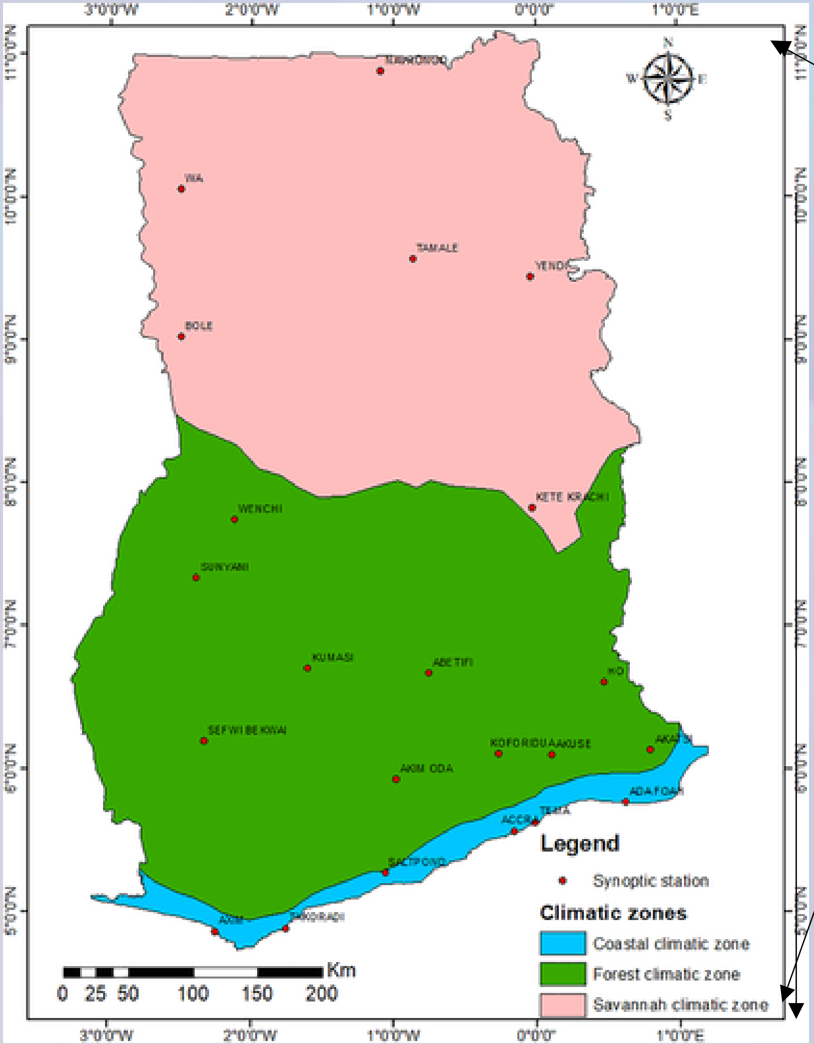
- The Climate Atlas will serve a wide range of stakeholders across government, private, and research communities.

- Diverse stakeholders' use of the Climate Atlas :

✓ Support informed decision making
✓ Strengthen climate resilience
✓ Guide long-term development strategies for Ghana.



Methodology – Study Area



- Ghana is characterized by dry and wet seasons
- The southern sector has a bimodal rainy season; Major (March – July) & Minor(September – November)
- The Northern sector has a unimodal rainy season from May – October
- The Dry season referred to as harmattan occurs from December to February
- Long-term mean annual rainfall is between 700 mm and 2030 mm
- Average minimum and maximum temperatures are 22°C and 32°C respectively

- Climatic zones of Ghana-based on rainfall, RH and temperature records from 1976 to 2018

Source: Bessah *et al.,* 2022

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Method – Datasets

The datasets used for the analysis are as follows:

Reference Period: 1991–2020

Observational Data:

- ERA5 Reanalysis(25km resolution) – Temperature & Rainfall

Climate Model Data:

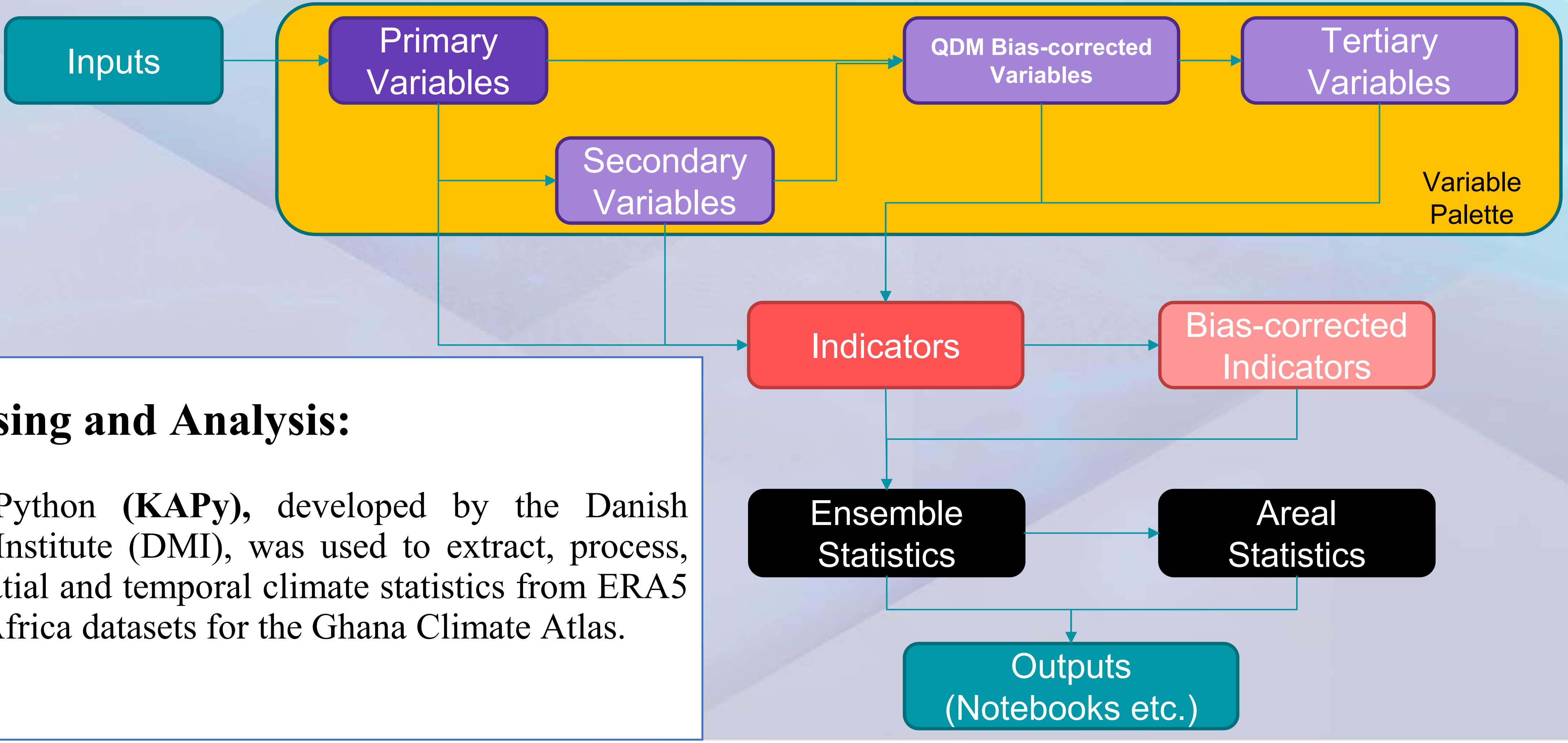
- CORDEX-Africa (39 dynamically downscaled climate models)

Sea level rise Projection:

Intergovernmental panel on Climate Change(IPCC) – Sea level rise

<table>
<tr><th>Climate Indicator</th><th>Emission Scenarios</th><th>Projection Periods</th><th>Uncertainty Range</th></tr>
<tr><td>Average Temperature (Annual / Seasonal)</td><td rowspan="2">Low (RCP 2.6)
Medium (RCP 4.5)
High (RCP 8.5)</td><td rowspan="3">Near Term: 2021–2040
Mid-Century: 2041–2060
End of Century: 2081–2100</td><td rowspan="3">10th, 50th, and 90th Percentiles</td></tr>
<tr><td>Total Rainfall (Annual / Seasonal)</td></tr>
<tr><td>Sea Level Rise</td><td>Low (SSP 1–2.6)
Medium (SSP 3–4.5)
High (SSP 5–8.5)</td></tr>
</table>

Method – The KAPy Workflow



Data Processing and Analysis:

Klimaatlas in Python **(KAPy),** developed by the Danish Meteorological Institute (DMI), was used to extract, process, and compute spatial and temporal climate statistics from ERA5 and CORDEX-Africa datasets for the Ghana Climate Atlas.

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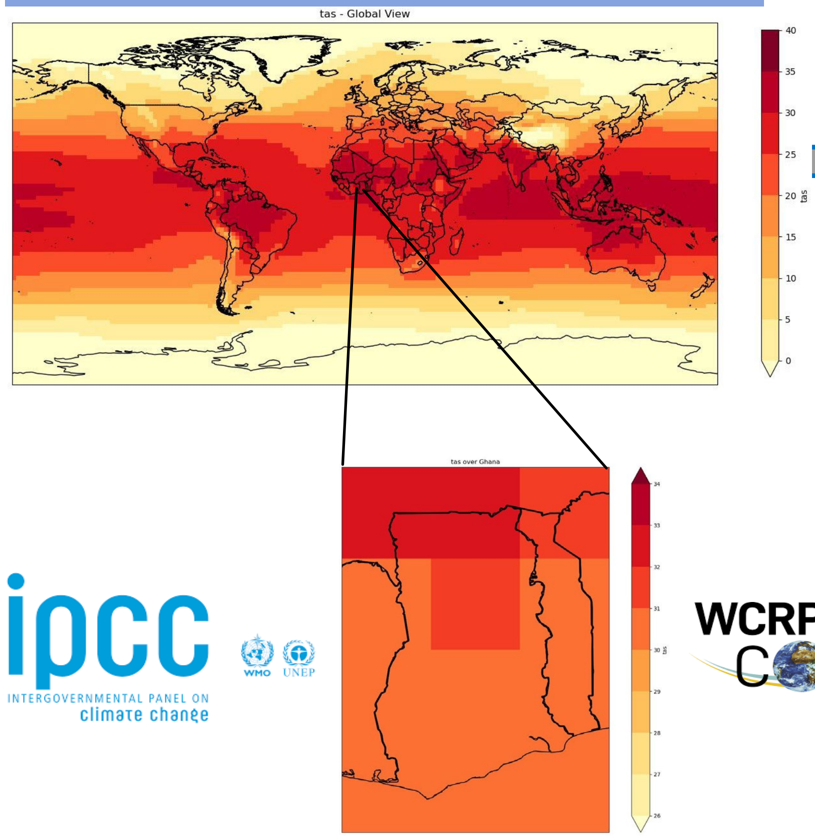
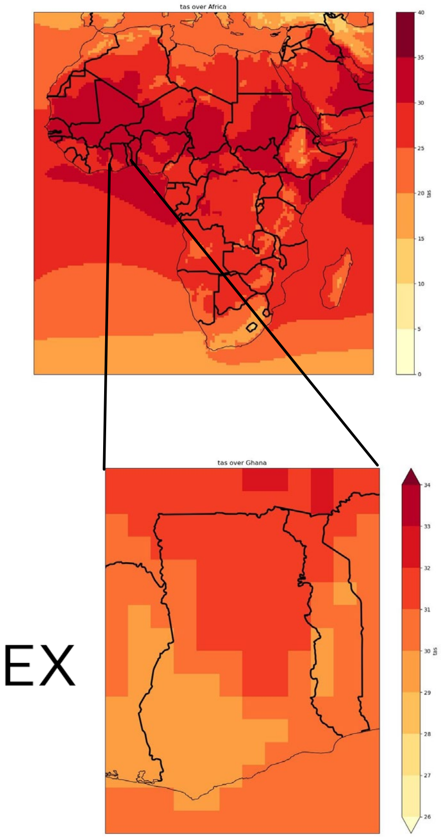
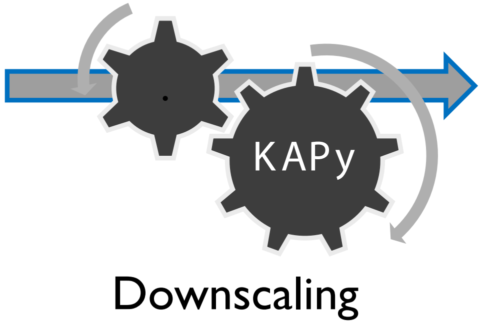
Method – Downscaled Climate Projections

Global Models
~100 km

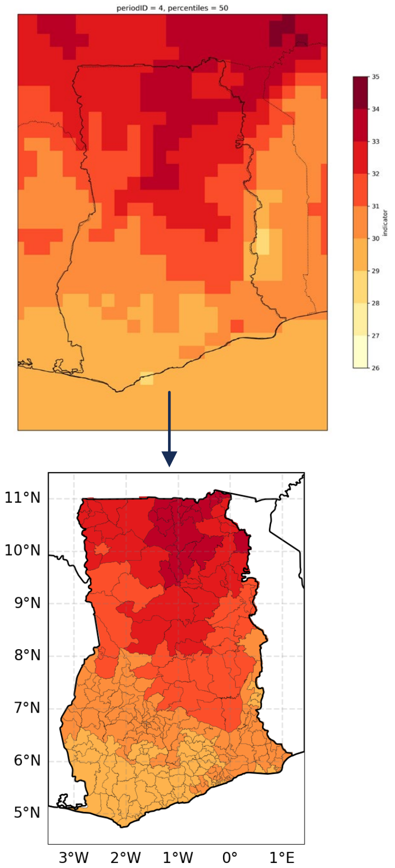


Regional Models
~50 km

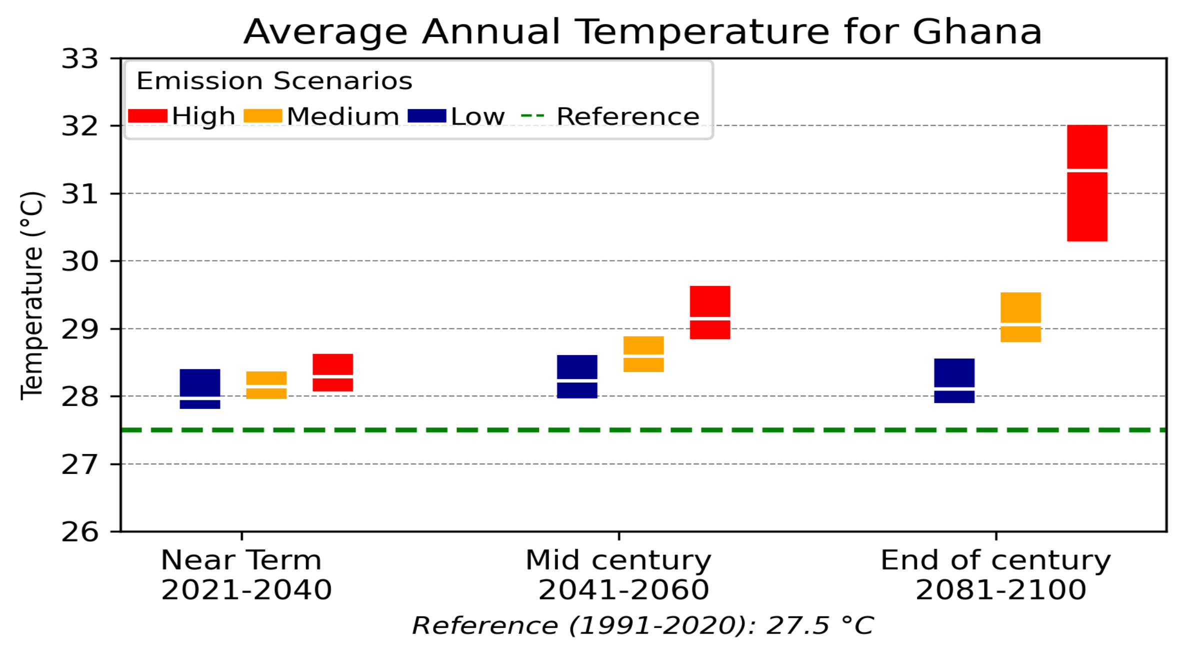




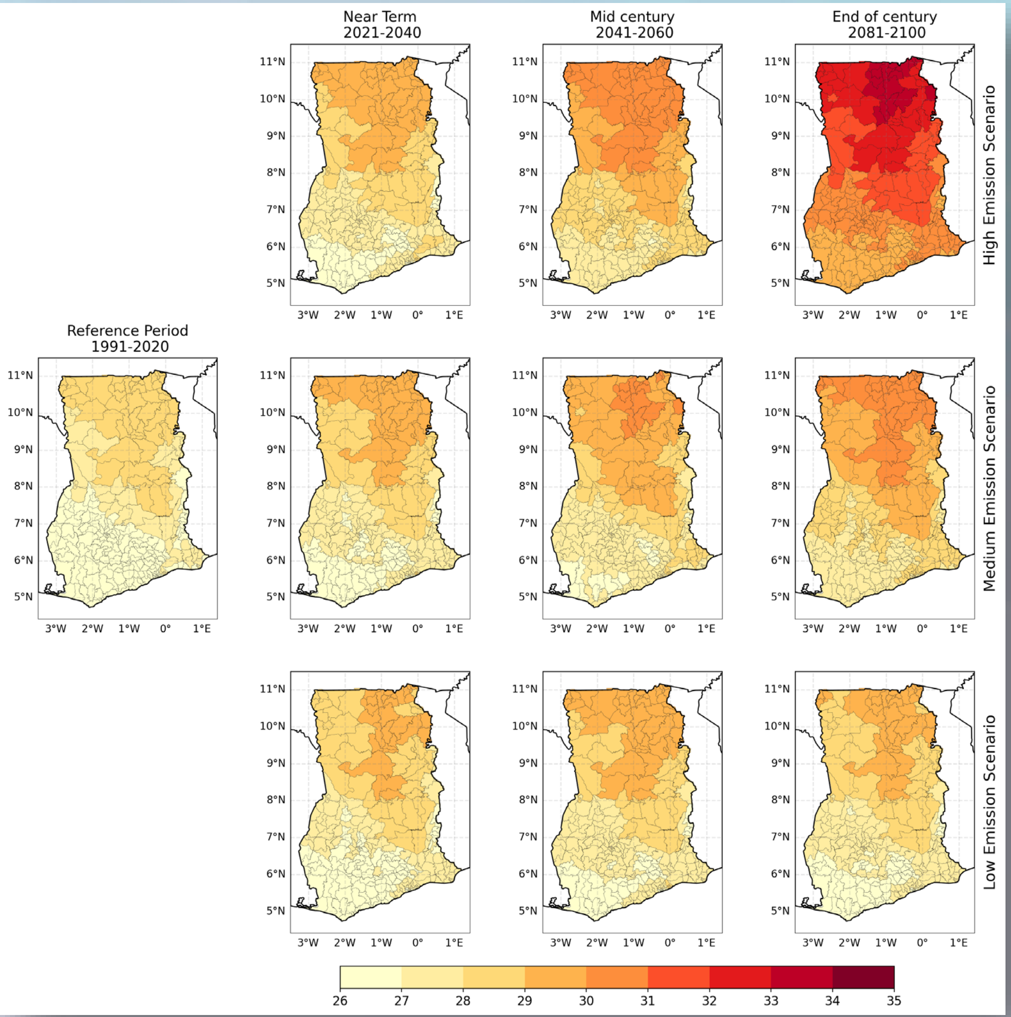
Ghana Climate Atlas
~25 km



Results – Average Annual Temperature



Key finding (RCP 4.5):
Increase by **1.6°C**, reaching **29.1°C** by 2081–2100.
Implication:
↗heat stress on crops, livestock, and humans ↘↗ risks to agriculture, health, and energy demand.



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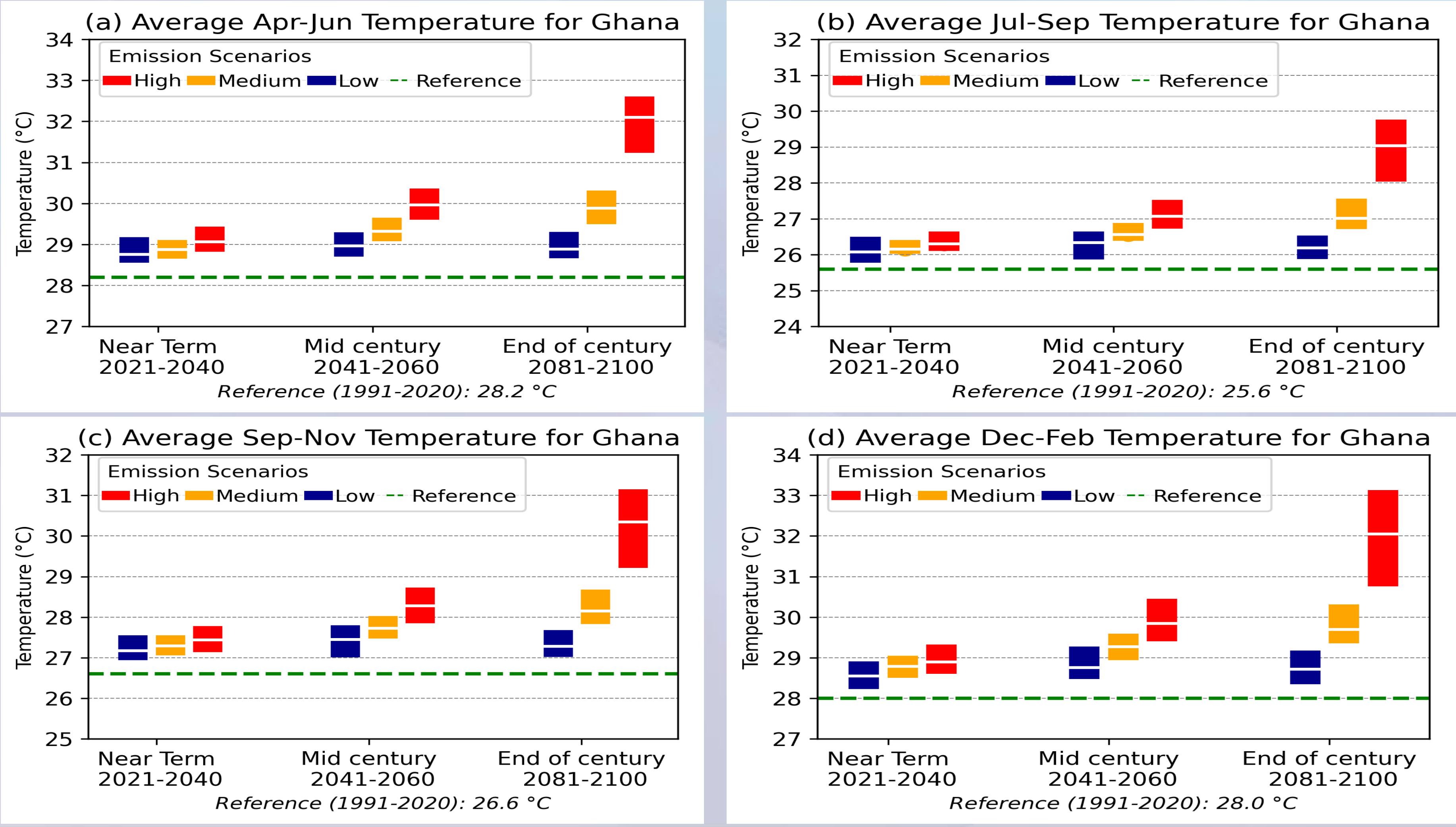
Average Seasonal Temperature



Key finding:
Highest warming in DJF **(+1.7°C)**; **lowest** in JAS **(+1.4°C)** by 2100.

Implication:
Hotter dry seasons and increased heat stress for people and agriculture

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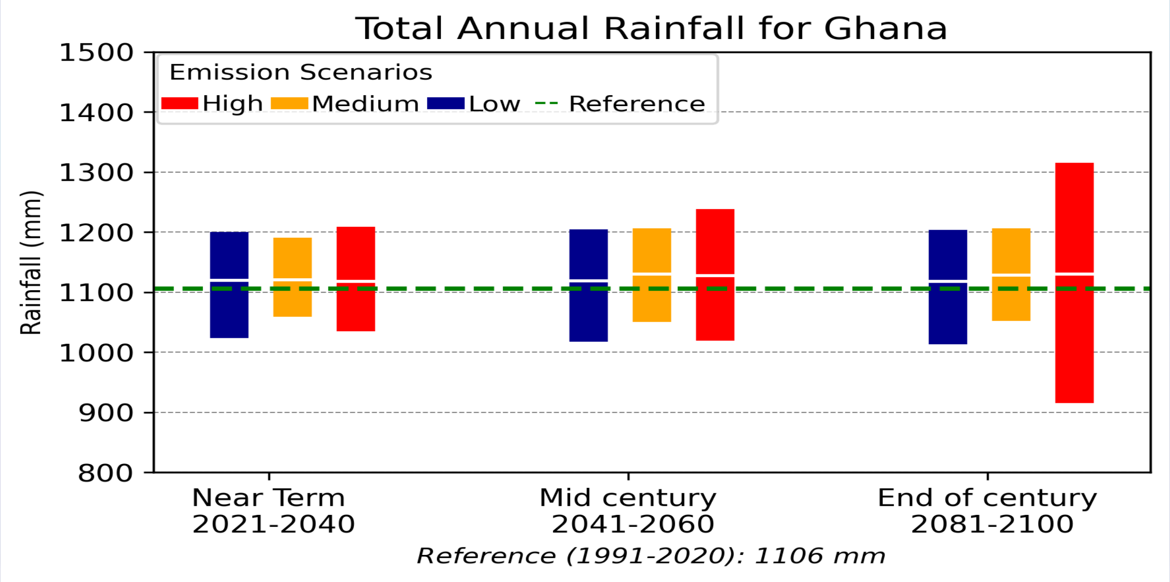
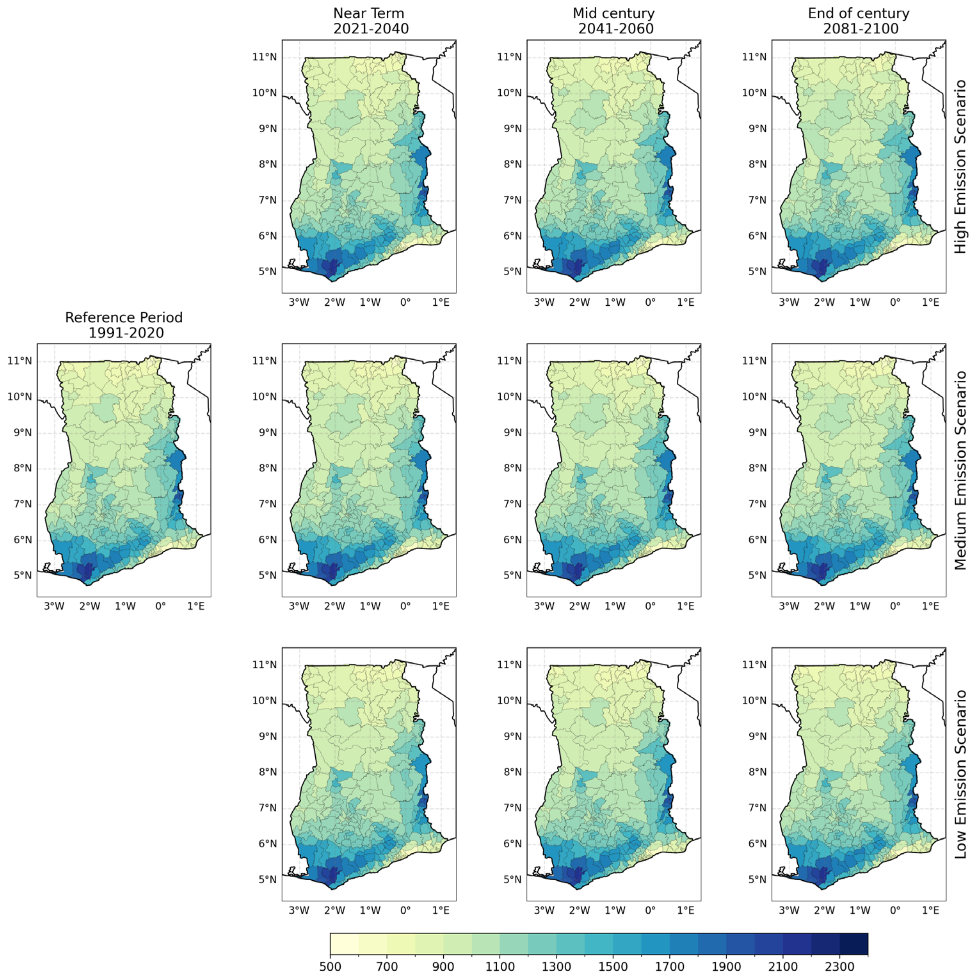
Total Annual Rainfall





Key finding (RCP 4.5):
Annual rainfall increases slightly by **22 mm (≈2%)**, reaching **1128 mm** by 2100.

Implication:
Minor change, but possible shifts in water availability and flood/drought risks.

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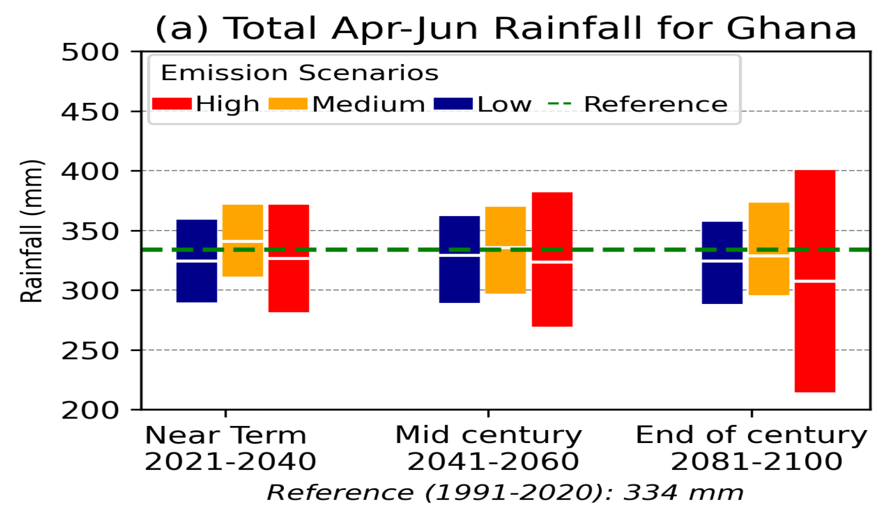
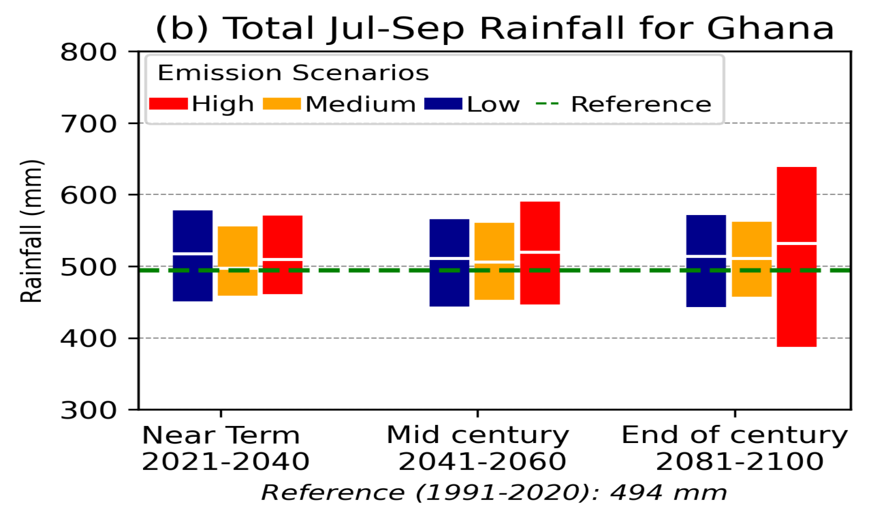
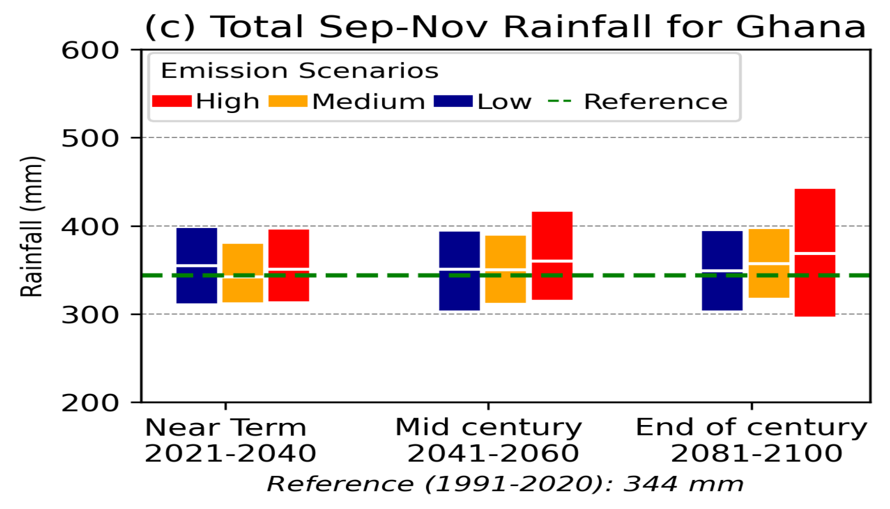
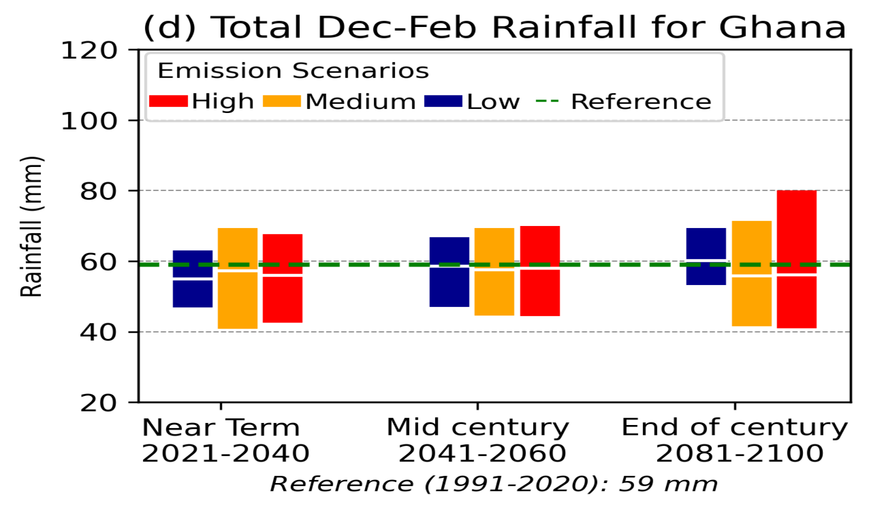
Total Seasonal Rainfall





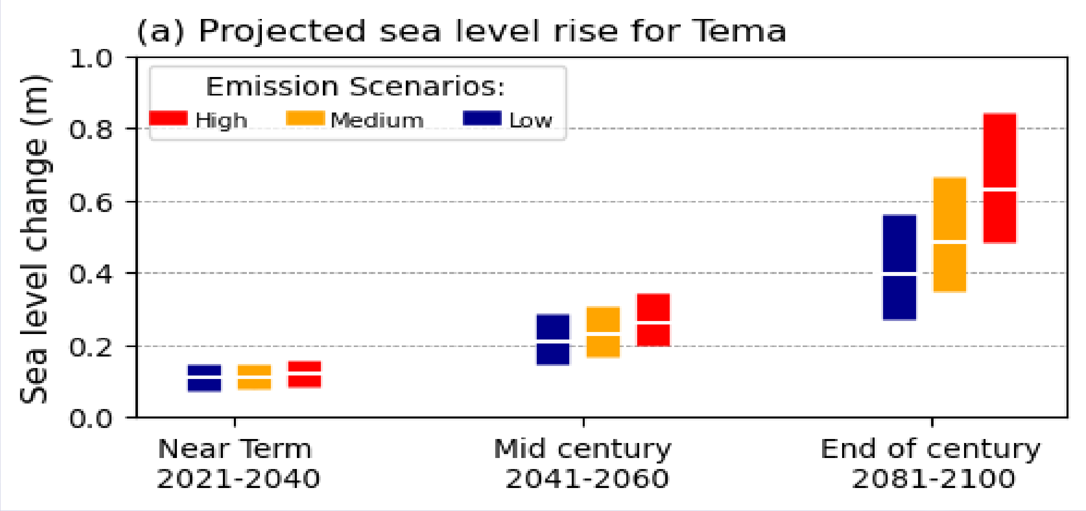


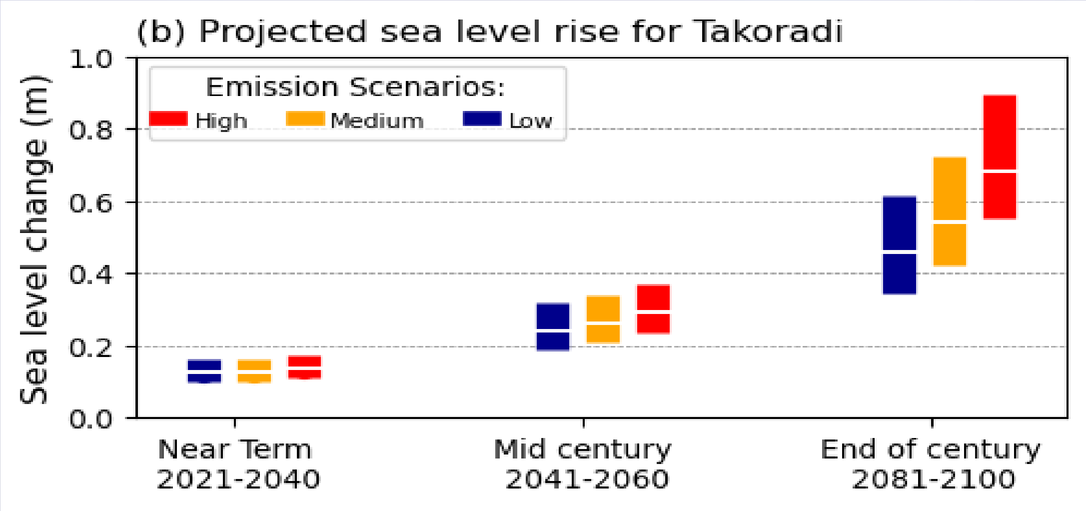


Key finding (RCP 4.5):
Key Finding: SON wetter (+13 mm), AMJ drier (−5 mm) by 2081–2100.

Implication:
Increased flood and disease risk in SON; possible early-season water stress in AMJ affecting agriculture and energy. → *Planting window*

Sea Level Rise





Key finding:
By End-of-Century (SSP3-4.5), mean sea level ↗, Tema (east) ≈ 0.48 m, Takoradi (west) ≈ 0.54 m.

Implication:
Higher coastal flooding and erosion risk, threatening coastal communities, infrastructure, fisheries, and port operations.

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Summary

The Climate Atlas has served a robust tool to understand the climate trend and future projections from national to district levels for planning and decision making.

Climate Indicators results indicated that, by the end of the century (2081-2100), in a medium emission scenario (RCP4.5/SSP3-4.5):

Temperature

- Average annual temperature projected to increase by **+1.6°C**, reaching **29.1°C** (from 27.5°C baseline).
- Strongest seasonal warming of **+1.7°C** expected during **December-February (DJF)**.
- Smallest increase (**+1.4°C**) projected for **July-September (JAS)**.

Rainfall

- Average annual rainfall projected to increase by 22 mm/year (≈2%).
- Greatest increase: September-November (SON) by 13 mm/year (3.8%).
- **Decrease**: April-June (AMJ) by **5mm (1.6%).**

Sea Level Rise

- Continuous rise along both coasts.
- Tema (east coast): **+0.48 m** by 2100.
- Takoradi (west coast): **+0.54 m** by 2100

Way Forward

1. **Expand the Climate Atlas** by including additional climate variables and climate zone classification

2. **Engage stakeholders** to coproduce and promote awareness on the use of the Ghana Climate Atlas.

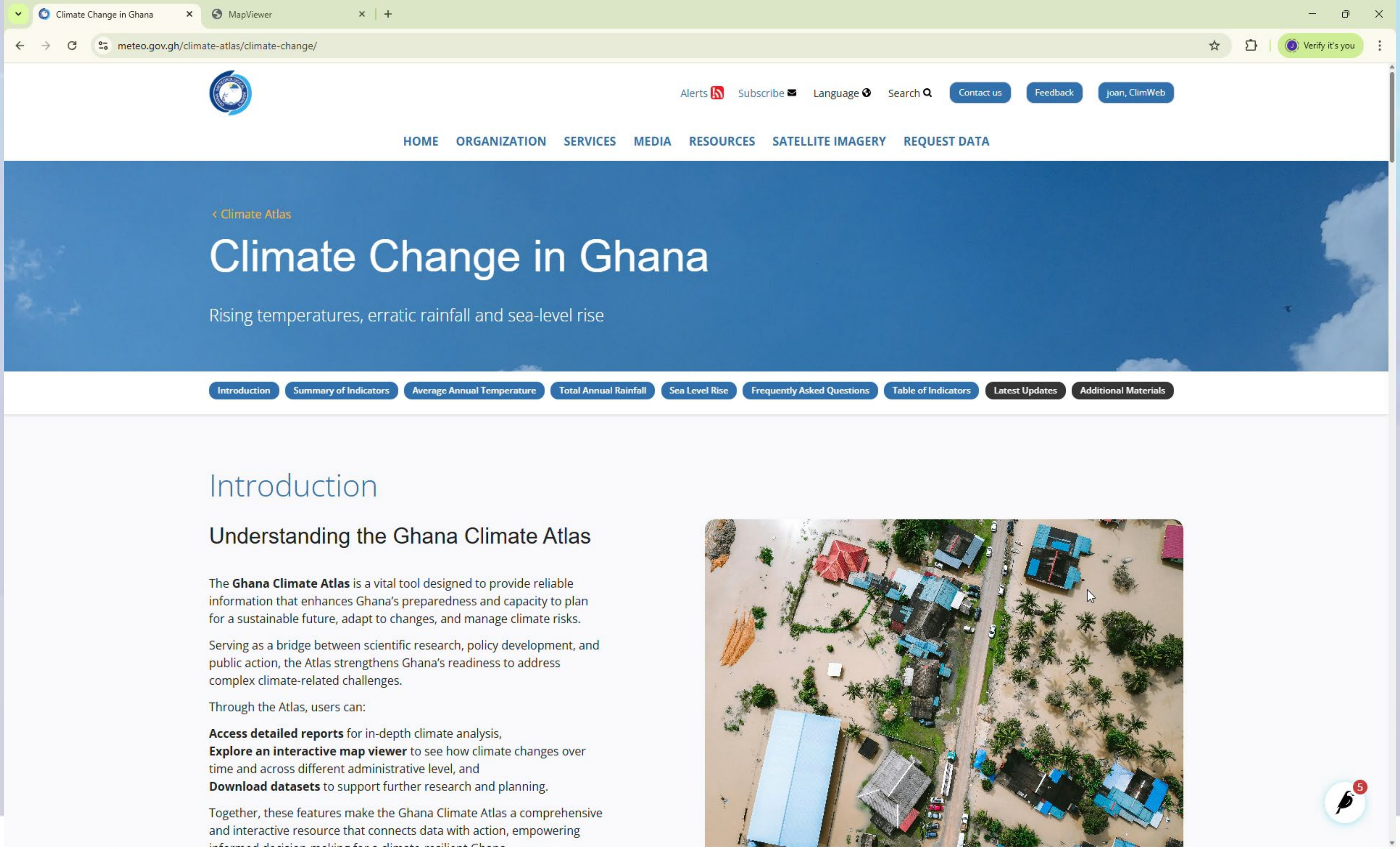
3. **Publish** the research paper on the *Ghana Climate Atlas*.

4. **Classify projections** according to Ghana's **climatic zones** to enhance sectoral relevance.

5. **Develop gridded observation merged datasets** to enhance data for projections.

6. **Enhance visualization** of Atlas outputs through **interactive dashboards and story maps** on the GMet website.

Visualization – Content Management System



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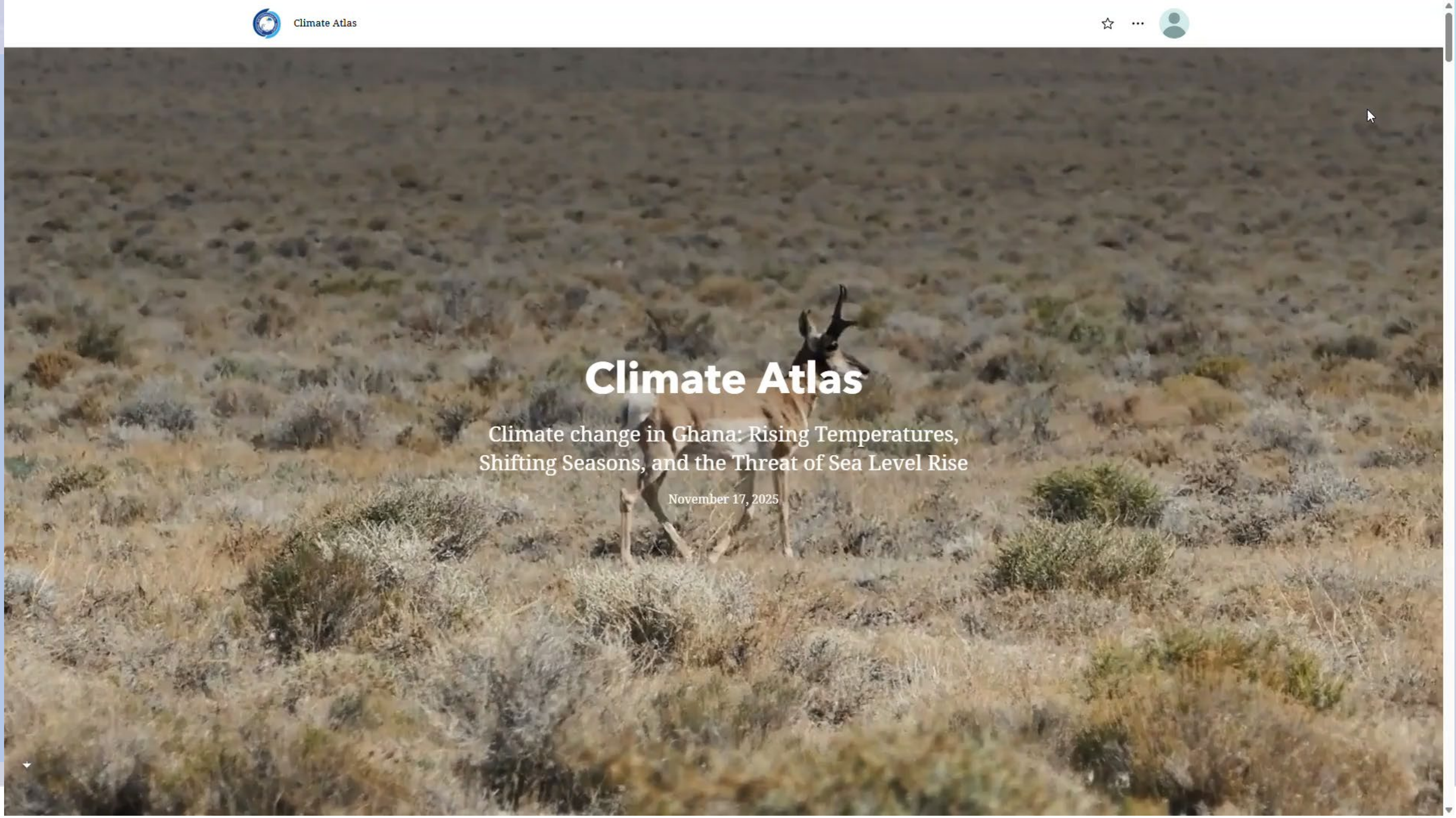
Visualization – Story Maps By ESRI



Acknowledgement

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Expertise, rigorous analytical contributions, and sustained efforts in co-developing this vital resource.

DANISH EMBASSY

Danish Embassy in Accra

Financial and strategic support

ESRI
Technical support and platforms

WORLD METEOROLOGICAL ORGANIZATION(WMO)

World Meteorological Organization (WMO)

Technical guidance, standards, and overarching coordination in strengthening climate services.

Thanks – Medaase - Oyiwaladon

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