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Research Paper

GROUNDWATER EXPLORATION ZONES OF MUBI LOCAL GOVERNMENT OF ADAMAWA STATE USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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Groundwater is one of the major resources contributing to the total annual supply for economic development and ecology diversity; it is of great importance in the urban and rural areas. Groundwater is a major source of water supply for human consumption and the rate at which human scout for water on a daily basis is becoming alarming coupled with exploitation process of unskilled professionals which causes degradation to our valuable lands at some places because of the problems of identifying points where groundwater can be found for exploration. The combination of Remote Sensing and Geographic Information System (GIS) has become a useable tool for mapping groundwater potential zone to enable water exploration point for water supply and boreholes sighting. In the study, Remote Sensing and GIS based technique is developed and tested for the evaluation of the groundwater resources in Mubi Local Government Area, the Digital Elevation Model (DEM) and LandSAT TM image of the year 1999 was acquired for this research and the False Color Composite (FCC) of the images was formed by the use band 4, 3, 2 to enhance feature extraction within the area of study, it was further classified into six (6) different land use such as urban area, bareland, rock-Outcrop, thick vegetation, cropland and grassland using maximum likelihood supervised classification technique. The Digital Elevation Model (DEM) was used to generate the drainage density map; slope, aspect, flow accumulation and stream order, thus; all images that influences groundwater were then ranked and weighted for final composite map for groundwater potential zones of Mubi. The Geomorphology, slope, drainage density, Land use/land cover, geology and slope, are considered for the identification of groundwater potential. The final composite map depicting the groundwater zone of the study area is classified into five (5) groups; very poor, poor, moderate, good and excellence.

Keywords: Remote sensing, GIS, Weighted overlay, Thematic maps, Ground water, Land use/ Land cover

INTRODUCTION

Water is one of the most important resources to humanity which enhances economic development, ecological diversity; it is a major water supply means in climate regions both for urban and rural areas. Groundwater occurs within a geological

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stratum (Kumar *et al.,* 2010). The integration of Remote Sensing and Geographic Information System (GIS) is a dynamic tool in mapping potential zones for ground water exploration. The increase in infiltration is as a result of topographic depression and high relief while steep slope enhances the runoff in a particular environment of interest (Murugesan *et al.*, 2012).

Ground water is the major means of water supply for human consumption in Mubi town but with the increase in demand of water for farming and irrigation, there is the need to map out areas with groundwater potentials so as to ease the drilling of bore holes and sitting of wells, groundwater's served as the only source of water for drinking, agricultural and other usage within the area and the economic activities due to increase in population which tends to increase, the demand of water is expected to increase proportionally. It occurs in cracks and fractures in crystalline rocks (Rocktalk, 2002).

Therefore, the need for water resources development and mapping is required to counter the increase demand of ground water and this increase in demands has led to unprofessional exploration of groundwater, creating more concern to the hydrological system and the immediate environment. The exploration of groundwater required a collective work of Geology, Hydrology, Hydrogeology, Hydro-Chemistry and Geo-Physics. The traditional method of groundwater exploration consumes much time and finances, therefore; the integration of Remote Sensing and GIS tool are alternatively used to detect areas with groundwater potentials (JWARP 2012 5, 6). The exploration of groundwater is becoming pronounced due to drought, desertification, rural water supply and the low cost efficiency it required for development while the exploration of groundwater remain uncertain because there is no direct method or technique to enhance groundwater exploration due to research and technological advancement but this can only be carried out by observing the surface parameter and the geology of the area (Waikar and Aditya, 2014)

The advantages of groundwater exploration using GIS and RS is to reduce cost expenses and time exerted into groundwater exploration, to really extract the occurrence of groundwater for the enhancement of exploration, there is need to map areas with the groundwater potentials (Helen, 1999). Rahaman (1976) asserted that the crystalline basement complex rocks not permeable and without storage capacity. To ensure maximum yield of groundwater, the source of the water must be situated where the thickness of the fracture can be penetrate.

PrasirMukharjee *et al.* (2012) mapped groundwater potential zone using Weighted Overlay Analysis with the ranking for each parameters of the maps arranged in respect to their influence and Cheng-Haw Lee *et al.* (2008) also assessed groundwater potentials, water protection and management system by the use of RS and GIS, the Land Cover/ LandUse, Geomorphology, Geology, Lineament, drainage density and slope were considered for this purpose while Waikar and Aditya P Nilawar (2014) identified groundwater potential zones with different factors; geology, slope, Drainage density, lineament density and geomorphic units as parameters integrated to assess groundwater zones by assigning ranks and weighted overlay.

Study Area

Martins *et al.* (2015) cited Max Lock Group (1973-1976), that Mubi lies in the Mandara hills, close to the Camerouns border. Mubi Local Government Area lies between latitude 10º11 N and 10º16 N of the equator and longitude 13º20 E and 13º35 East of Greenwich Meridian in Adamawa State, Nigeria It has had a chequered history since it first grew up as a settlement of the Ilega en Fulani in the eighteen century. These people coming as pastoralist developed a symbiotic relationship with local tribes, exchanging their produce with that of the cultivators of crops. Sometime this lead to the Fulani settling more permanently themselves, cultivate the land and intermarrying with the local families. Each settlement was under the Ardo (or headman) who owed allegiance to a Lamido (chief) but it was not until the Jihado 1804-10 that the Fulani usurped power and claim suzerainty over local tribes. In this area their sovereignty was frequently challenged by the continued independence of spirit of the hill people which continue today. Mubi was never an emirate and after the jihad came under the Lamido of Adamawa who added it to his kingdom with the approval of the sarkin Musulmi. The area seems to have been troubled by the second emir, Hamman, warring against the Fali of Mubi. In 1959 a plebiscite was held to decide on their future; as this was indecisive a further plebiscite was held in 1961 when a majority vote decides on incorporation into Nigeria. But instead of returning this land to Adamawa, a new province of sardauna was created to administer the erstwhile trust territorie, and Mubi became the capital of the province. The main stays of Mubi economy are trade, agriculture, and its position as an administrative, service and institutional centre, there is a large central market held one day a week on Wednesday. Many of the market traders will move round from village market to village market during the rest of the week and Mubi relief and drainage comprised of predominantly upland and low land with maximum and minimum height of 1036 m and 523 m above sea level, respectively with some few outcrops of hills around Vimtim in Mubi and Michika.

Methodology

The various activities of map preparation begins with acquisition of data including Digital Elevation Model (DEM) and LandSAT TM image, the False Colour Composite (FCC) of the images was formed by the use band 4, 3, 2, it was further classified into six (6) different land use such as urban area, bareland, rock-Outcrop, thick Vegetation, Cropland and grassland using maximum likelihood supervised classification technique. The Digital Elevation Model (DEM) was used to generate the drainage density map; slope, aspect, flow accumulation and stream order, thus; all images that influences groundwater were then ranked and finally overlaid for groundwater potential zones for this research. Geomorphology, slope, drainage density, Land use and land cover, geology, slope, geomorphology are considered for the identification of groundwater potential.

The groundwater potential zone map was obtained by ranking and weighting process using the Spatial Analysis Tools in ArcGIS 10.1, the rank for each parameter were assigned for the thematic maps and later weighted proportionally to it influence on groundwater potential zone, the parameter with lower influence were assigned with lower values while the higher groundwater potential zone with higher value of influence as illustrated in Table 1.

All the thematic maps generated were converted to raster format and the weighted overlay method was used to integrate them together through the ArcGIS Spatial Tools, the geomorphology and Slope were assigned higher weight but the drainage, land use, lineament and geology maps were given different parameters according to their influence on groundwater mapping (Butler *et al.*, 2002, Asadi *et al*., 2007, Yammani, 2007).

The highest value was assigned for gentle slope and lower value is assigned to higher slope. The higher rank factors are assigned to low drainage density because the low drainage density factor enhances infiltration than surface runoff, the lineament density classes, and the very high lineament density category is assigned higher rank value as it has greater chance for groundwater infiltration. Lower value is assigned for very low lineament density. In LULC, the crop land has the higher value and low value assigned to barren land. Hence, the weighted and the ranked thematic maps were integrated to a composite map of groundwater potential zone. The total weightage of the final map were derived as sum or product of the weightage assigned to the different layers according to their suitability. The broad flowchart methodology used for the mapping of groundwater zone of Mubi is thereby represented in Figure 1.

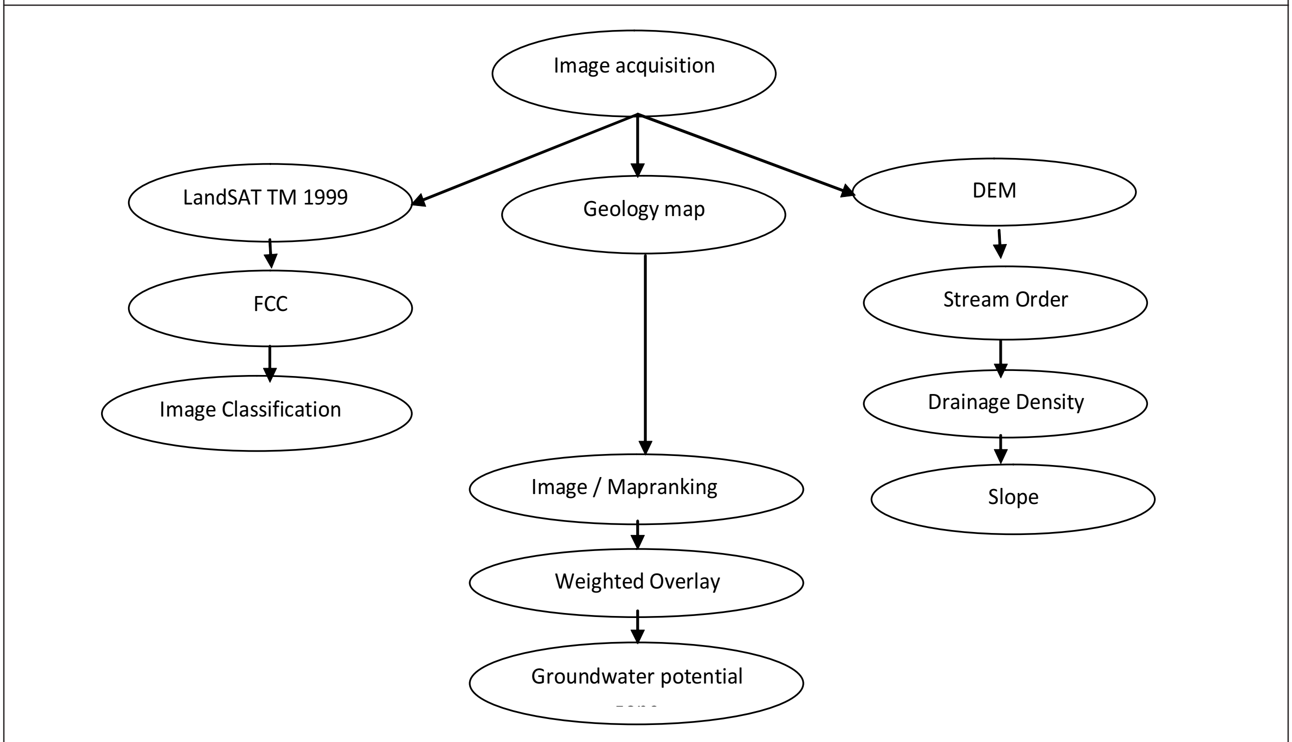
Geology *25 + Slope*20 + Drainage Density*15 + Geomorphology*20 + Soil*10 + Land Use/Cover*10 = Groundwater Potential Zone Map

RESULTS AND ANALYSIS

Drainage / Drainage Density

The drainage basin is the part of the earth surface which is drained by main stream and its tributaries, the geomorphic unit flow of land surface is governed by its properties and it is an open system in which energy flows (Jayakumar

Figure 1: The Flowchart Methodology used for the Research



and Siraz, 1997). The major river that flows through the area is the River Yedzeram, and it is one of the rivers that drain into Lake Chad. It has a total length of about 330 km. It takes it source from the Hudu Hills south-east of Mubi and flows northward into the Chad (Adebayo and Umar, 2004). The density map is as presented in Figure 3.

Hydrology and Water Resources

Groundwater is an important source of water in Mubi Local Government Area of Adamawa State and most of the water scheme found in Mubi is groundwater based in form of wells and boreholes. Mubi is underlain by basement complex rock of the Pre-Cambrain period, the groundwater occurrence in the basement complex is unpredictable and the yield from the boreholes vary widely been of a few hundred liters per day and the draw down is high. However, clastic formation provide reliable aquiver for portable water and such formation are found all over the state (Adebayo and Umar, 2004). In Figure 2, the hydrological system of Mubi Local Government is descriptively identified in stream order.

Slope

The Slope is terrain parameters which explain the horizontal spacing of contours, steeper slope are closely spaced contour represented by and spares contour depicts gentle slope. The higher value represented on the slope portrays hilly terrain while lower cell value depicts flat terrain. The elevation raster (DEM) encompasses the slope value calculation either in percentage or in degree in raster format. In Figure 5, the nearly leveled slope area is from (0-3.667) degree, within this range, the surface runoff is very slow allowing more time for rainwater to percolate for good groundwater zone, where (8.9-51) depicts relative to strong slope areas which enhances high runoff

Figure 2: Hydrological Map of Mubi

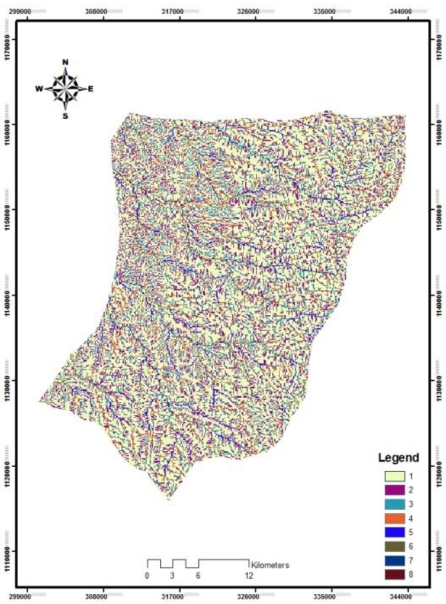


Figure 3: Drainage Density map of Mubi

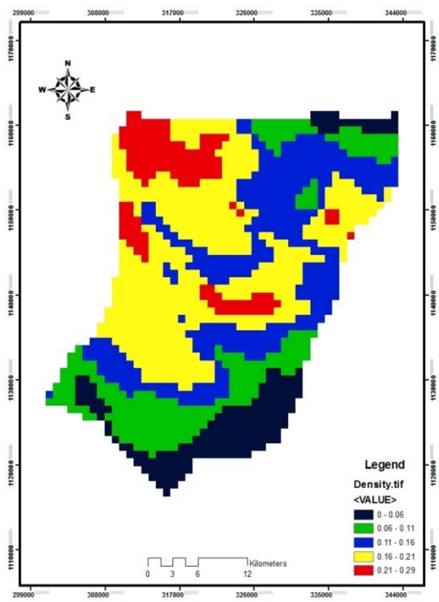


Figure 4: Slope map of Mubi

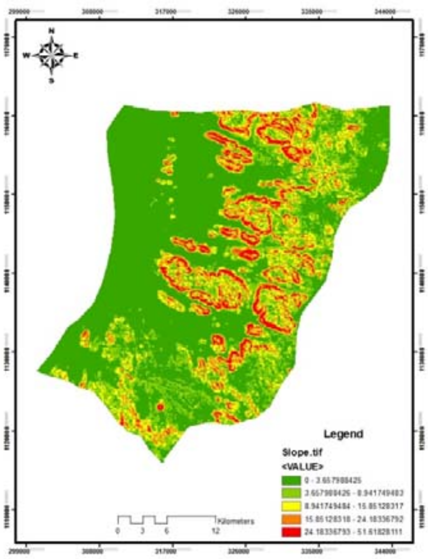
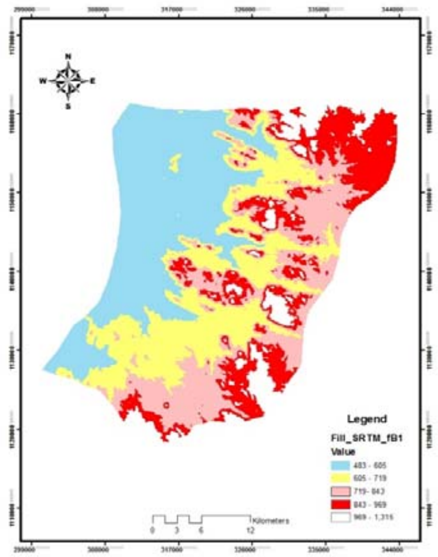


Figure 5: Digital Elevation Model of Mubi



with less infiltration and poor groundwater zone. The slope was then classified into five (5) different classes in Figure 4.

Geology and Geomorphology

Geomorphology is the study of land form which describes the genesis (Gupta, 2003). This is an aspect of science which grown after the emergence of Photogrammetry (Aerial Survey) and Satellite Remote Sensing, the information extracted from soil, water, and vegetation has become an instrument of planning and different developmental activities. The structural evolution and geological formation of the area depend on the geomorphology which enhances the groundwater occurrence of that region as in Figure 6.

Opeloye and Deo (1999) asserted that Mubi encoun passes parts of an ancient craton that was active in geological past and the hard crystalline cratonic basements are ancient precambrain rocks formed from series of orogenic cycles within the mobile belt of Central Africa. The granitisation by intrusion of Granite, Granodiorites and Syenites during this period transformed the older rocks into oriented Biotite-granite, Biotite and porphyroid – granite and alkaline granite. These recycled crystalline rocks are outcrop at Mubi as prominent ridges consequent to compression during the orogenic events. Most rock within the catchment Gneisses, migmatities and quarzites, but laterob literated by the late proterozoic and pan-Africa events.The predominant geological structures in the area are quartz veins, folds, dykes and sheer zones. The dominanttectonic directions in the area are NW-SE making pre-africa deformation and NE-SW making the thermotectonic event (Adebayo and Dayya, 2004). The soil of the study area falls into the hydromophic and ferruginous tropical soil of granitic material which is made up of Entisols and Inceptisols based on USDA soil order (Nwaka, 2004).

Figure 6: Geology map of Mubi

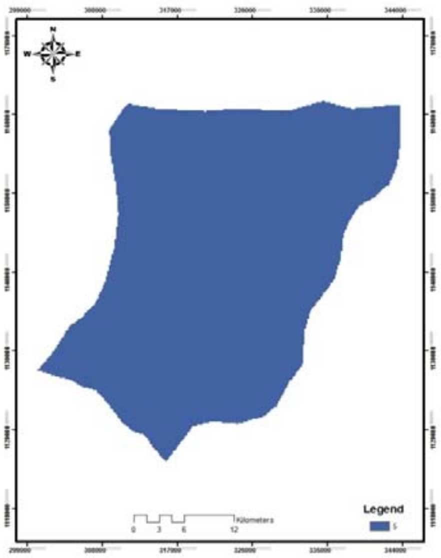


Figure 7: Soil map of Mubi

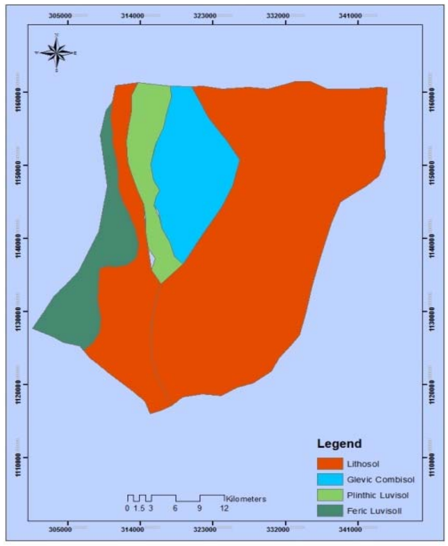


Figure 8: LandUse/Landcover map of Mubi

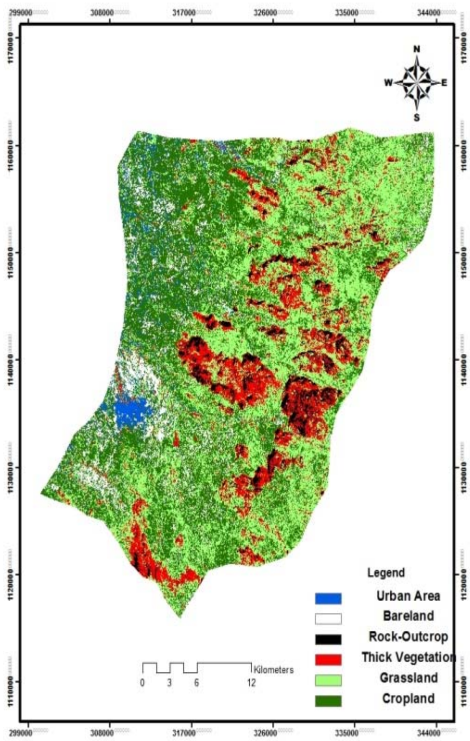


Figure 9: Watershed Map of Mubi

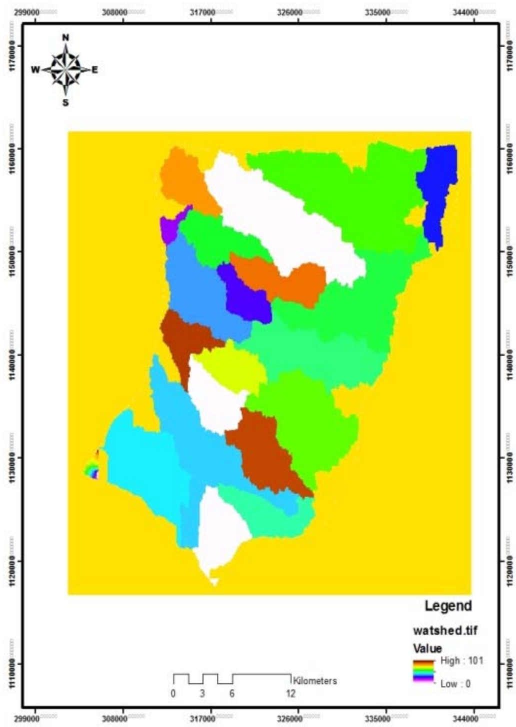
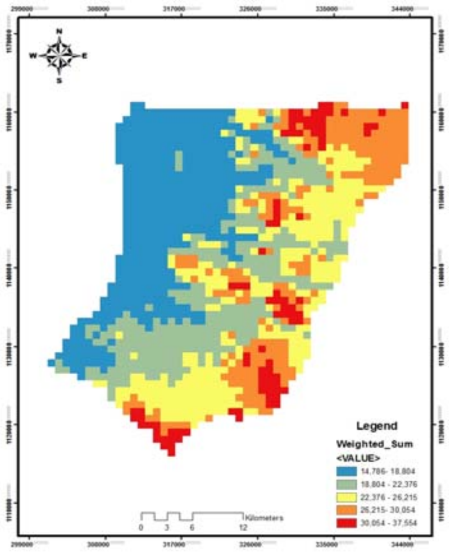


Figure 10: Groundwater Potential Map of Mubi



Soil Type

The soil type in Mubi are the lithosols, they are shallow in nature of less than 10 cm deep on bedrock and found within the basement complex, they consists mainly the hills, mountain ranges, rocky terrain, inselbergs and inter vening plains and valleys. This soil is strongly acidic to neutral, it possess little available soil volume for root extension after crop plants scants growth potentials. The nature or types of soil within a locality also encourage groundwater potential zone identification. Figure 7 depicts the soil nature of the research area. Groundwater occurrence in the basement complex is unpredictable but places with clastic formation provide reliable aquiver for portable water which can be found all

Table 1: Rank and Weight for Different Parameter of Groundwater Potential Zone

Parameter	Classes	Groundwater prospect	Weight(%)	Rank
Soil	Lithosol	Good		4
	GlevilCombisol	Poor	10	3
	Luvisol	Moderate		2
	0-0.36	Very good		5
	0.36-8.9	Good		4
Slope	8.9-15.8	Moderate	20	3
	15.8-24.1	Poor		2
	24.1-51.6	Very poor		1
	Hills and Mountain	Very good		5
Geomorphology	Uplands	good	20	4
Geology	Basement complex	Good	25	4
	Urban Area	Poor		2
	Bareland	Very poor		1
Land Use/Land Cover	Rock-Outcrop	Good		4
	Vegetation	Very good	10	5
	Cropland	Very good		5
	Grassland	Good		4
	0-0.6	Very good		5
Drainage density	0.06-0.11	Good		4
(Km/Km2)	0.11-0.16	Moderate	15	3
	0.16-0.21	Poor		2
	0.21-0.29	Very Poor		1

around Mubi Local Government Area (Helen, 1999).

Land Use and Land Cover

Land Cover map refers to the type of features present on the earth surface in a particular area. It is the physical property or material, e.g., water, sand, crops and asphalt. Land use relates with human activity or economic function for specific piece of land, in this research; the land use was classified into six different classes with urban area cover of about 3.289%, Bareland 51.037%, Rock-outcrop 4.694%, Vegetation 8.963%, Cropland 13.956% and Grassland 18.069% in Figure 8.

Watershed

Murugesan B, *et al.,* 2012 defined that watershed as an area of land where all water or drains off goes into the same place, it is an area of land, a bounded hydrologic system which all living things are inextricably linked by their common water course and where as human settlement, An area of land that drains water, sediment and dissolved materials to a common receiving body or outlet. The term is not restricted to surface water runoff and includes interactions with subsurface water (Asadi S S *et al.,* 2007). They come in different shapes and sizes; the watershed of the research area of Mubi is hereby presented in Figure 9.

CONCLUSION

Geographic Information System and Remote Sensing has become has become a useful tool in determining the groundwater potential zone of Mubi, the study reveals that different parameters can be used for groundwater detection. For this research, six thematic maps such as Geology, Geomorphology, Slope, Drainage density, Lineament density and Landuse/Landcover gives firsthand information to local authorities, Planners, Surveyors, Geologist on locations suitable for groundwater exploration. The output result of the groundwater mapwasclassissifiedinto five (5) different classes; Very Poor ranges from 14786-18804, Poor with 18804-22376, Moderate 22376-26215, Good 26215-30054 and Excellence 30054-37554 as described in Figure 10.

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