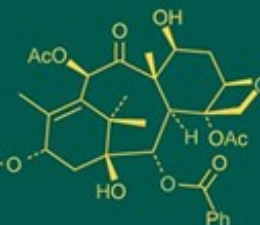
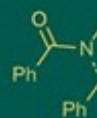
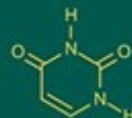


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GIS-based spatial analysis and land suitability assessment for maize cultivation in Kandhamal district, Odisha

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ABSTRACT

Covering an area of 8,021 km², Kandhamal district was considered to determine its agricultural potential for growing maize. Adopting the land evaluation guidelines developed by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), the research utilized Geographic Information System (GIS) spatial tools to categorize the landscape into distinct suitability zones (Samanta *et al.*, 2011; Bhagat *et al.*, 2009) [1, 2]. The evaluation integrated key agro-climatic and physiographic variables, placing primary importance on elevation, precipitation, and thermal trends, alongside edaphic and terrain characteristics. Ultimately, these spatial insights determine optimal cultivation zones, providing critical data to guide strategic land management, optimize crop production, and refine district level agricultural policy.

Keywords: Land suitability, Maize, Kandhamal district

1. Introduction

Geographic Information Systems (GIS) provide a powerful framework for assessing agricultural land capability. By integrating and analysing diverse datasets such as soil characteristics, terrain, climate variables, and precipitation patterns GIS can accurately map zones optimal for specific crops. These spatial visions enable farmers to make informed planting decisions, ultimately enhancing crop yields and overall farm productivity. Maize is an important food grain crop in India. It is mainly grown as a dryland crop. It can be cultivated under both rainfed and irrigated conditions. Maize grows well in warm and moist climatic conditions. It is generally suitable for areas receiving about 500-800 mm of rainfall. It can also be grown in areas with higher rainfall when proper drainage or irrigation facilities are available. Maize is an important food crop for many local communities. The plant grows upright and has a strong, fibrous root system. These roots help the plant absorb water and nutrients from the soil. Maize is mainly a cross-pollinated crop. It can be cultivated in different seasons depending on the local climate and availability of water. According to NBSS (2006), soil, climate, rainfall, and other environmental conditions are important factors for successful maize cultivation.

2. Objective of study

The study follows a two-phase objective: first, by establishing the baseline biophysical and climatic envelope that governs maize cultivation locally; and second, by translating these soil-climate interactions into a structured land suitability classification to guide targeted crop deployment.

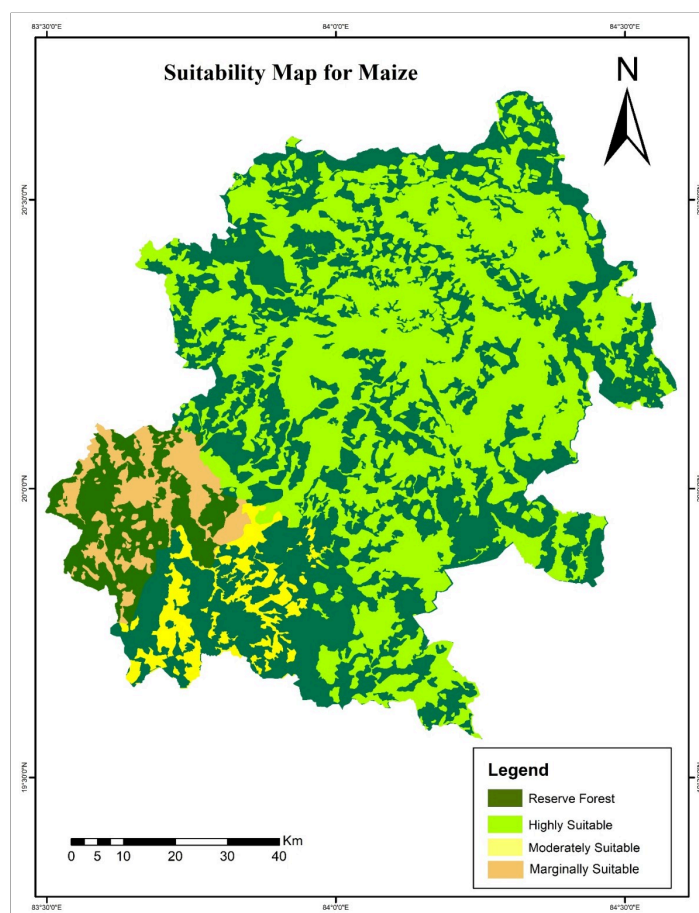
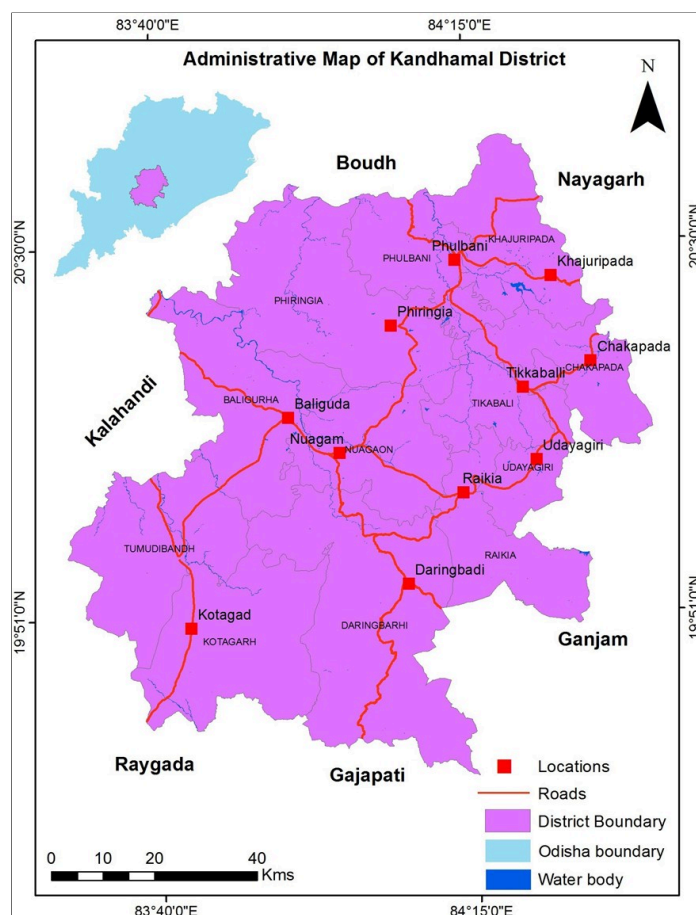
3. Methodology

Grounded in the methodological frameworks established by the Food and Agriculture Organization (FAO) and the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP, 1990) [3, 4], this evaluation models land capability for crop cultivation. The assessment integrates critical biophysical drivers such as climatic conditions, topsoil characteristics, drainage efficiency, effective soil depth, texture, and topographic gradient which collectively govern crop performance. For Kandhamal district, spatial categorization relies heavily on temperature regimes, precipitation levels, and elevation gradients. Each assessed variable is mapped into standardized suitability tiers: Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), and Non-Suitable (N) (NBSS & LUP, 1990) [4].

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4. Study area

The district is located between 83.30° E and 84.48° E longitude and 19.34° N and 20.54° N latitude, as shown in Figure 1.



5. Suitability analysis

Table 1. Type of Land suitability in Kandhamal District for maize crop- 2024

Order	Area in ha (%TGA)
S1	13603.4 (80.02%)
S2	1883.6 (11.08%)
S3	1530.0 (9.0%)

5.1 Highly suitable (S1)

Maize blooms primarily within warm agro-climatic zones and exhibits adaptability across various cropping cycles. Thermal requirements range between 20 °C and 32 °C, with 20 °C to 25 °C serving as the ideal physiological range. While a cumulative annual precipitation of 1,250-1,500 mm supports vigorous growth, seasonal rainfall distribution remains the more critical climatic factor. Edaphic requirements favor well aerated, adequately drained profiles, as the crop is particularly sensitive to waterlogging (5). It tolerates diverse textural classes surrounding loamy, silty, clayey, sandy loam, and composite variations provided the soil depth exceeds 75 cm, slopes remain below 5%, pH levels hover between 6.0 and 7.8, and electrical conductivity stays below 2.0 dS/m. Based on the spatial evaluation, roughly 80.02% of the surveyed landscape (13,603.4 ha) qualifies as highly suitable (S1) for maize production, as summarized in Table 1 and mapped in Figure 2.

5.2 Moderately suitable (S2)

Land categorized as moderately suitable (S2) presents biophysical constraints that require targeted agronomic interferences to sustain productive maize yields. In these zones, thermal regimes peak higher

(33 °C to 38 °C), and annual rainfall decreases to 1,000-1,250 mm. Edaphic conditions exhibit minor to moderate drainage limitations, shallower rooting depths of 50-75 cm, and steeper inclinations of 5-10%. Chemically, these soils feature moderate deviations in reaction falling either on the slightly acidic (pH 5.5-5.9) or moderately alkaline (pH 7.9-8.4) spectrum alongside elevated electrical conductivity levels between 2.0 and 4.0 dS/m. Geographically dispersed throughout the surveyed region, S2 land accounts for roughly 11.8% of the total acreage (approximately 1,883.6 ha), with specific spatial patterns illustrated in Figure 2 and detailed in Table 1.

5.3 Marginally suitable (S3)

Land classified as marginally suitable (S3) has several limitations for maize cultivation. Maize can grow in these areas, but the climatic conditions are less favourable. The temperature ranges from 38 °C to 40 °C or 16 °C to 20 °C. Annual rainfall ranges from 750 to 1000 mm or may be more than 1500 mm. The soil may have poor drainage capacity, which can affect maize growth and development. A soil pH of 5.0-5.4 or 8.4-8.9 is considered marginally suitable. The soil electrical conductivity (EC) ranges from 4.0 to 8.0 dS/m. A soil depth of 25-50 cm is considered marginally suitable. Slopes of 10-15% and 15-25% are also considered marginally suitable for maize cultivation. Spatially distributed across various sectors of the region, land categorized as marginally suitable (S3) occupies roughly 1,530.0 hectares or 9.0% of the surveyed territory. The geographic extent of these marginal zones is detailed in Table 1 and illustrated in Figure 2.

Appendix 1

Soil-Site suitability criteria (crop requirements) for Maize

Soil - Site Characteristics	Unit	Highly Suitable S1	Moderately Suitable S2	Marginally Suitable S3	Not Suitable N
Mean temperature in growing season	°C	> 0.80	0.60 – 0.80	0.40 -0.60	0.30 – 0.40
Total rainfall	mm	1200-1500	1000-1250	750-1000 > 1500	500-750
Soil drainage	Class	Well /SW Excessive	SW Poor/ Mod. Well	Poor	Very Poor
Texture	Class	l,sil,sl,cl, sicl, scl	sic,sl,sc	ls, c (< 60%v)	fs, ms, c (> 60%v)
pH	1:2.5	6.0-6.5 6.6-7.8	5.5–5.9 7.9-8.4	5.0-5.4 8.4-8.9	4.5-4.9 > 9.0
Effective soil depth	cm	> 75	51-75	25-50	< 25
Salinity (EC saturation extract)	ds/m	< 2	2-4	4-8	8-12
Slope	%	0-3 3-5	5-10	10-15 15-25	25-33

6. Conclusion

Spatial evaluation exposed that 80.02% of the surveyed land offers prime conditions (S1) for maize production. Blocks such as Nuagaon, Daringbadi, Phiringia, and Baliguda appear as prime cultivation hubs, driven by harmonious soil characteristics and optimum local weather condition. Conversely, certain pockets remain agriculturally unviable, predominantly constrained by thick canopy cover from natural forests and extremely heavy precipitation regimes. Ultimately, this land capability modeling pinpoints priority cultivation clusters, providing an empirical basis for strategic crop zoning, regional resource allocation, and sustainable agrarian policy.

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