LAND SUITABILITY ASSESSMENT FOR RICE CULTIVATION IN OPA RIVER BASIN IN OSUN STATE NIGERIA USING MULTI-CRITERIA AND GEOGRAPHICAL INFORMATION (GIS) APPROACH

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ABSTRACT
Land suitability assessment is a prerequisite to achieving optimum utilization of the available land resources. Lack of knowledge on best combination of factors that suit production of rice has contributed to the low produce. The aim of this study was to determine and map out suitable site for rice crop cultivation using CropSDSS Multi-criteria Evaluator (MCE) Integrated with GIS. The study was carried out in Opa River Basin in Ile-Ife, Osun state Nigeria. Soil and soil related factors for rice cultivation such as soil texture, soil type, soil slope and their attribute were identified in the study area using expert opinion of a crop specialist. The identified factors were processed into spatial data. The factors were weighed according to the relevance of the factors. Land suitability model was constructed in CropSDSS software and spatial data were imported in cropSDSS to link the land suitability model constructed. The spatial data integrated in the Built CropSDSS were computed to identify land suitability areas for rice cultivation. The land suitability map was computed and final visualization of land suitability map was produced by CropSDSS to identify potential areas. The result obtained showed that 25% were unsuitable, 20% marginally suitable, 30% Suitable and 25% highly suitable in the study Area. Based on the findings, it is recommended that rice cultivation should be practised in Opa River Basin in Ile-Ife Osun State.

Keywords: Land suitability, Rice, CropSDSS Multi-Criteria Evaluator, GIS.

1.0 INTRODUCTION.

Rice is a major food in sub-Saharan Africa and is set to overtake maize, cassava, sorghum, and other cereals in the near future (Kihoro *et al.,* 2013). The demand is at the increase with rise in population. Globally, rice is a very important food crop. It is an ancient crop consumed as staple food by more than half of the world population including millions of people in West Africa and the fastest growing commodity in Nigeria's food basket (Akande, 2003).
The demand for rice has been increasing at much faster rate in Nigeria than in other West African countries since the mid 1970s. Although rice production in Nigeria has boomed over the years, there has been a considerable lag between production and demand level with imports making up the shortfall. In order to close this gap, different measures have been implemented by government while different strategies have been adopted by farmers.
Optimizing rice production can be achieved through sustainable agriculture which involves producing quality products in an environmentally, socially acceptable and economically efficient way (Addeo *et al.,* 2001), ensuring optimum utilization of the available natural resources for efficient agricultural production hence the need for land suitability analysis. Suitability is a function of crop requirements and land characteristics (Mustafa *et al.,* 2011). Land suitability analysis has to be carried out in such a way that local needs and conditions are reflected well in the final decisions (Prakash, 2003). This involves multi-criteria weighting and integration. Multi-Criteria Evaluation (MCE) approaches and GIS is useful because various production variables can be evaluated and each weighted according to their relative importance on the optimal growth conditions for crops (Perveen *et al.,* 2007). Before now the traditional approaches made use of single criteria at a time mostly soil or climate with little or no consideration for spatial parameter such as slope, drainage elevation, geology multiple climatic elements e.t.c. while most maps used to designate rice production area have to be based on soil maps alone, devoid of adequate inclusion of order spatial parameter which are also important. This has contributed to low yield annually experienced in rice production in Nigeria even with the huge capital investment in the sector. There is no doubt that other factor such as seed quality, farming methods, implement, fertilizers and pesticides used go a long way to affect yield but in a case of crops planted, a wrong and unsuitable site is more devastating.
Based on this there is need to re-evaluate farming site and produce suitability maps for rice cultivation using multi-criteria approach. The quest to achieve this forms the objective of this study. In this study, Analytical Hierarchy process (AHP) will be applied to weigh the participating factors while the MCE and visualizations will be achieved with the use of Land Suitability Decision Support (LSDS) integrated with GIS. The specific objectives of this research is to develop a suitability map for rice crop (*Oryza sativa*) based on physical and topographic factors of production and to identify potential areas for expanding and optimizing rice production.

2.0 MATERIALS AND METHODS.

Study Area

The study area is the Opa River Basin area of Ile-Ife in osun State Nigeria located between lat 7° 30’ E to 7° 35’ N and long 4° 30’E to 4° 35’N.

It has a catchment area of about 116 km^2 which is characterized by a rainy season of about eight months and a dry season of about four months, a mean annual precipitation of 1000-1250 mm (Oguntoyinbo, 1982) and a mean annual temperature of about 27 °C (Ndifon and Ukoli, 1989). The settlements within the Opa basin includes: Adara, Oloji, Apena, Oke-Opa, Lukosi, Ogangi, Sabo, OAU Campus etc.

The Opa reservoir within the University campus is part of the Opa basin dam at the higher order of the stream. It was established in 1978 by the impoundment of Opa River which took its source from Okeopa Hills. (Akinbuwa and Adenyi, 1996).

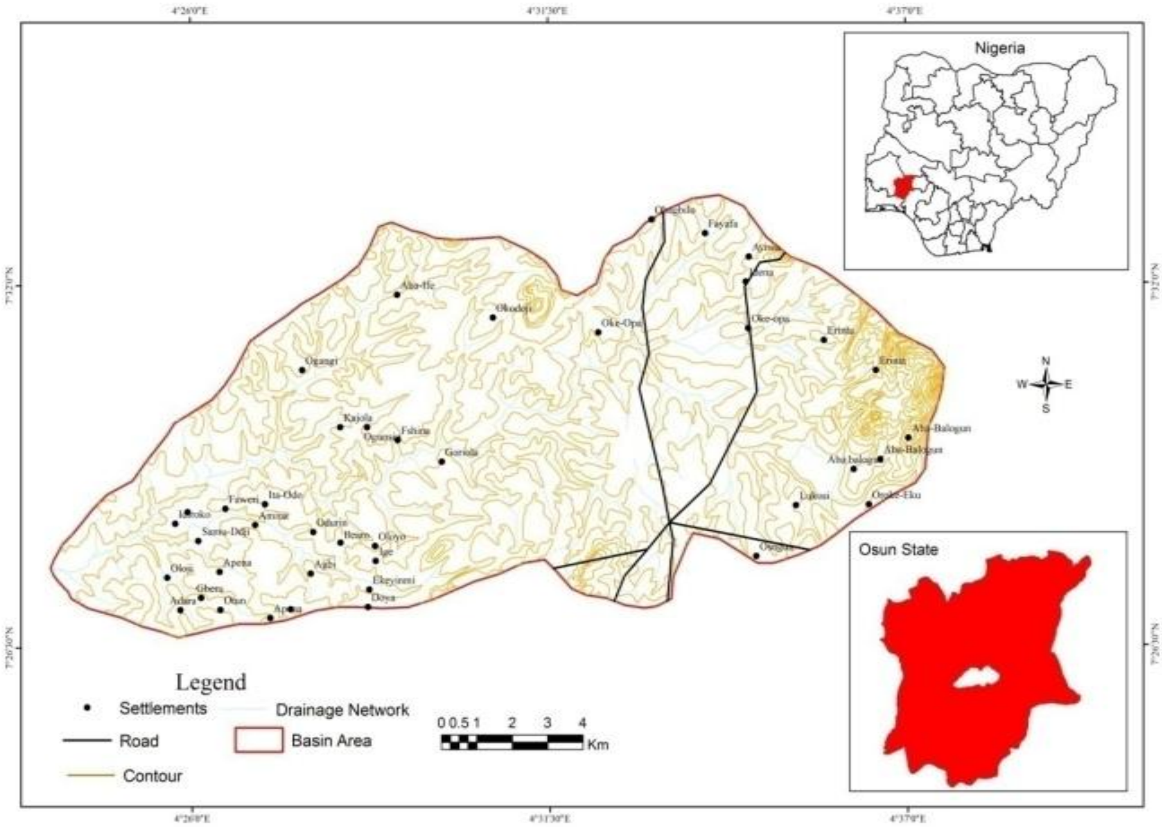

FIG. 1: Map of the Study Area

2.1 Geology

The Opa River Basin in Ile-ife, Osun state is underlain by metamorphic rocks of the basement complex, which outcrop over many parts. Rocks of the basement complex found here are schists, associated with quartzite ridges of the type found in llesa area. Metasediments consisting of schiests and quartzites, calsilicates, meta conglomerates, amphibolites and metamorphic iron beds make up the second group.

2.2 Relief and Drainage

The land surface is generally undulating and descends from an altitude of over 450m in ljesa area to 150m and below in the southern parts of the state. Two main relief regions may be identified; the first is the inselberg land scape which is part of the Yoruba highlands, while the second is the coastal plain. The region of inselberg landscape covers more than half of the state. The northern part is characterised by numerous domed hills and occasional flat topped ridges, the more prominent hills in this region, are found at llesa, lgbajo, Okemesi, Elu and Oba. At Erin ljesa, there is a sharp drop in the elevation, and this has given rise to a waterfall which has become one of the tourist attractions of the state

2.3 Soil

The soils belong to the highly ferruginous tropical red soils associated with basement complex rocks. As a result of the dense humid forest cover in the area, the soils are generally deep and of two types, namely, deep clayey soils formed on low smooth hill crests and upper slopes; and the sandier hill wash soils on the lower slopes.

The lighter loams are more suitable for cultivating the local food crops, such as yam, cassava rice and maize.

2.4 Vegetation

The Opa River Basin in Ile-ife, Osun state is covered by secondary forest and in the northern part, the derived Savannah mosaic predominates. Originally, virtually all parts of the state had a natural lowland tropical rain forest vegetation; but this has since given way to secondary forest re-growths. Among the reasons for this are fuel wood production, road construction, clay and sand quarrying and traditional farming practices.

3.0 Data Types

S/N	Data name	Year	Format	Resolution/Scale	Source
1	Landsat ETM+	2013	Digital	30m	GLCF
2	Arster SRTM	1999	Digital	30m	NASA
3	Soil Map	1997	Analogue	1: 250000	Wegeningen the Netherland

3.1 DATA COLLECTION AND ANALYSIS

Ground truthing was carried out to acquaint the researcher to the study area (Opa River Basin) to know whether the area is suitable for rice cultivation. The areas visited include Lukosi, Ogensi, Sabo, OAU campus, Oke-Opa, Oloji and Adara. The area was observed as a Wetland. The predominant soils are luxisols, Fluxisol. These are characterized by imperfectly drained clays very deep dark to black, firm to very firm, and prone to cracking. The factors identified were related to soil texture, soil drainage and topographic slope.

Information on soil types was obtained from the Nigeria soil survey Map. The soil map was overlaid on Nigeria Administrative map to clip out Osun state soil map. Subsequently the map of the study area was overlaid in Osun soil map so as to clip out the soil of the study area. The soil map of the study area was digitized to obtain the soil map of the study area.

The polygons of the digitized soil map consisted of various mapping units linked to an attribute table of soil properties. Soil texture and soil drainage were obtained from the attributes table and thematic maps of soil factors were developed.

Slope of the study area was obtained from Shuttle Radar Topographic Mission Digital Elevation Model(SRTM DEM). LANDSAT ETM+ 2013 of the area was georeferenced and classified into various landuse/landcover(fig3.1) . The spatial factors identified related to Landuse data include: Vegetation, Wetland, Built-up areas, Rock outcrop, and Water body and stream network. Water body and stream were buffered 100m around the stream and water body to ensure water availability for rice crop. Soil map, drainage map, and topographic Map (slope) and Terrain data include: slope, Flood accumulation, DEM maps was generated. The generated maps was reclassified and stored in database.

Applying Multi-Criteria Evaluator: Weight and Modelling the Spatial Factors in CROPSDSS.

The model for the spatial factors was carried out using CROPSDSS software version 1.0.

These factors identified were weighed into Factors and constraints. The purpose of weighing was to express the importance or preference of each factor relative to other factor effects on crop yield and growth rate. In this research the Ten Classes used are Soil drainage, Vegetation, Stream network, Water body, slope and soil class. The constraints are Built-up-areas, Rock outcrop, Bare Surface.

The land suitability model construction used in this research for the execution of crop land suitability was computed according to the model Specification. The first method carried out was the importation of the prepared spatial data containing the land mapping units to be assessed for suitability into CropSDSS.

The imported spatial data were linked to land suitability model and a logical set of Record set objectives was defined. All the relations and their records were Cache in the model into these sets of record sets objectives.

In this research because of the presence of constraints in the record, computation of suitability for that record was not executed, the record was assigned zero percentage and if the modelling technique is AHP for the factors, the list of classes in the factors were retrieved relative to the weights of factors. The percentage ratings of the class of the factors present in that record and suitability computed using the following formula.

$$\% \text{ Suitability} = \sum (RW_i * PR_j)$$

RW = Relative Weight of Factor.

PR = Percent Rating of the class of the factor.

i = 1 to number of factors used in the suitability assessment.

Integrating Multi-Criteria Evaluation with GIS in CROPSDSS.

The built model and prepared spatial data was integrated in the SDSS Software (CropSDSS) Version 1.0 in order to run land suitability for rice. The final visualization of land suitability map was produced in CROPSDSS to identify potential areas.

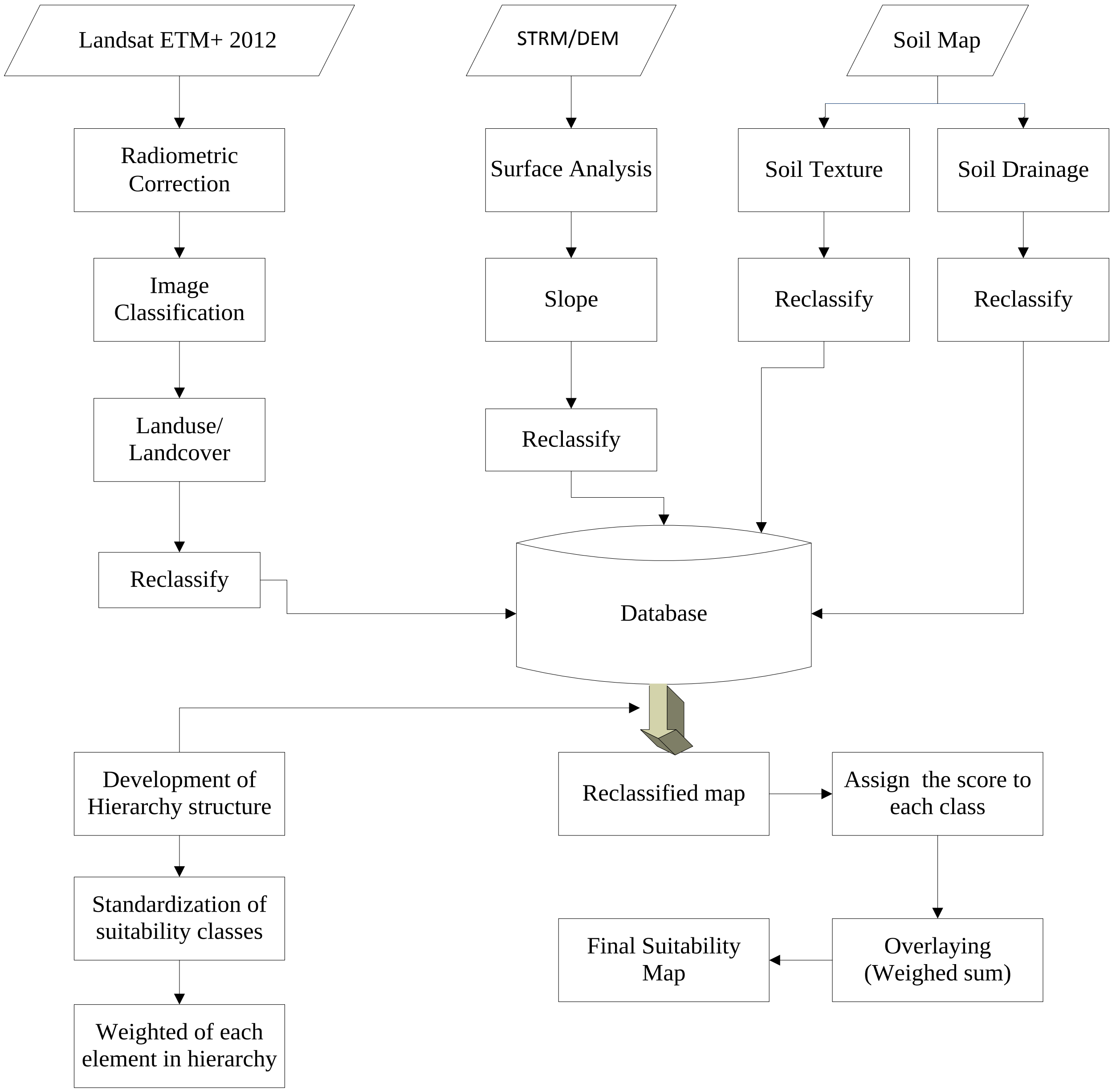

Figure 2: Flowchart Model of Methodology.

4.0 RESULTS AND DISCUSSION

These spatial factors (parameters) were overlaid in Opa River Basin to produce a spatial factor Map as shown below.

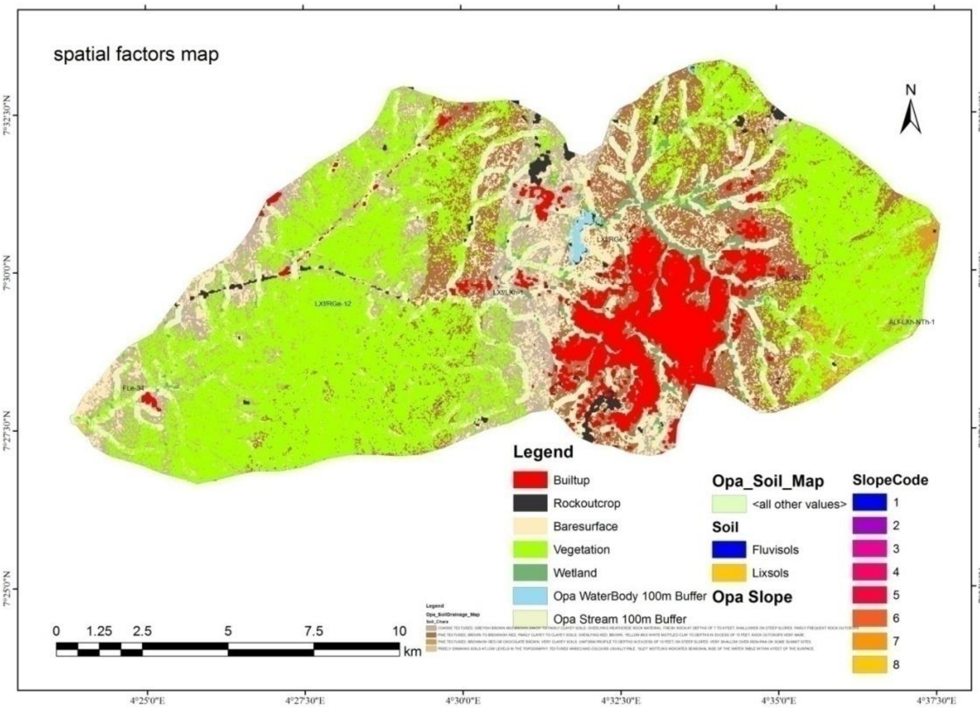

Figure 3.0: Spatial factors overlaid in study area to produce spatial factor map.

4.1. The thematic maps of the spatial factors identified are shown below.

The land use data of Opa River Basin which includes, built-up areas, rock out crops, bare surface, vegetation and wetland was used to produce land use land cover map.

The spatial factors for rice cultivation which was identified in Opa River Basin includes soil drainage (texture), soil type, slope, water body, and stream network and land use data of the study area. These spatial factors (parameters) were overlaid in Opa River Basin to produce a spatial factor Map as shown below.

Factor: Maps.

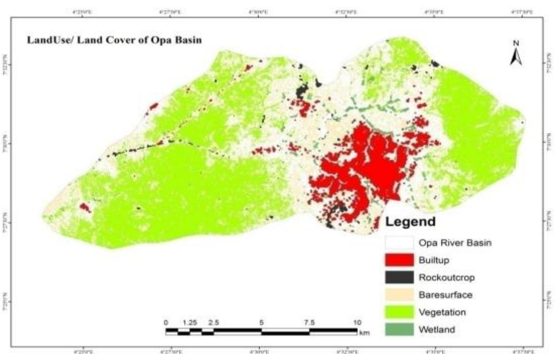

Fig 3.1: Landuse and landcover Map

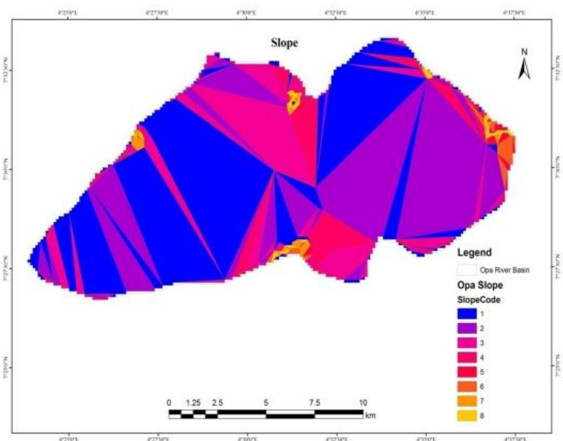

Fig 3.2 : slope map

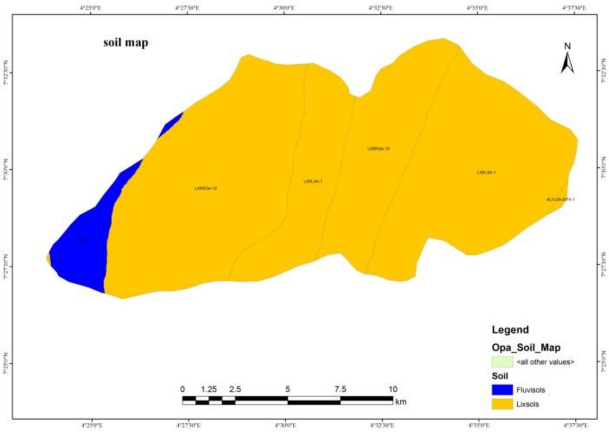

Fig 3.3:opa soil map

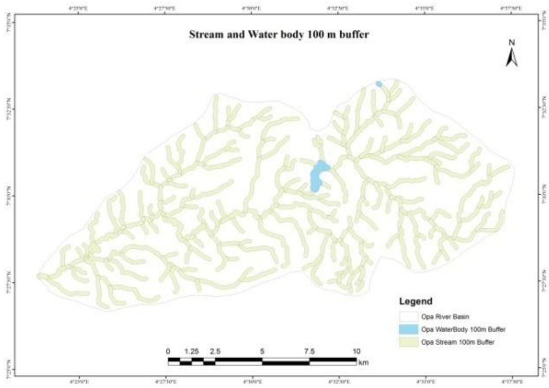

Fig 3.4: Buffered water body and stream map

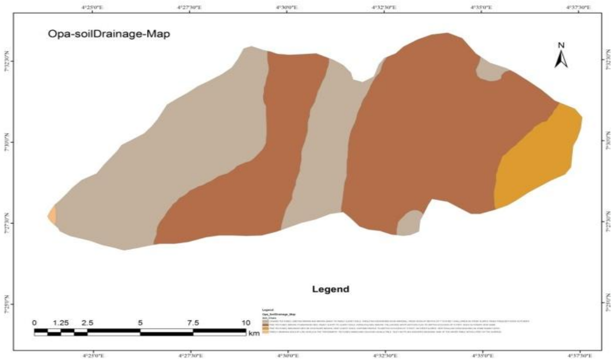

Fig 3.5 :opa soil drainage map

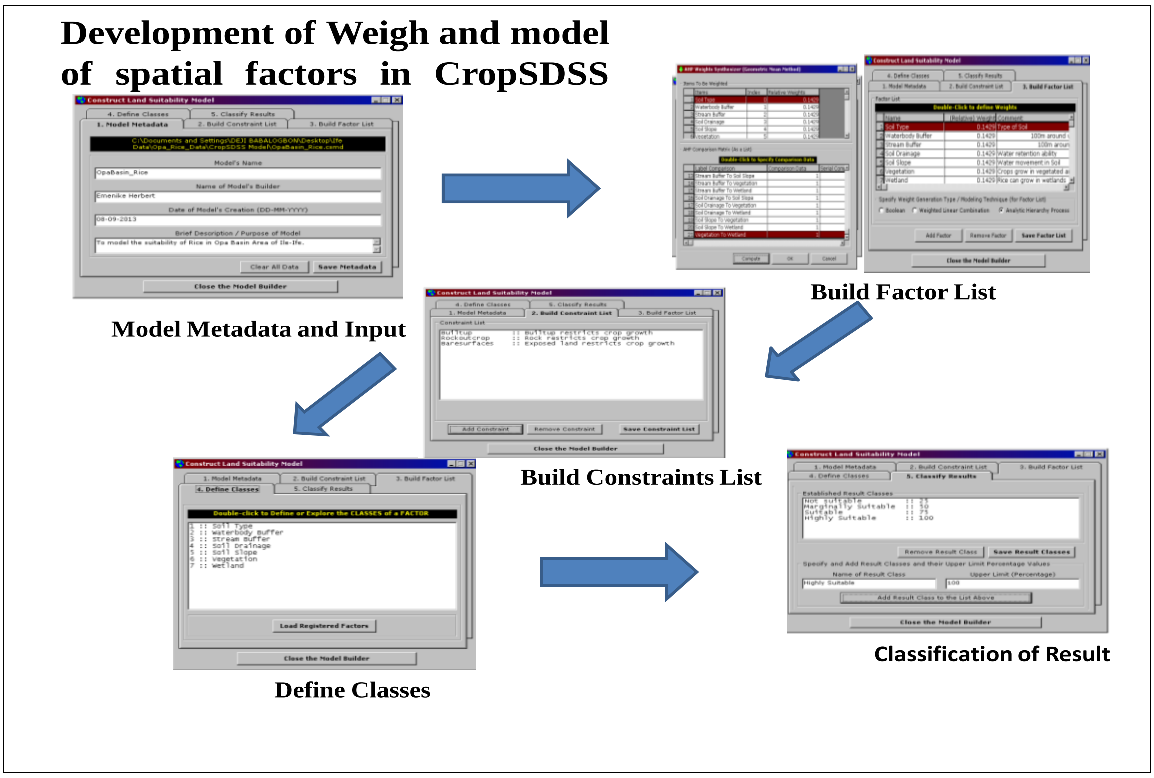

Figure 3.7: CROPSDSS MODEL

INTEGRATING MCE WITH GIS IN CropSDSS TO PRODUCE LAND SUITABILITY MAP.

The result of land suitability computation by CropSDSS is shown below.

The result showed that the land suitability map for rice cultivation, integrated with weighted factors in GIS using CropSDSS identified that 25% were not suitable, 20% marginally suitable, 30% suitable and 25% highly suitable for the study area.

The results showed that suitable areas were found mostly in areas characterized by factors needed for rice cultivation, these were in agreement with those considered in the literature.(kihoro*et al* 2013, Samanta*et al* 2011, Bhagat*et al* 2009, FAO).

The result also showed that the CropSDSS model can be easily utilized for the land suitability assessment for rice cultivation. The finding was in line with (Babalogbon.B.A, 2013).

Generally, not suitable areas were found mostly in areas characterized by constraints such as Built-up-areas, Bare surface and rock outcrop.This was in line with (Perveen*et al* 2012).

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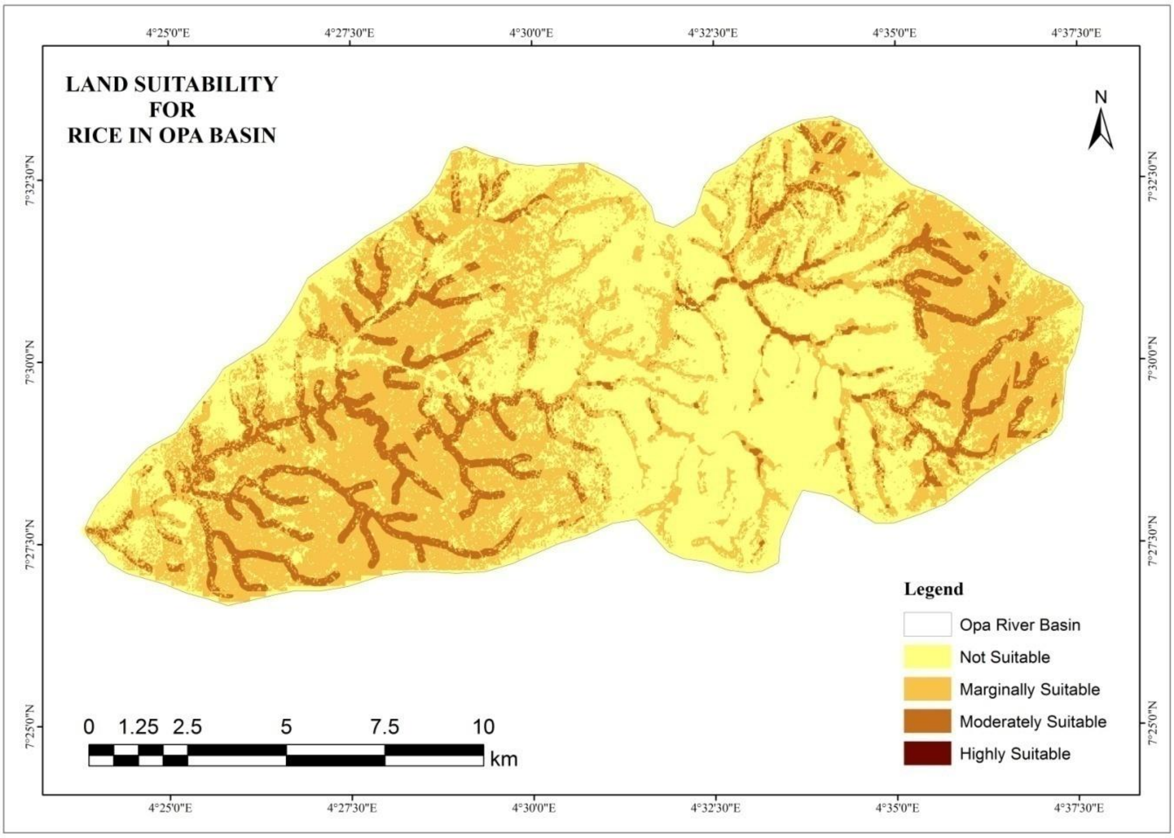
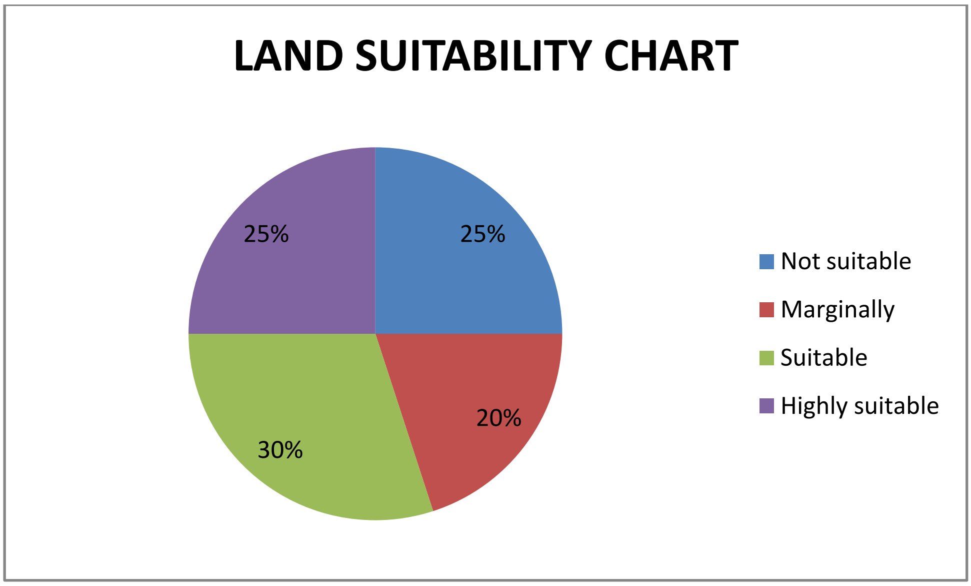


Figure 4.0 : Land suitability Map



5.0 Conclusion

The results obtained from this study indicate that the use of GIS and application of multi-criteria Evaluation using CropSDSS could provide a database for rice production.

However, there is no rice cultivation in Opa basin Areas but based on the findings, it is recommended that rice cultivation should be carried out in those areas identified in the Opa basin areas to increase rice production.

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