



## APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM (G.I.S.) IN EVALUATING SUITABLE AREAS FOR WHEAT CULTIVATION IN ADAMAWA STATE NIGERIA

ALFRED MISHELIA, ELIZABETH MATHIAS ZIRRA

Department Of Geography, Adamawa State

University P.M.B.15, Mubi Adamawa State.

C/O Pharmacist Mathias Zirra Bubanani, Ministry Of Health Yola. Adamawa State Secretariat.

Email: [Alfredmishelia@yahoo.com](mailto:Alfredmishelia@yahoo.com)

### ABSTRACT

*Land Suitability Analysis (LSA) is a GIS-based process applied to determine the suitability of a specific area for considered use, i. e. it reveals the suitability of an area regarding its intrinsic characteristics (suitable or unsuitable) ( Sudabe etal 2010). In Nigeria as a whole and Adamawa in specific, wheat is one of the important cereal crops but the production is very low. In particular the wheat production does not meet the demands. The aim of this study is application of geographic information system in evaluating suitable areas for wheat cultivation in Adamawa state Nigeria. FAO 1976 suitability guidelines Boolean method, and GIS technique were used in order to get suitable areas for wheat production in the study area and the result showed that 12% of the total land mass of Adamawa State is highly suitable for wheat cultivation, 19% moderately suitable, 52% marginally suitable, 8% currently not suitable and 4 % permanently not suitable.*

### INTRODUCTION

Nowadays, the population of the planet is growing dramatically. In order to meet the increasing demand for the food, the farming community has to produce more and more. Under present situations, where the land is a limiting factor, it is impossible to bring more area under cultivation (*extensive farming*), so farming community should tackle this challenge of producing more and more food with the available land only (*intensive farming*). On the contrary, the increasing global concern towards the health of mankind and environment protests the use of higher amount of pesticides and fertilizers, genetically manipulated plants etc. Hence much attention is shifted on selection of a crop, which suits an area the best. This suitability is a function of crop requirements and soil/land characteristics (Prakash. 2003).

Land Suitability Analysis (LSA) is a GIS-based process applied to determine the suitability of a specific area for considered use, i. e. it reveals the suitability of an area regarding its intrinsic characteristics (suitable or unsuitable) ( Sudabe

etal2010). This is achieved through the process of finding out whether the land resource is suitable for a specific use or not, this analysis for sustainable crop production involves the interpretation of data relating to soils, vegetation, topography, climate etc (FAO, 1976). Geographic Information Systems (GIS) are tools for acquiring, managing, analyzing, and presenting spatially related Information. GIS is a powerful tool for geo-environmental analysis and appraisal of natural resources. It allows the user to integrate data bases generated from various sources on a single platform and analyze them efficiently in a spatio-temporal domain (Prakash T.N. 2003).

In Nigeria as a whole and Adamawa in specific, wheat is one of the important crops but the production is very low. In particular the wheat production does not meet the demands (Farida,et al 2013).

With world population is increasing and food security projected to become more critical, increasing wheat yield potential and other crops in the developing world remains a high priority. Agriculture is important as a source of food and



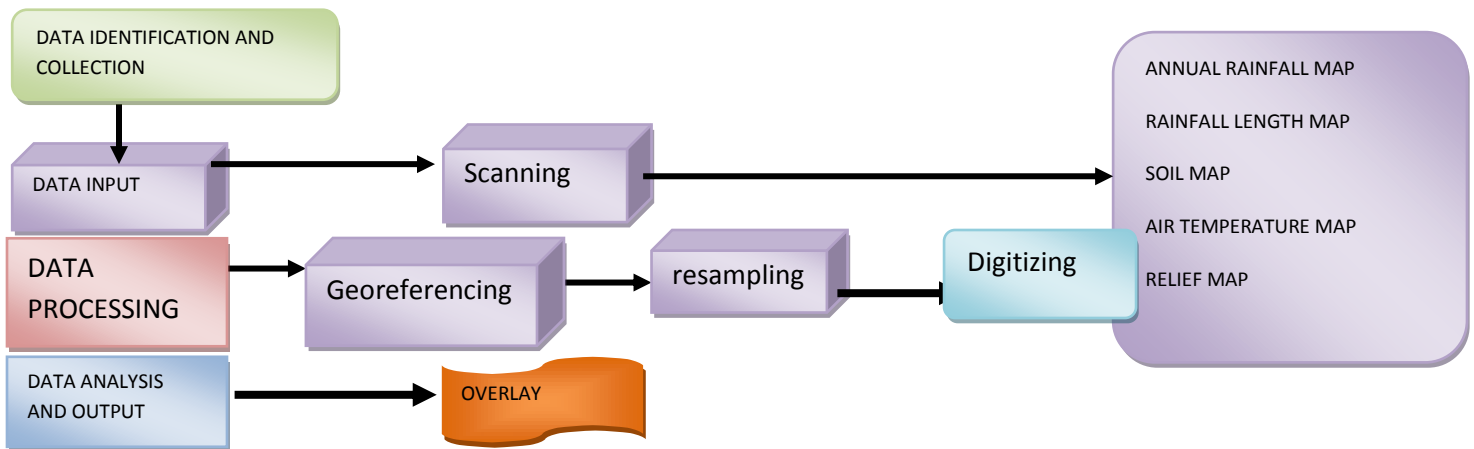
income, but how, where and when to properly cultivate are the main issues that farmers and land managers have to face day to day. (Mokarram et al., 2013). Matching land characteristics with crop requirements gives suitability. 'Suitability is a measure of how well the qualities of a land unit match the requirements of a particular form of land use (FAO, 1976).

and longitude 11° and 14°E of the Greenwich Meridian. It shares boundaries with Taraba State in the south- Western part, Gombe State in the north-western part and, Yobe and Borno States to the north. Adamawa State has an inter- national boundary with the Cameroun Republic up along its eastern side. The state covers a land area of about 38,741. Sq. km. The mountainous land- forms between Adamawa State and the Cameroun Republic provide an effective political boundary (Ernest,etal 2005).

Adamawa State is located on the north eastern part of Nigeria. It lies between latitude 7° and 11°N,

**MATERIALS AND METHOD**

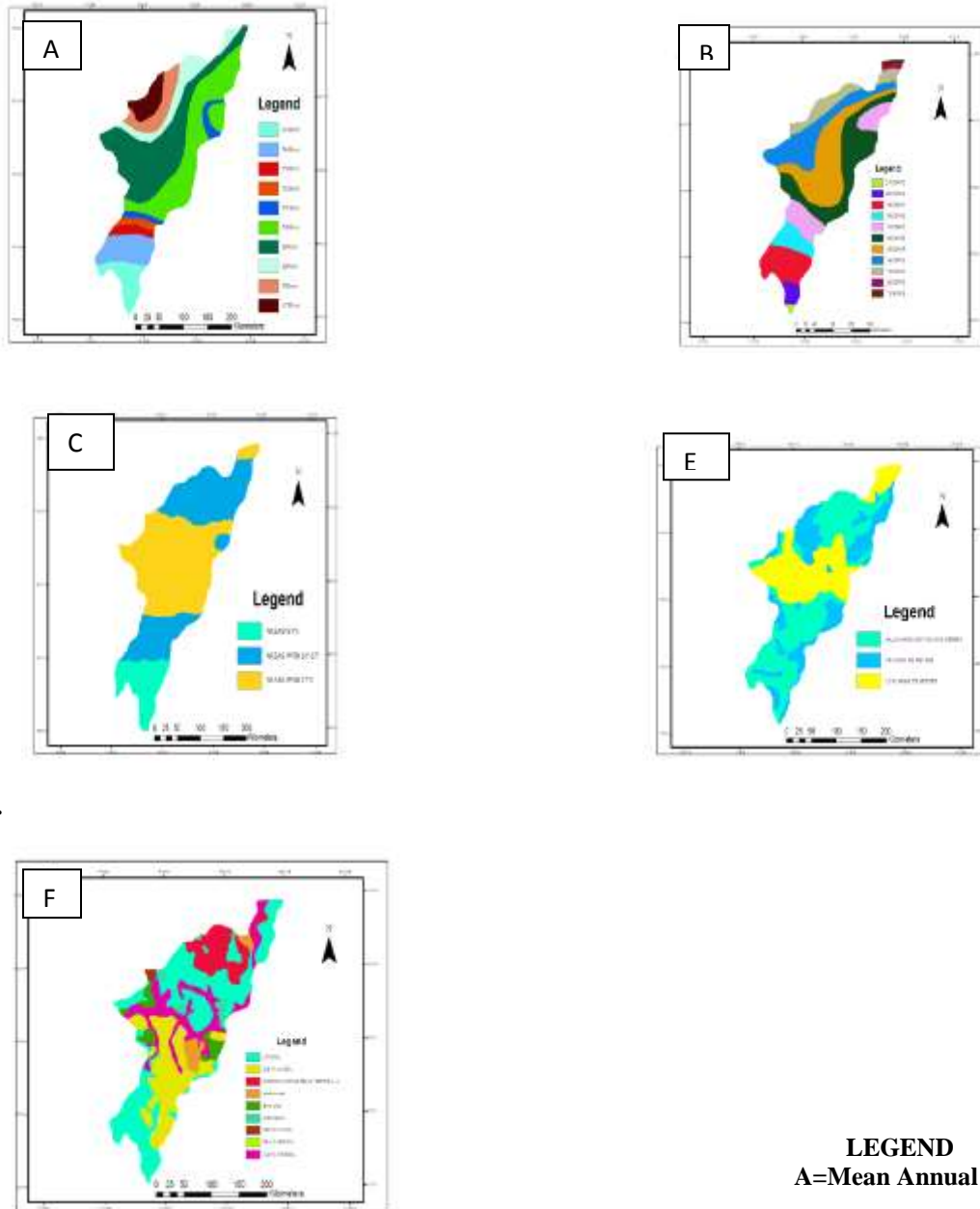
The schematic diagram below is the stepwise procedures used which described the strategies used in collecting data from problem identification to final output and the approaches adopted in the suitability analysis for actualizing GIS application.



11°00'00N **Methodology Schematic Diagram.**

After identification and collection of data used in this work (figure: 2), the five maps were scanned into CorelDraw software, through the use of Hp laptop, Hp4400series scanner and converted into the Tagged Image File Format (TIFF) then exported into

GIS software for data processing like georeferencing, resampling, digitizing, overlay analysis and presentation in order to get the final map product.



**LEGEND**  
A=Mean Annual Rainfall Map  
B= Rainfall Length Map  
C= Temperature Map  
D= Relief Map.  
E= Soil Map.

Figure 2: five criteria maps used in this study



## DATA SOURCE

Adamawa State topographic maps containing information on relief map, air temperature, annual rainfall. Rainfall length, soil and political map were obtained from GIS lab Adamawa state university.

## MATERIALS AND SOFTWARE USED

Air temperature map, Annual rainfall map, Rainfall length map, soil and political maps of Adamawa State were used for overlay, Hp laptop, 44series printer were used for inputting data, Arcview3.2a, arcgis 9.3, and idrisi32 were used for gis analysis.

## RESULTS AND DISCUSSIONS

This project is all about mapping out areas that are suitable for wheat production. After all the processes of reclassify in idrisi in order to know suitable and not suitable areas, there was the need to know how suitable the areas are. The processes of evaluating how suitable areas are for wheat cultivation involved overlaying of the five maps used in this study as shown in figure 2.

In mapping procedures, the reclassified maps in figure3 were overlaid, taking two maps at a time. The first set was the mean annual rainfall map and rainfall length map as shown on map algebra flowchart to give “wheat rainfall map” (i.e.  $A+B=C$ ). This was further added to air temperature map (D) in order to give wheat climatic map (E) ( $C+D=E$ ). The soil map and relief map were overlaid too to give wheat physical map ( $F+G=H$ ). The final map was produced by adding the

wheat climatic map (E) with the wheat physical map (H) to give wheat suitability map (I) ( $E+H=I$ ).

On the final map, using Boolean method of FAO 1976, all areas that carried value 5 was assigned S1 and considered as highly suitable areas for wheat cultivation, areas with value 4 was given value S2 and taken as moderately suitable areas for wheat cultivation and areas with values 3 was assigned S3 and considered as marginally suitable areas for wheat cultivation. Finally, areas with value 2 was assigned N1 and considered as currently not suitable areas while areas with value 1 was assigned N2 and considered as areas permanently not suitable. This means that five classes of suitability for wheat cultivation was derived from the algebra. In doing that, query module-a tool in Idrisi environment was used to identify areas with the same value on the final map (suitability map) representing a certain number of criteria met by a given area and this was done by clicking on the query module on the idrisi menu bar then click it on the suitability map in order to know value that each area carried. For example areas with value ‘5’ (navy blue color) in figure3 means areas that met five conditions on the map and were considered the highly suitable areas for wheat production. Areas that have value ‘4’ (red color) means areas that met four conditions out of five and were taken as the moderately suitable areas and those with value ‘3’ (yellow color) as marginally suitable. Lastly, all areas with values ‘2’, ‘1’, and ‘0’ were considered unsuitable areas for the production of wheat in the state which could be currently and permanently not suitable.

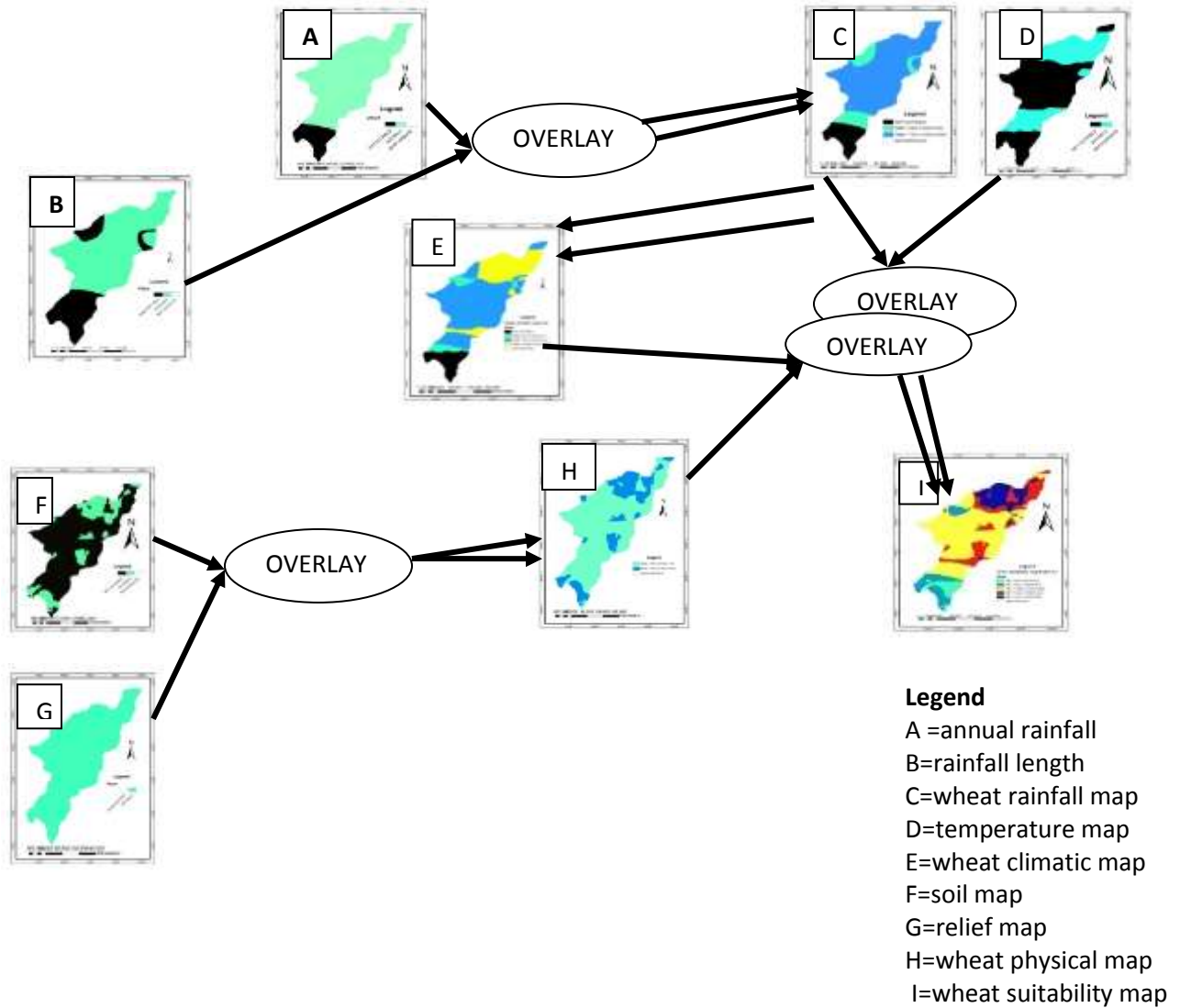


Figure 3: Procedure for Creating Suitability Map for Wheat Production.

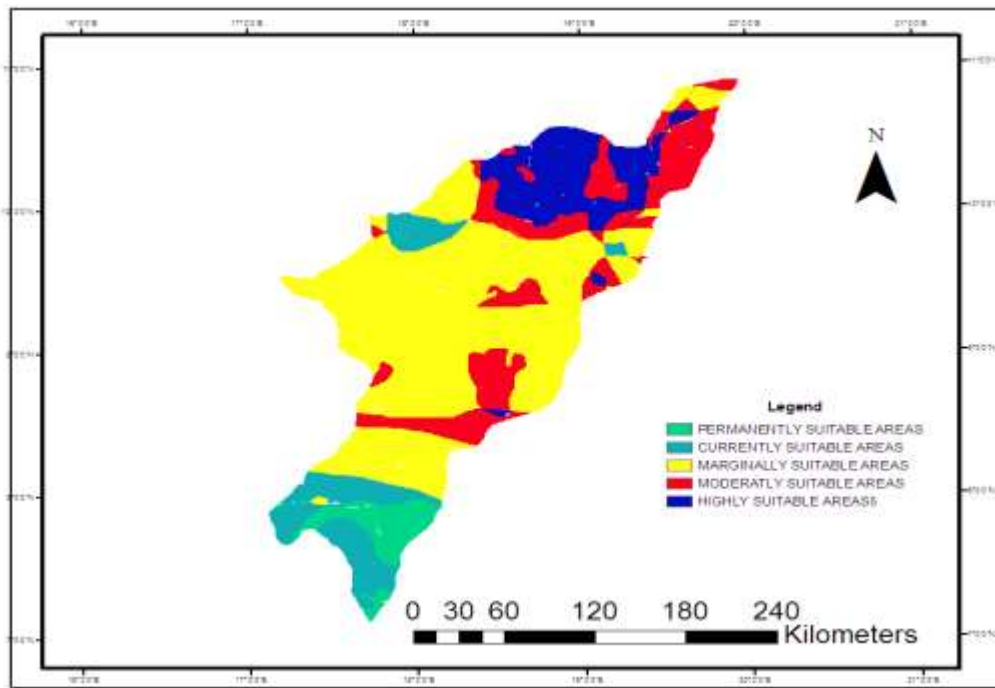


Figure 4: Wheat Suitability Map.

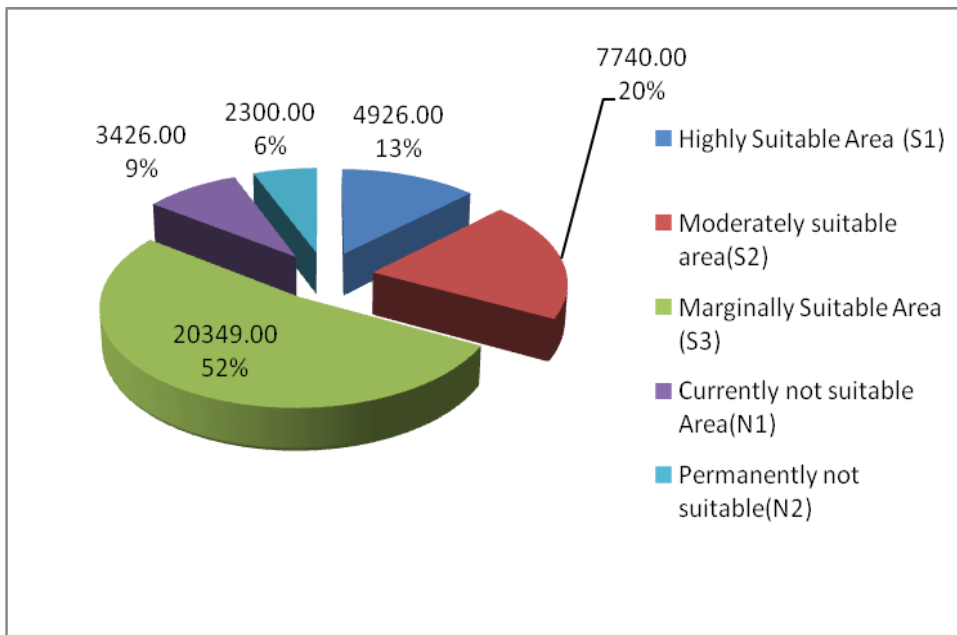


Figure 5: suitable areas for wheat production in Adamawa State.



Based on the (FAO 1976) guidelines of Suitability classification, suitability classes are sub-classified in to five (5) these are: the highly suitable, moderately suitable marginally suitable, currently unsuitable, and permanently unsuitable. In this study, the highly suitable areas which are mostly in the northern part of the state covered a total area of 4926.500 km<sup>2</sup> (12.72%). The moderately suitable area covered total area of 7740 km<sup>2</sup> (19.98%) this is found mostly in the Northern and central parts of the state with few areas in the south. The marginally suitable areas covers the largest part of the state with a total area of 20349 km<sup>2</sup>

(52.53%) cutting across several local government areas of the state, this landmass spreads mostly in the central and the western part of the state with a small portion in the Northern part of the state in Madagali and Maiha Local Government Areas. Finally, the Unsuitable (currently and permanently unsuitable) areas covered a small portion of the state. Where currently unsuitable areas covered total area of 3426 km<sup>2</sup> (8.84%) and found in southern and western part of the state, permanently unsuitable covered total area of 2300 km<sup>2</sup> (4.9%) and are found in the southern part of the state.]

**Table 1: Suitability Areas for Wheat Cultivation**

Category of suitability	Criteria met (value)	Areas covered(km <sup>2</sup> )	percentage%
Highly suitable areas (S1)	“5”	4926	12.72
Moderately suitable (S2)	“4”	7740	19.98
Marginally suitable areas (S3)	“3”	20349	52.53
Currently not suitable areas (N1)	“2”	3426	8.84
Permanently not suitable areas(N2)	“1”	2300	4.94
Total		38,741	100

From the map in (Figure4 and table 2 ), highly suitable areas (areas that met five conditions) for wheat production which covered nearly 4926 km<sup>2</sup> ( 12.72%) are found in northern part of the state, in areas like Hong, Gombi, part of Michika, part of Jada, part of Maiha and Mubi north. Moderately suitable areas (areas that met four conditions) covered 7740 km<sup>2</sup> (19.98% ) and are found in

northern part of Madagali, southern part of Michika, Mubi south, Mubi north, part of Maiha, part of song, part of Demsa, Mayobelwa, Jada, Fufore e.tc while marginally suitable areas (areas that met three conditions for wheat cultivation) covered more than half of the state with total land cover of 20349 km<sup>2</sup> (52.53%) and are found in part of madagali, part of Maiha, Gombi, Maiha, Fufore, Girei, Yola north,



Guyuk, Lamurde, Numan, part of Demsa, Mayobelwa, Ganye. and unsuitable areas (areas that met zero to two conditions) covered area of 5726 km<sup>2</sup> (14.78%). And are found in Toungo, part of Ganye, Shelleng, and Maiha.

**Table2 Local Government Areas and Villages of each Suitability Categories**

Suitability class	Local government areas (villages)	Area (Km <sup>2</sup> )
Highly suitable areas	Maiha(Belel)	4926
	Gombi(Gaandu, Garkida)	
	Hong(Kopri, Pella, Vokuma, Madbula.)	
	Mubi north(Mayogari, Gella)	
Moderately suitable areas	Fufore (Nyibango, Malabu Nassarawa, Karlahi, Faran)	7740
	Mayobelwa(Tola)	
	Song(Konkul, Golla, Konkul, Zumo,)	
	Hong(Madbula, Mijilli,Jabagaya)	
	Mubi north(Mijillu)	
Marginally suitable areas	Gulak( Duhu)	20349
	Girei(Geren,)	
	Mayobelwa(Tola,Sivi)	
	Jada(Bula,Dalami, Bakari bussau)	
	Fufore(Yolde,Malabu,Dasin, Faran,	
	Maiha(Balei)	
	Song(Holma,Pakim,Zummo,Golla,Bassangi,Dumne,Murke, Gurhi)	
	Shelleng(Bobore,Dahara, Yan)	
	Guyuk(Gunda, Kiri)	
	Numan(Bolla, Mayo lope)	
(Demsa, Ngurore, Mbula)		
Currently not suitable areas	Fufore(Gurin, Ribadu, Dasin, Malabu,Faran,	5726
	Song(Gurhi)	
	Shelleng(shelleng)	
Permanently not suitable areas	Toungo(Wajiri Dungle, Arne da bako, kaginbaba, taraba,gumti)	
Permanently not suitable areas	Toungo(Malo butale,Killa,part of Gumti, M. Koran)	

**CONCLUSION**

In this study, GIS technique was applied to identify suitable areas for wheat cultivation in Adamawa state. The result obtained from the study indicates that GIS technique could provide a superior guide map for decision makers which could be used to consider crop substitution in order to achieve better agricultural production. The study clearly brought out areas suitable for wheat cultivation which was derived from overlay of five criteria map after evaluating the suitability of the criteria to wheat cultivation in GIS context.

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