Multi-Hazard Risk Assessment of the Agricultural Landscape in Kura Local Government Area, Kano State, Nigeria

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***Abstract*—Assessing agricultural vulnerability to multiple environmental hazards is essential for sustainable land management and climate change adaptation in semi-arid regions. This study evaluated the multi-hazard sensitivity of the agricultural landscape of Kura Local Government Area, Kano State, Nigeria, by integrating satellite-derived environmental indicators within the Google Earth Engine (GEE) cloud-computing platform. Sentinel-2 Surface Reflectance imagery was used to derive the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI), while Landsat-9 Collection 2 Level-2 thermal data were employed to estimate Land Surface Temperature (LST). The three indices were normalized into a standardized five-class risk scale and combined using an equal-weight overlay approach to generate a Multi-Hazard Sensitivity Index (MHSI). The results revealed considerable spatial variability in environmental conditions across the study area. Higher NDVI and NDWI values, indicating healthier vegetation and better moisture availability, were concentrated around Garun Kaya, Shafawa, Sadauki, and parts of Gora, whereas elevated land surface temperatures and lower vegetation and moisture conditions characterized Bakin Kogi, Karfi-Ruga, Bakwatu, and surrounding areas. The MHSI identified extensive zones of high to very high environmental sensitivity, demonstrating the combined influence of thermal stress, vegetation degradation, and moisture deficiency on agricultural vulnerability. The findings highlight the effectiveness of integrating multi-source satellite data and cloud-based geospatial analysis for identifying environmental hazard hotspots and supporting evidence-based agricultural planning. The generated hazard sensitivity map provides valuable information for policymakers, environmental managers, and agricultural stakeholders in prioritizing irrigation development, vegetation restoration, soil and water conservation, and other climate-smart interventions aimed at enhancing resilience and promoting sustainable agricultural production in Kura Local Government Area and comparable semi-arid environments.**

Keywords: Multi-Hazard Sensitivity Index (MHSI); Google Earth Engine; Remote Sensing; GIS; Land Surface Temperature (LST); Normalized Difference Vegetation Index (NDVI); Normalized Difference Water Index (NDWI); Agricultural Vulnerability; Climate Change; Kura Local Government Area; Nigeria.

***Index Terms*—Google Earth Engine, Land Surface Temperature, Multi-Hazard Sensitivity Index Normalized Difference Vegetation Index, Normalized Difference Water Index**

I. INTRODUCTION

Environmental hazards have become increasingly complex due to the combined effects of climate change, rapid land-use transformation, vegetation degradation, and increasing surface temperatures, thereby posing serious threats to ecosystem sustainability, agricultural productivity, and human livelihoods worldwide. Rather than occurring independently, these hazards often interact spatially and temporally, amplifying environmental vulnerability and necessitating integrated assessment approaches for effective planning and disaster risk reduction. In recent years, remote sensing and Geographic Information Systems (GIS) have emerged as indispensable technologies for environmental monitoring because they provide consistent, cost-effective, and spatially explicit information over large geographical areas. The advent of cloud-based geospatial platforms such as Google Earth Engine (GEE) has further transformed environmental hazard assessment by enabling rapid processing of large volumes of satellite imagery and facilitating the generation of environmental indicators with high temporal and spatial resolution. Consequently, multi-index approaches that integrate vegetation, moisture, and thermal characteristics have gained considerable attention as reliable tools for mapping environmental sensitivity and supporting evidence-based environmental management (Agrawal et al., 2024).

Among the numerous remotely sensed environmental indicators, the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Land Surface Temperature (LST) are widely recognized as robust indicators for evaluating ecosystem conditions and environmental stress. NDVI provides valuable information on vegetation vigor and biomass, serving as an indicator of land degradation, drought severity, and ecosystem resilience, whereas NDWI effectively characterizes surface water distribution and vegetation moisture conditions that are essential for monitoring hydrological processes. Conversely, LST reflects the thermal characteristics of the Earth's surface and is closely associated with urbanization, vegetation loss, soil moisture depletion, and climate-induced environmental changes. Numerous recent studies have demonstrated that integrating these complementary indices improves the identification of environmentally sensitive areas because vegetation density, surface moisture, and thermal conditions are strongly interrelated. Areas exhibiting low NDVI, low NDWI, and high LST generally correspond to environmentally stressed landscapes that are more susceptible to ecological degradation and multiple hazards. The integration of these indicators into a Multi-Hazard Sensitivity Index (MHSI) therefore provides a comprehensive framework for quantifying cumulative environmental sensitivity and supporting sustainable land management and hazard mitigation strategies (Agrawal et al., 2024).

In Nigeria, particularly within the Sudan Savannah region, increasing agricultural expansion, deforestation, population growth, declining vegetation cover, rising land surface temperatures, and seasonal variability in water availability have heightened environmental vulnerability and accelerated land degradation. Kura Local Government Area of Kano State represents one of the country's major agricultural zones, where irrigation farming, rapid land-use changes, and increasing climatic variability have significantly altered vegetation dynamics, moisture availability, and surface thermal characteristics. Despite the ecological and socioeconomic importance of the area, few studies have integrated vegetation, moisture, and thermal indicators into a unified framework capable of identifying environmentally sensitive zones for sustainable planning. Therefore, developing a Multi-Hazard Sensitivity Index (MHSI) using Sentinel-2 and Landsat-9 imagery within the Google Earth Engine environment offers an efficient and scientifically robust approach for evaluating the spatial distribution of environmental sensitivity. The findings of such an assessment could provide valuable information for environmental managers, agricultural planners, and policymakers in developing effective strategies for climate adaptation, ecosystem conservation, sustainable agricultural management, and hazard risk reduction in Kura Local Government Area and similar semi-arid environments.

A. The Study Area

Kura Local Government Area (LGA) is situated in the southern part of Kano State, northwestern Nigeria, between approximately latitudes 11°30′–11°50′N and longitudes 8°20′–8°45′E (Figure 1). The LGA covers an estimated land area of about 206 km² and lies within the Sudan Savannah ecological zone, which is characterized by a tropical continental climate with distinct wet (May–October) and dry (November–April) seasons. The area experiences mean annual rainfall ranging from 800 to 1,000 mm and average annual temperatures between 26 and 34°C, making it highly suitable for rain-fed and irrigated agriculture. Geologically, Kura forms part of the Precambrian Basement Complex terrain of northern Nigeria, which consists predominantly of granites, migmatites, gneisses, and schists that have undergone extensive weathering to produce sandy loam and loamy sand soils suitable for crop production. Recent geospatial soil investigations further indicate that the soils are moderately acidic to neutral and contain varying levels of essential micronutrients required for sustainable agriculture (Umar et al., 2026; Yakasai & Rabiu, 2024).

The vegetation of Kura LGA is dominated by Sudan Savannah species, consisting mainly of short grasses, shrubs, and scattered drought-resistant trees such as Acacia, Faidherbia albida, Parkia biglobosa, and Azadirachta indica, although much of the natural vegetation has been modified by intensive farming and human activities. Agriculture remains the dominant land use, with rice, maize, vegetables, millet, and sorghum cultivated extensively, particularly within the Kano River Irrigation Project (KRIP). Water resources in the area include seasonal streams, shallow groundwater aquifers, open wells, boreholes, irrigation canals, and reservoirs associated with the Kano River system, which provide water for domestic, agricultural, and livestock uses. Recent studies have shown that although groundwater and open wells constitute the principal sources of potable water, seasonal variations in physicochemical characteristics and occasional microbial or parasitic contamination highlight the need for continuous monitoring and effective water resource management to ensure sustainable utilization (Matazu et al., 2023; Zawiyya et al., 2026).

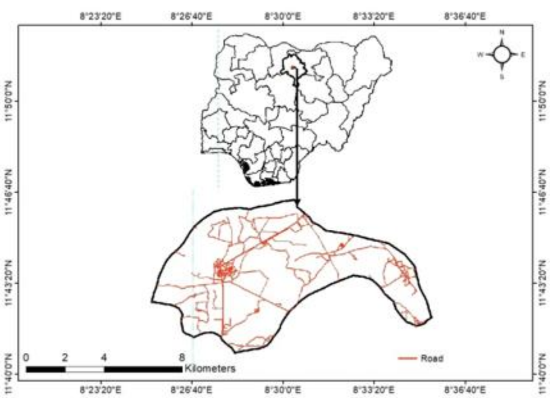

Fig 1. The Study Area

II. MATERIALS AND METHODS

A, Data Materials and Cloud Computing Architecture

The empirical foundation of this research relies on cloud-based, multi-sensor satellite imagery and open-source global administrative datasets integrated through the Google Earth Engine (GEE) platform. The primary spatial data components consist of the Copernicus Sentinel-2 Surface Reflectance (Harmonized) collection, utilized to extract high-resolution (10-meter) optical bands for vegetation and canopy moisture monitoring, and the NASA/USGS Landsat 9 Collection 2 Level-2 dataset, specifically targeting the thermal infrared sensor (Band 10, ST_B10) to map microclimate thermal dynamics.

B. Multi-Sensor Image Acquisition and Temporal Compiling

Following spatial boundary definition, a targeted temporal filter was applied to capture high-quality satellite observations during a critical climatological window. The image collections for both Sentinel-2 and Landsat 9 were subsetted to cover the period from January 1 to March 1, capturing the peak dry season in Northern Nigeria. This specific timeframe was selected because agricultural production in the region becomes entirely dependent on irrigation during these months, meaning that environmental stress factors such as thermal radiation, high evaporation, and vegetation moisture deficits are at their maximum intensity. Surface reflectance collections were utilized to guarantee that both datasets have undergone rigorous atmospheric correction, adjusting for aerosol scattering and absorption to ensure temporal consistency and high data integrity.

C. Pixel-Based Reductions and Spatial Clipping

To generate clean, analytical baselines free from seasonal anomalies, cloud contamination, and transient atmospheric noise, a median pixel-based composite reduction is applied to the filtered image collections. The median reducer evaluates the statistical median value for each individual pixel across the entire two-month image stack, compressing multi-temporal observations into a single, cloud-free representative image for the dry season. This statistical approach maintains radiometric stability and effectively filters out outlier pixels caused by cloud edge effects or sensor errors. Once the median composites for both Sentinel-2 and Landsat 9 are built, they are programmatically clipped using the pre-defined Kura LGA vector boundary mask, discarding all extraneous peripheral data to optimize processing efficiency during subsequent spatial indexing.

D. Spectral Index Formulation and LST Extraction

With the cloud-free composites prepared, mathematical band transformations were executed to derive key environmental parameters from the multi-spectral and thermal imagery. Using the Sentinel-2 composite, the Normalized Difference Vegetation Index (NDVI) was computed using the Near-Infrared (Band 8) and Red Band 4 bands to assess chlorophyll absorption and track structural vegetation health across the irrigated landscape. Concurrently, the

Normalized Difference Water Index (NDWI) was generated using the Near-Infrared (Band 8) and Shortwave-Infrared (Band 11) wavelengths to detect liquid water content in vegetation canopies and surface soils, identifying zones experiencing water stress. To map thermal variations, the raw digital numbers from Landsat 9's thermal infrared band (Band 10) were converted into absolute Land Surface Temperature (LST) in degrees Celsius (^{0}C) by applying the sensor-specific multiplicative scaling factor (0.00341802), adding the additive offset (149), and subtracting the absolute zero constant (273.15).

E. Normalization and Rule-Based Reclassification

Because NDVI, NDWI, and LST operate on fundamentally different physical units and mathematical scales, they were normalized into a standardized, dimensionless ordinal risk scale ranging from 1 (Very Low Risk) to 5 (Very High Risk). The reclassification logic is designed to reflect the inverse environmental relationships that vegetation health and water content share with hazard vulnerability compared to surface temperature. High NDVI (>0.60) and high NDWI (>0.30) values represent robust crop vigor and ample moisture, which correspond to low environmental vulnerability (Risk Class 1), while low values NDVI (< 0.15); NDWI (< 0.00) indicate severe degradation and drought conditions, triggering a high vulnerability assignment (Risk Class 5). Conversely, LST shares a direct relationship with hazard exposure; cooler surfaces (<32^{0}C) were assigned to Risk Class 1, whereas thermal hotspots exceeding 44^{0}C are reclassified as Risk Class 5 using conditional pixel thresholding via the .where() function in GEE.

F. Synthesis of the Multi-Hazard Sensitivity Index (MHSI)

The final stage of the methodology executes a spatial overlay analysis to combine the standardized risk layers into a single Multi-Hazard Sensitivity Index (MHSI). An equal-weight arithmetic overlay was performed by programmatically summing the reclassified NDVI, NDWI, and LST risk layers together and dividing the cumulative sum by three to compute the mean environmental risk per pixel. The output was rounded to the nearest whole integer and cast as an unsigned 8-bit integer (uint8) to maintain the strict 5-class ordinal scale. This synthesis isolated geographic pockets within Kura LGA where low vegetation vigor, acute moisture deficits, and high surface temperatures overlap, pinpointing the zones most sensitive to drought and climate hazards.

III. RESULTS AND DISCUSSION

A, Land Surface Temperature (LST)

The spatial distribution of Land Surface Temperature (LST) across Kura Local Government Area revealed substantial thermal variability, with temperatures ranging from approximately 23°C to 36°C. Relatively low temperatures were observed around Shafawa, Garun Kaya, and parts of Sadauki, where cultivated lands are characterized by comparatively dense vegetation cover, whereas the highest temperatures were concentrated around Bakin Kogi, Gora, Karfi-Ruga, and Bakwatu, where sparse vegetation and exposed bare soils predominate (Figure 2). This spatial pattern highlights the strong influence of vegetation density and surface moisture on the thermal characteristics of agricultural landscapes. Vegetation moderates land surface temperature through evapotranspiration, increased canopy shading, and enhanced soil moisture retention, while bare soils absorb and re-radiate larger amounts of incoming solar radiation, resulting in elevated surface temperatures. The inverse relationship observed between vegetation abundance and LST in the present study agrees with recent findings that vegetation plays a critical role in regulating land surface thermal conditions and mitigating heat stress in semi-arid agricultural environments (Li et al., 2023; Li & Zhong, 2024).

The occurrence of extensive moderate- to high-temperature zones across Kura Local Government Area has important implications for agricultural sustainability because elevated LST is closely associated with increased evapotranspiration, accelerated soil moisture depletion, crop water stress, and heightened drought susceptibility. In semi-arid environments such as northern Nigeria, prolonged exposure to elevated land surface temperatures can substantially reduce crop growth, increase irrigation requirements, and ultimately lower agricultural productivity. The predominance of relatively high thermal conditions observed across much of the study area therefore suggests increasing vulnerability of agricultural production systems to climate variability and prolonged dry-season conditions. These findings are consistent with recent studies demonstrating that elevated land surface temperatures contribute significantly to agricultural drought development, reduced water availability, and declining resilience of farming systems under changing climatic conditions (Houmma et al., 2022; Le et al., 2024).

The spatial variation in LST further demonstrates the value of satellite-derived thermal information for agricultural hazard monitoring and multi-hazard assessment. Unlike conventional meteorological observations, remotely sensed LST provides continuous spatial coverage capable of identifying localized thermal hotspots that may not be detected by sparse ground-based weather stations. Such information is particularly valuable for drought monitoring, irrigation scheduling, agricultural early warning systems, and climate-smart land management. Consequently, integrating LST into the Multi-Hazard Sensitivity Index (MHSI) enhances the ability to characterize cumulative heat-related risks affecting agricultural landscapes and improves the spatial identification of vulnerable areas requiring intervention. Similar conclusions have been reported in recent remote sensing studies, which emphasize that integrating satellite-derived thermal indicators into agricultural hazard assessment substantially improves drought detection, vulnerability mapping, and evidence-based decision-making for climate adaptation (Li et al., 2023; Le et al., 2024; Varghese et al., 2021). Therefore, the LST analysis presented in this study provides a scientifically robust foundation for prioritizing agricultural adaptation strategies and strengthening the resilience of farming systems against future climate-induced hazards.

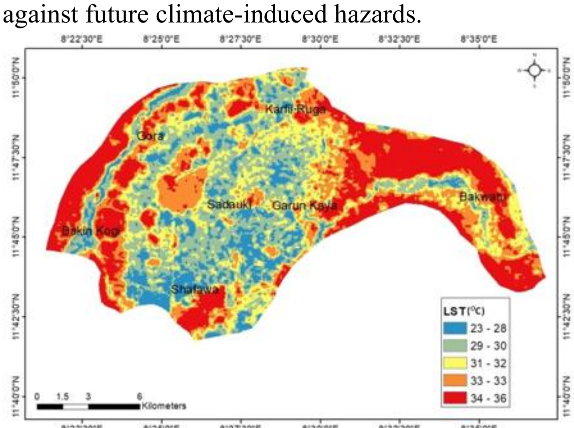

Figure 2 Land Surface Temperature (LST)

B. Normalized Difference Vegetation Index (NDVI)

The NDVI results for Kura Local Government Area, with values ranging from −0.30 to 0.80, reveal a pronounced spatial heterogeneity in vegetation condition that carries significant implications for agricultural sustainability in the region. The areas exhibiting higher NDVI values (0.60–0.80), particularly around Garun Kaya, Shafawa, Sadauki, and Gora, are indicative of vigorous vegetation growth, healthy crop development, and relatively high biomass production (Figure 3). This finding is consistent with recent research by Sampériz and Usón (2026), who demonstrated that NDVI-derived metrics effectively capture spatial variability in crop development associated with soil heterogeneity and management practices in semi-arid agricultural landscapes. Their study established that NDVI median values serve as reliable indicators of overall crop performance, while NDVI standard deviation captures within-plot variability linked to soil properties. Similarly, the observed high NDVI values in the cultivated fields of Kura LGA reflect the positive influence of improved irrigation practices, soil fertility management, and cropping intensity on vegetation health. The relationship between NDVI and soil colloidal status, as demonstrated by Bascietto et al. (2021), showing that even small variations in soil organic matter can significantly influence NDVI through improvements in soil structure and plant nutrition, further underscores the importance of soil quality in sustaining high vegetation productivity. The spatial concentration of healthy vegetation in specific settlements suggests that these areas have benefited from more effective land management strategies, including optimized irrigation schedules and enhanced soil conservation practices, which have collectively contributed to their agricultural resilience.

Conversely, the low NDVI values dominating portions of Bakin Kogi, Bakwatu, and scattered patches throughout the study area signify sparse vegetation cover, harvested farmlands, exposed soils, built-up areas, and degraded agricultural lands. These conditions are symptomatic of reduced biological productivity and heightened sensitivity to climatic extremes, particularly drought and soil degradation. This pattern aligns with findings from Alvarez and Govind (2025), who reported that declining NDVI trends across Moroccan croplands were closely associated with reductions in precipitation and rising land surface temperatures, with up to 60% of agricultural zones showing significant NDVI decline over a decadal period. The inverse relationship between temperature and vegetation health observed in their study, where higher temperatures negatively impacted cropland areas, resonates with the conditions in low-NDVI zones of Kura LGA, where reduced vegetation cover likely exacerbates local warming through diminished evapotranspiration and increased surface albedo. Furthermore, the research by Bharani et al. (2026) on vegetation health monitoring in Tamil Nadu demonstrated that areas with low vegetation indices were strongly linked to drought stress, soil degradation, and rapid urban expansion, resulting in significant vegetation decline. The presence of built-up areas and exposed soils within the low-NDVI zones of Kura LGA similarly points to anthropogenic pressures, including urbanization and unsustainable land use practices, that have compromised vegetation cover and, by extension, the ecological services provided by healthy vegetation, such as soil moisture retention and erosion control.

The observed spatial variability in NDVI across Kura LGA, even within cultivated zones, reflects underlying differences in irrigation practices, cropping intensity, soil fertility, and management strategies, which collectively determine the agricultural sensitivity of the landscape to environmental hazards. This finding corroborates the work of Sampériz and Usón (2026), who emphasized that NDVI variability metrics provide a robust approach for identifying soil-driven crop heterogeneity and supporting site-specific management decisions. The significant differences in NDVI standard deviation among soil units observed in their study, with greater variability in heterogeneous soil units and more homogeneous growth in stable platforms, mirror the cultivated-zone variations detected in Kura LGA. Moreover, the research by Alvarez and Govind (2025) highlighted that farmers' adaptation strategies, including the adoption of drought-resistant varieties, improved irrigation practices, and altered sowing dates, were essential for maintaining vegetation health under changing climatic conditions. The NDVI map of Kura LGA thus serves as a critical diagnostic tool for identifying agricultural areas requiring targeted interventions, such as enhanced irrigation infrastructure, soil fertility restoration, and climate-smart cropping systems. In this context, the integration of NDVI monitoring with other remote sensing indices, as recommended by Bharani et al. (2026), could provide a more comprehensive understanding of land-cover dynamics and guide sustainable land management policies. Ultimately, the NDVI findings underscore the urgent need for improved land management and climate adaptation interventions in low-NDVI zones to enhance agricultural resilience, mitigate soil degradation, and ensure long-term food security in the region.

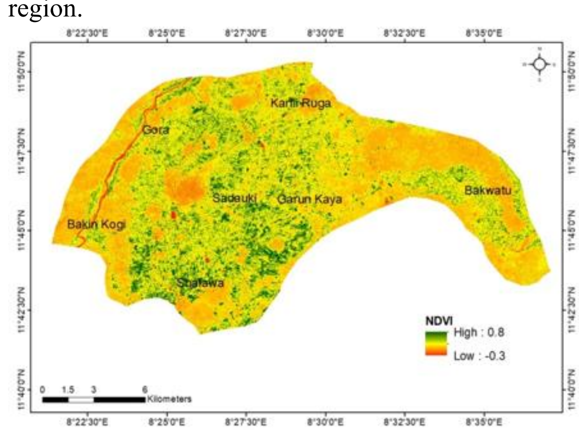

Figure 3 Normalized Difference Vegetation Index (NDVI)

C. Normalized Difference Water Index (NDWI)

The NDWI values obtained for Kura Local Government Area, ranging from −0.4585 to 0.4094 with the bulk of the landscape clustering between −0.1520 and −0.0364, point to a moisture-limited agroecosystem in which only a narrow fraction of the study area chiefly river corridors, irrigated plots, and wetlands around Gora, Garun Kaya, and Bakwatu retains appreciable canopy and surface water content (Figure 4). This pattern is consistent with recent remote sensing evidence that NDWI, because it exploits the differential absorption of shortwave infrared radiation by leaf and soil water, is highly sensitive to short-term moisture depletion and can register drought stress earlier than purely greenness-based indices such as NDVI (Alito et al., 2025). Alito et al. (2025) found that water-sensitive indices tracked soil and vegetation moisture deficits more responsively than temperature or greenness-based proxies, reinforcing the interpretation that the predominance of negative NDWI values across Kura reflects a genuine and spatially extensive moisture deficit rather than a transient sensor or seasonal artefact. Similarly, Pandya and Gontia (2023), working in the semi-arid Saurashtra region of India, demonstrated that an NDWI-derived anomaly index was among the strongest satellite-based predictors of crop yield when combined with meteorological drought indices, underscoring that the negative NDWI values dominating the Kura landscape are not merely descriptive but carry direct implications for productivity outcomes in rain-fed farming systems of this kind.

The concentration of higher, moisture-favourable NDWI values along drainage lines and irrigated fields in Kura aligns with findings from other West African agricultural contexts, where localized access to surface or shallow groundwater has been shown to substantially buffer crops against the broader regional moisture deficit. Akpoti et al. (2023), in an assessment of groundwater and surface-water irrigation potential for cocoa systems in Ghana, similarly found that irrigation-accessible zones displayed markedly different vegetation-moisture signatures from surrounding rain-fed areas, and argued that such zones should be prioritised for climate-smart irrigation investment precisely because they demonstrate resilience where the wider landscape does not. This comparison suggests that the moisture-rich patches identified in Kura are not incidental but represent strategically important nodes for adaptive water management, and that scaling up irrigation infrastructure around these corridors could meaningfully extend the area of drought-resilient cultivation. At the same time, Satapathy et al. (2024) caution, from their work developing a combined regional drought index in Odisha, India, that vegetation-moisture indices alone often show only moderate correlation with realised crop yield, implying that while the NDWI map is a valuable diagnostic of relative moisture stress within Kura, it should ideally be triangulated with soil moisture, precipitation, or yield records before being used as the sole basis for targeting interventions.

Taken together, the NDWI results carry clear implications for agricultural risk management and land and water governance in Kura. The dominance of negative-to-moderately-negative values signals that a large share of the LGA's cropland is operating under chronic moisture limitation, a condition that recent literature associates with reduced resilience to both short-duration dry spells and prolonged seasonal droughts (Alito et al., 2025; Pandya & Gontia, 2023). This reinforces the case for prioritising supplemental irrigation, water harvesting, and soil-moisture conservation practices in the moisture-deficient zones, while the identified high-NDWI corridors around Gora, Garun Kaya, and Bakwatu offer tangible, evidence-based targets for expanding irrigated agriculture, consistent with the irrigation-potential mapping approach advocated by Akpoti et al. (2023). agricultural drought in Kura and comparable semi-arid zones of northern Nigeria.

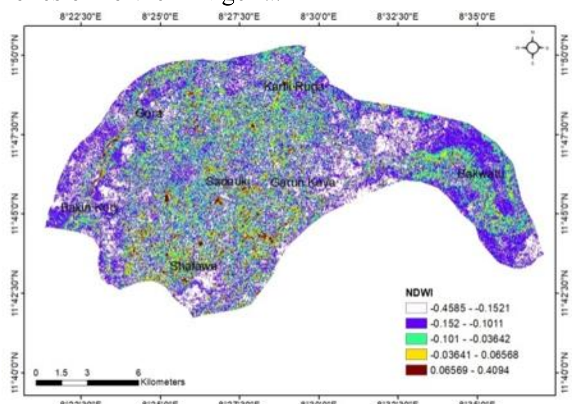

Figure 4 Normalized Difference Water Index (NDWI)

D. Multi-Hazard Sensitivity Index (MHSI)

The dominance of the Very High sensitivity class across Bakin Kogi, Gora, Sadauki, Garun Kaya, Karfi-Ruga, Bakwatu, and Shafawa indicates that agricultural land in Kura is simultaneously exposed to thermal stress, vegetation degradation, and moisture deficiency rather than to any single hazard acting in isolation (Figur 5). This composite pattern is consistent with the underlying logic of the Vegetation Health Index (VHI) family of indicators, which Hang et al. (2024) recently re-examined in the Yellow River Basin, showing that combining a vegetation condition component with a thermal condition component captures drought severity more reliably than either component alone, and that the relative weighting of vegetation versus temperature signals is itself climate- and land-cover-dependent. The fact that the MHSI in Kura draws on land surface temperature, vegetation condition, and moisture together, in a manner conceptually similar to Hang et al.'s optimized VHI, lends methodological credibility to the finding that so much of the landscape falls into the highest sensitivity category: it suggests that heat, vegetation stress, and dryness are co-occurring and mutually reinforcing across the LGA rather than being isolated, unrelated signals.

The scale and spatial concentration of the Very High sensitivity class in Kura also corroborate with findings from composite drought and vulnerability indices developed elsewhere in comparable semi-arid, smallholder-dominated agricultural settings. Guria et al. (2025), for instance, combined optical, thermal, and microwave-derived indices using an Analytic Hierarchy Process to build an integrated drought severity index for Odisha, India, and found that a substantial share of the study area fell into severe-to-extreme categories during the 2023 Kharif season, with the composite index outperforming any single indicator in identifying cropland at risk. Similarly, Alito et al. (2025) demonstrated in the Ethiopian highlands that multi-indicator drought characterizations reveal spatial heterogeneity that single-variable approaches tend to mask, with some indices responding more quickly to emerging stress than others. Read against this literature, the concentration of Kura's high-sensitivity zones in specific settlements, alongside only scattered pockets of moderate-to-low sensitivity, is not an anomaly but a pattern typical of rain-fed agricultural landscapes where thermal, vegetative, and hydrological stressors converge spatially; it reinforces the interpretation that these zones constitute genuine multi-hazard hotspots rather than artefacts of the compositing method.

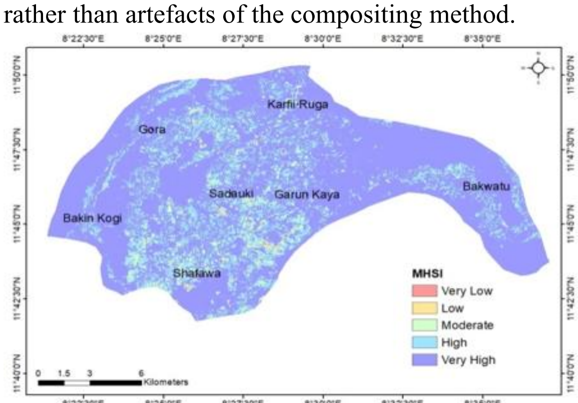

Figure 5 Multi-Hazard Sensitivity Index (MHSI)

IV CONCLUSION

This study successfully demonstrated the application of cloud-based remote sensing and Geographic Information System (GIS) techniques for assessing multi-hazard sensitivity across the agricultural landscape of Kura Local Government Area, Kano State, Nigeria. By integrating satellite-derived Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI), and Normalized Difference Water Index (NDWI) within the Google Earth Engine environment, a Multi-Hazard Sensitivity Index (MHSI) was developed to identify areas simultaneously affected by thermal stress, vegetation degradation, and moisture deficiency. The results revealed pronounced spatial variability across the study area, with several locations exhibiting high to very high environmental sensitivity, indicating that agricultural productivity is increasingly threatened by the combined effects of elevated surface temperatures, declining vegetation health, and persistent moisture stress. The study further demonstrates that integrating multiple environmental indicators provides a more comprehensive assessment of agricultural vulnerability than relying on individual indices alone, thereby offering a robust framework for environmental monitoring and climate risk assessment.

The findings provide valuable geospatial information that can support evidence-based decision-making for sustainable agricultural development, climate change adaptation, and disaster risk reduction in Kura Local Government Area and other semi-arid regions with similar environmental conditions. Priority interventions should focus on improving irrigation infrastructure, promoting soil and water conservation practices, restoring degraded vegetation, and implementing climate-smart agricultural techniques within the identified high-sensitivity zones. Furthermore, future studies should incorporate additional environmental and socio-economic variables, including rainfall variability, soil characteristics, groundwater availability, land-use change, and crop productivity data, while employing multi-temporal analyses to better capture seasonal and long-term environmental dynamics. Such integrated approaches will further enhance the accuracy of hazard assessment and strengthen the capacity of policymakers and land managers to improve agricultural resilience and environmental sustainability under changing climatic conditions.

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