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REVIEWER'S REPORT

Manuscript No.: IJAR- 59100

Title: ***Changing drought patterns in Sierra Leone under a warming climate: a spatiotemporal analysis of meteorological and climatic water deficits from 1981 to 2025.***

Recommendation:
Accept as it is .....
Accept after Major revision.....
Accept after Minor to moderate revision
Do not accept (*Reasons below*)

Rating	Excel.	Good	Fair	Poor
Originality		✓		
Techn. Quality		✓		
Clarity			✓	
Significance			✓	

Reviewer Name: **Dr. ANAPANA GOPAL**

Reviewer's Comment for Publication.

General Comments

The manuscript examines changing drought patterns in Sierra Leone during 1981–2025 using the Standardized Precipitation Index (SPI) and Standardized Precipitation–Evapotranspiration Index (SPEI). The study aims to assess drought frequency, duration, severity, spatial distribution, and the contribution of temperature-driven evaporative demand. It also incorporates future climate projections and discusses implications for agriculture, water resources, food security, and adaptation.

The topic is highly relevant to climate-change impact assessment and water-resource management in West Africa. The combined use of precipitation-based and temperature-sensitive drought indices is potentially useful. However, the manuscript in its present form requires **Moderate revision** because several important methodological details are missing, many quantitative results are presented without sufficient underlying evidence, and some claims appear to be derived from previously published studies rather than directly demonstrated by the analysis described in this manuscript.

The manuscript should be strengthened substantially before publication.

Content and Originality

The study addresses an important research problem and clearly identifies three research questions concerning historical drought changes, spatial patterns, and the contribution of warming to drought intensification.

However, the scientific novelty needs to be articulated more clearly.

The manuscript currently relies extensively on previously published results, particularly from Amara and Ullah (2023), Ogunrinde et al. (2026), Ekolu et al. (2025), and the Green Climate Fund report. Many numerical values and regional conclusions are attributed directly to these sources.

The authors should clearly distinguish:

- Results newly calculated in the present study.

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- Results obtained from external datasets.
- Findings taken from previous publications.
- External climate projections incorporated into the study.

The paper should explain what new information is generated by the present analysis beyond the existing Sierra Leone and West African drought literature.

Data Sources and Methodology

The manuscript uses CRU TS precipitation data, ERA5 temperature data, CORDEX-Africa/CMIP6 projections, and World Bank drought-index information.

This is a potentially appropriate data framework, but the methodology requires much greater detail.

1. CRU Dataset

The manuscript states that CRU TS4.01 precipitation data at 0.5° × 0.5° resolution were used.

The authors should provide:

- Exact spatial domain/grid points used.
- Number of grid cells covering Sierra Leone.
- Method used to extract national and regional averages.
- Treatment of missing values.
- Whether the data were bias-corrected.
- Whether station observations were used for validation.

2. ERA5 Temperature Data

ERA5 temperature data are described as having approximately 30 km spatial resolution.

The manuscript should specify:

- Which temperature variable was used.
- Whether monthly mean temperature was calculated from daily/hourly data.
- How temperature was spatially aggregated.
- How PET was calculated.

Most importantly, the **exact PET method must be reported**. SPEI depends critically on PET estimation, and the choice of Penman–Monteith, Thornthwaite, Hargreaves, or another method can substantially affect results.

SPI and SPEI Methodology

The use of SPI and SPEI is appropriate for distinguishing precipitation deficits from climatic water deficits. The manuscript uses SPI at 1-, 3-, 6-, and 12-month timescales and describes SPEI as incorporating precipitation minus PET.

However, important methodological information is missing.

The authors should report:

1. Probability distribution used for SPI.
2. Distribution used for SPEI.
3. Reference/calibration period.
4. Method of standardization.
5. PET calculation method.
6. SPEI timescales used.
7. Software/package used for calculation.
8. Treatment of missing observations.
9. Whether stationarity assumptions were tested.

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Without these details, the analysis cannot be reproduced adequately.

Drought Event Definition

The manuscript defines moderate drought as SPEI ≤ −1.0 and calculates duration, severity, frequency, and intensity.

This section should be improved.

The authors should clearly define the thresholds for:

- Moderate drought.
- Severe drought.
- Extreme drought.

They should also explain how an individual drought event is separated from another event. For example, the methodology should state whether a single month above the threshold terminates an event or whether an inter-event criterion is applied.

The calculation of severity should also be given mathematically.

Trend Analysis

The manuscript reports use of the Modified Mann–Kendall test and Theil–Sen estimator.

This is appropriate for climate time-series analysis, but the actual results are insufficiently reported.

For each major trend, the manuscript should provide:

- Mann–Kendall statistic.
- p-value.
- Sen's slope.
- Confidence interval, where possible.
- Direction and magnitude of trend.

Simply stating that a trend is statistically significant is not sufficient.

For example, the manuscript states that annual rainfall shows a statistically significant decreasing trend with $p < 0.05$.

The actual trend magnitude should be reported, such as mm/year or percentage change per decade.

Spatial Analysis

The manuscript claims substantial spatial heterogeneity and identifies Kambia and Port Loko as particularly vulnerable northern areas.

However, the paper needs stronger spatial evidence.

The authors should provide high-quality maps showing:

- Mean annual precipitation.
- Precipitation trends.
- SPI trends.
- SPEI trends.
- Drought frequency.
- Drought duration.
- Drought severity.
- Spatial distribution of significant trends.

The statistical significance of spatial patterns should also be clearly indicated.

A map should distinguish statistically significant trends from non-significant trends rather than presenting all spatial changes as equally robust.

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Moderate Concern: Results Versus Previously Published Information

A Moderate concern is that several quantitative results appear to be directly taken from cited studies.

Examples include:

- National meteorological drought coverage of approximately 14%.
- Agricultural drought affecting approximately 26.8%.
- Hydrological drought affecting approximately 26%.
- Particular regional drought characteristics.
- Several projected temperature changes.
- Changes in drought frequency and return periods.

The manuscript needs to make clear whether these values were **recalculated using the datasets described in the present study** or simply reproduced from previous publications.

If they were reproduced from previous studies, the manuscript should not present them as original results.

If they were independently calculated, the authors should provide sufficient methodology, tables, figures, and statistical outputs to demonstrate this.

Climate Projection Methodology

The future projection section requires substantial clarification.

The manuscript states that projections were obtained from CORDEX-Africa downscaled models and CMIP6 ensemble simulations, while simultaneously referring to **RCP 4.5 and RCP 8.5**.

This needs careful clarification because RCPs are generally associated with CMIP5-era scenario frameworks, whereas CMIP6 commonly uses SSP-based scenarios.

The authors should specify:

- Which CORDEX experiments were used.
- Which CMIP generation corresponds to each projection.
- Exact scenarios.
- Models included.
- Number of models.
- Ensemble methodology.
- Baseline period.
- Bias-correction procedure.
- Downscaling methodology.

The statement that projections cover **2011–2040** and **2041–2070** should also be clarified because the historical analysis extends through 2025.

The authors should explain why 2011–2040 is designated as a future period when it overlaps substantially with the observational/reanalysis study period.

Interpretation of Temperature Effects

One of the central conclusions is that increasing temperature and evaporative demand intensify drought beyond precipitation deficits alone. This is an important hypothesis and is consistent with the conceptual distinction between SPI and SPEI.

However, the manuscript should provide direct quantitative evidence.

For example, the authors could compare:

SPI versus SPEI

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for the same:

- Years,
- Regions,
- Drought events,
- Frequencies,
- Durations,
- Severities.

The manuscript should demonstrate quantitatively how many drought events are detected by SPEI but not SPI and how drought severity changes when PET is included. This would substantially strengthen the central scientific argument.

Discussion

The Discussion identifies several possible drought drivers, including:

- ITCZ and West African monsoon variability.
- Atlantic sea-surface temperatures.
- ENSO.
- Temperature-driven evaporative demand.
- Land-use change.

The discussion is relevant, but some mechanisms are presented without being directly tested in the current study.

For example, land-use change and ENSO are discussed as possible drivers, but no corresponding quantitative analysis is presented.

The authors should therefore either:

1. Perform appropriate attribution/correlation analyses, or
2. Clearly identify these mechanisms as possible contributing factors based on previous literature rather than findings demonstrated by this study.

Agriculture and Water-Resource Implications

The manuscript appropriately connects drought characteristics with rain-fed agriculture, food security, and water resources.

The recommendations regarding drought-resistant crops, water management, early warning systems, livelihood diversification, and ecosystem-based adaptation are relevant.

However, the recommendations are somewhat general.

The authors could improve this section by linking specific recommendations to the identified regional drought patterns.

For example:

- Northern region → agricultural drought and rain-fed farming.
- Southern/coastal region → hydrological and coastal vulnerability.
- Western Area → urban water stress.
- Eastern region → specific drought characteristics.

This would make the practical implications more directly connected to the results.

Study Limitations

It is positive that the authors include a limitations section. They acknowledge the 0.5° × 0.5° CRU resolution, uncertainties in CRU and ERA5, and limitations associated with the 1981–2025 record.

However, additional limitations should be discussed:

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- Lack of dense ground-station validation.
- Uncertainty associated with PET estimation.
- Dependence on gridded/reanalysis datasets.
- Uncertainty in climate-model projections.
- Scenario uncertainty.
- Model structural uncertainty.
- Lack of direct agricultural yield or soil-moisture observations.
- Potential limitations of using SPI/SPEI as proxies for actual drought impacts.

Data Availability

There is an important inconsistency in the Data Availability statement.
The manuscript states that the study uses CRU and ERA5 datasets, but the Data Availability section additionally mentions **CHIRPS** as a source for the empirical implementation.
CHIRPS is not described as one of the primary precipitation datasets in the Methods section.
The authors should clarify whether CHIRPS was actually used in the study.
If CHIRPS was not used, it should be removed from the Data Availability statement.
If it was used, its role and processing methodology should be added to the Methods section.

Figures and Tables

The manuscript would benefit greatly from stronger visual presentation.
The revised manuscript should include:

1. Study-area map showing Sierra Leone and analyzed regions/districts.
2. Spatial distribution of CRU/ERA5 grid cells.
3. Annual precipitation trend map.
4. SPI time-series plots.
5. SPEI time-series plots.
6. Comparison between SPI and SPEI.
7. Drought frequency/severity maps.
8. Historical versus projected temperature trends.
9. Future drought projections.
10. Tables containing statistical trend results.

Each figure should have:

- Clear axis labels.
- Units.
- Appropriate legends.
- Statistical significance information.
- Source/data information.
- Informative captions.

Language and Editorial Quality

The manuscript requires careful English-language editing.
Several editorial issues are apparent.

Examples

- The title ends with **"2025s"**, which should be corrected.

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- Heading formats are inconsistent, e.g., "Introduction:-", "Methods", "3 Results", and "5.0 Conclusions."
- "Key words:-" should be standardized to "Keywords".
- Some sentences are excessively long.
- Some statements repeat information already presented.
- Numerical formatting and punctuation should be standardized.
- Citation formatting is inconsistent.
- "EIC Data" appears in the References, whereas the text uses "CEIC Data."

A thorough language and formatting revision is recommended.

References and Citations

The reference list is relatively short and should be expanded.

The manuscript relies heavily on a small number of sources, particularly Amara and Ullah (2023), Green Climate Fund (2024), Ekolu et al. (2025), and Ogunrinde et al. (2026).

The authors should include additional peer-reviewed literature addressing:

- SPI and SPEI methodology.
- Drought trend analysis.
- PET estimation.
- West African climate variability.
- Climate-change attribution of drought.
- Sierra Leone climate observations.
- CORDEX-Africa projections.
- CMIP6 drought projections.

All references should be checked carefully for:

- Author names.
- Publication year.
- Journal title.
- Volume and pages.
- DOI.
- Consistency between in-text citations and reference list.

Strengths of the Manuscript

The manuscript has several positive features:

1. **Important research topic** related to climate change and drought.
2. **Long historical period** covering 1981–2025.
3. Use of **both SPI and SPEI**, allowing precipitation deficits to be distinguished from temperature-sensitive climatic water deficits.
4. Consideration of **spatial heterogeneity** across Sierra Leone.
5. Inclusion of **future climate projections**.
6. Discussion of implications for agriculture, water resources, food security, and adaptation.
7. The manuscript explicitly acknowledges several important limitations.

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Overall Recommendation

The manuscript addresses a significant climate-related problem in Sierra Leone and has the potential to contribute to understanding drought variability and climate-related water deficits in West Africa. The integration of SPI, SPEI, spatial analysis, trend detection, and future projections provides a useful overall framework.

Nevertheless, the current manuscript requires substantial methodological clarification and stronger evidence supporting its quantitative conclusions. In particular, the authors need to demonstrate which results are newly generated, provide reproducible details of the drought-index calculations and trend analysis, clarify the climate-projection framework, and improve the presentation of spatial and statistical results.

Final Decision:
Minor to Moderate REVISION