Mapping Land Use and Land Cover in parts of the Niger Delta for Effective Planning and Administration

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Abstract— This research paper presents an analysis of land cover/land use characteristics within some coastal states in the Niger Delta as a basis for critical long term regional land use planning. The objective of the study is to help administrators in identifying high priority development and conservation zones including areas of production potentials for cropping pattern and specific areas necessary for land use optimization. The land use/ land cover mapping of the study area revealed a cluster of urban settlements at the center of each of the three states. A cluster settlement is an indicator of organized human habitation within which socio-economic activities (transportation systems, communication, administrative system and education) and other developmental activities revolve around. This study identified 13 significant cluster settlements with 6 of the clusters occurring within Akwa Ibom State, 4 in Rivers State and 3 in Bayelsa state. These clusters are settlement areas of dense habitation ranging from 63.5 Sq. Km to 581 Sq. Km with the largest occurring in Port Harcourt, Rivers State. The Land use analysis within the study area shows a high pressure on forest resources over other land resources (such as farm and grass land). Among the three states covered wthin this study, Rivers State has the highest forest resources, while Bayelsa State has the highest water resources.

Index Terms— Land use planning, Niger Delta, Effective Planning, Natural Resources Potential, Land use, land cover mapping

1 Introduction

The need for establishing land use and land cover baseline in the Niger Delta has become imperative in view of the rapid urbanization of the region. This is due to rapid industrialization and increasing concentration of human population in urban areas of the Niger Delta region. This rapid demographic transformation has presented a myriad of challenges for the various cities within the area. This problem is further aggravated by inadequate and improper land use planning and policies. Similarly, serious environmental degradation has taken place in the Niger Delta thereby affecting the total dependence of the rural population on agriculture, fishing, forestry and wildlife exploitation with serious socio-political implications to the region.

Land cover refers to the vegetation and artificial constructions covering the land (Burley, 1961), and Land Use is the human activities on the land which are directly related to the land (Clawson and Stewart, 1965). Global concerns on land use and land cover mapping has increased due to the connection of land surface processes to climate change. Land use and climate change are major drivers of the Earth's water and energy cycle.(Mahnood et al. 2010) Depletion in forest land has shown negative impact on water and energy fluxes as well as other near surface climate dynamics (Pielke et al, 2002)

Generally, micro-organisms within an ecosystem interact in diverse ways with the other environmental components to sustain a fragile but dynamic equilibrium. Any slight change within the ecosystem or other environmental components can drastically alter or affect this fragile equilibrium. This equilibrium can be disrupted when environmental components drastically change or when external sudden impacts overwhelm the system. For example, some researchers have shown that conversion of forest to cropland or grassland will result in cooling in temperate regions (e.g Diffrnbaugh and Sloan, 2002, Oleson et al., 2004, Bala et al) .Mapping ecosystems with all

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their habitats and its associated components is very difficult as they are very dynamic, interrelated and change through time either due to environmental factors. Habitats or ecosystem are dynamic, interrelated and change through time either due to environmental factors or anthropogenic challenges (Lamb et al 2001;Osborne et al. 2001; Edwards et al 1996).

Generally, there are two broad approaches for applying remote sensing to monitoring of ecosystems and other biodiversity assessments. These are the direct observations of organisms and communitiesand indirect observations of environmental proxies of biodiversity (Turner et al. 2003). GIS processed satellite imageries has therefore evolved over the years as an immense indirect remote sensing tool for of modelling spatial and temporal characteristics of biodiversity forms/ types using environmental parameters. Using this method, discreet habitats or ecosystems like woodland, grassland, or seabed grasses can be mapped. This therefore forms the basis of landcover/ landuse mapping worldwide. Making use of GIS/satellite remote sensing technology, a wide variety of habitat variables have been assessed for diverse thematic purposes worldwide (Herr et al. 1993, Aspinall et al. 1993, Hepinstall et al. 1997, McCloy 1995, Lillesand et al. 2004).

Similarly, the use of GIS processed satellite imagery for regional mapping of landcover/landuse characterization has long been demonstrated as a vital tool for regional ecosystems mapping. This is as result of its ease of operation, speed, accuracy, low cost and coverage. In addition, advancements lately in satellite and digital technologies have led to remarkable improvement in this technique. The increasing availability of information products generated from satellite imagery data has added greatly to our ability to understand the patterns and dynamics of the earth resource systems at all scales of inquiry. As satellite data are generally digital and consequently amenable to computer-based analysis for classifying land cover types, the advances in GIS and its growing availability for the general users is a promising trend for the application of low cost remote sensing in mapping landuse characteristics in developing countries. A particularly important application of remote sensing is the generation of landuse/ land-cover maps from satellite imagery. Compared to more traditional mapping approaches such as terrestrial survey and basic aerial photo-interpretation, land-use mapping using satellite imagery has the advantages of low cost, large area coverage, repetitively, and computability (Franklin, 2001). Consequently, land-use information products obtained from satellite imagery such as land-use maps, data and GIS layers have become an essential tool in many operational programs involving land resource management.

The increasing availability of satellite imagery with significantly improved spectral and spatial resolution has offered greater potential for more detailed land-use mapping. It was predicted that in the near future, more than 50 percent of the current aerial photo market will be replaced by high-resolution satellite imagery (Fritz, 1996). At the same time, rapid advances in the computer science as well as other information technology (IT) fields have offered more powerful tools for satellite image processing and analysis. Image processing software and hardware are becoming more efficient and less expensive. Accesses to faster and more capable computer platforms has aided our ability to store and process larger and more detailed image and attribute data sets using GIS technology.

This study was carried out using an integration of Geographic Information System technology and remote sensing with the aim of providing a basis for effective land use planning for increased economic productivity and sustainable development in the study area. This work will there attempt to identify the various land cover/ land use attributes within the Niger Delta, provide a quantitative assessment of their areal extent and identify clusters within the study area and to identify a set components that can be used as fundamentals units for general development policies for the area. This research intends to set the pace for mapping and characterization of various land use and land cover factors within some coastal states in the Niger Delta as a basis for critical long term regional scale land use planning effort. This will help administration identify high priority development and conservation zones, areas of production potentials for cropping pattern and specific areas nec-

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essary for land use optimization

1.1 Location, Geomorphology and Geology of the Study Area

The Niger Delta is located at the southern part of Nigeria as shown in figure 1 below. It ranks high among the major wetland and deltas in the world and has one of the largest mangrove ecosystems. It has an overall regressive clastic sequence and is divided into three formations ranging from Eocene to Recent age(Short and Stauble, 1967).They include the Benin Formation, Agbada Formation and the Akata Formation. The Akata is made up of shale deposited as turbidites and continental slope channel fills, while the Agbada is mainly sandstone and shales intercepted by a number of growth faults. The Benin Formation is made of porous sands and gravels with localized shales and clays interbeds occurring a point bars or channel fills and deposits in a continental fluvial conditions.

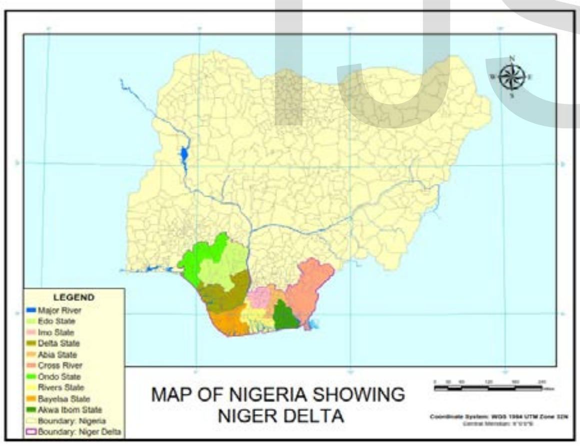

Fig. 1. Map of Nigeria showing the Niger Delta

The weather conditions in this region can be divided into wet and dry season. The wet season occurs between March and September, while the dry season is between October and February. According to Akpokodje (2000), the mean annual rainfall ranges from 2000mm to 4000m an 85% of this rainfall occurs in within August and October.

The geology and geomorphology of the Niger delta have been described in details by various authors(Allen,1965; Akpokodje,1979,1986; Assez,1972;Doust and Omatsola,1990;Short and Stauble,1965; Evamy et al,1978).The formation of the present day Niger delta started during Early Paleocene and it resulted mainly from the buildup of fine grained sediments eroded and transported by the River Niger and its tributaries. The subsurface geology of the Niger delta consists of three litho-stratigraphic units(Akata, Agbada and Benin Formations) which are in turn overlain by various types of Quaternary deposits(Etu–Efeotor and Akpokodje,1990).The Quaternary deposits(normally 40–150m thick) generally consist of rapidly alternating sequencies of sand and silt/clay with the latter becoming increasingly more prominent seawards.

The Niger Delta, covering an area of about 200,000 square kilometers, is situated on the West African continental margin at the apex of the Gulf of Guinea, which formed the site of a triple junction during continental break-up in the Cretaceous. The delta sequence comprises an upward-coarsening regressive association of Tertiary clastics up to 12 km thick (Doust, 1990). It is divided into three gross lithofacies:

(i) marine claystones and shales of about 6.5km thick at the base (Akata Formation)

(ii) alternations of sandstones, siltstones and claystones of about 3.5km thick (Agbada Formation); and

(iii) Alluvial sands of about 2km thick at the top (Benin Formation) (Doust, 1990).

The Benin Formation, on which the study area sits, consists of predominantly massive, highly porous, fresh water-bearing sandstone, with local interbeds of shale. It is a continental deposit of Miocene to recent age (Weber and Daukoru (1975); Ejedawe (1981)).

2.0 MATERIALS AND METHODS:

The use of remote sensing technique in the mapping of land use and Land cover is gaining global acceptance. It has been adopted to extensively derived biophysical variables as well as understand urbanization trend, potential natural resources an hydrological accumulations. For this research, land use and land cover products were derived from United State Geologi-

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cal Survey Landsat Enhance Themtic Mapper 2014 and also from toposheet generated from scale 1:50,000. All these dataset were brought under the same coordinate system in a GIS environment (ArcGIS 10.2) using a Universal Transverse Mercator (UTM) projection 32N .

Preprocessing of satellite images prior to image classification and change detection is essential. Preprocessing commonly comprises a series of sequential operations, including atmospheric correction or normalization, image registration, geometric correction, and masking (e.g., for clouds, water, irrelevant features) (Coppin & Bauer, 1996).The normalization of satellite imagery takes into account the combined, measurable reflectances of the atmosphere, aerosol scattering and absorption, and the earth's surface (Kim & Elman, 1990). It is the volatility of the atmosphere which can introduce variation between the reflectance values or digital numbers (DN's) of satellite images acquired at different times Although the effects of the atmosphere upon remotely sensed data are not considered errors, since they are part of the signal received by the sensing device (Bernstein et al, 1983), consideration of these effects is important. The goal aptly stated by Hall et al (1991), should be that following image preprocessing, all images should appear as if they were acquired from the same sensor. Geometric rectification of the imagery resample or changes the pixel grid to fit that of a map projection or another reference image. This becomes especially important when scene to scene comparisons of individual pixels in applications such as change detection are being sought (ERDAS, 1999).

2.1 Band Combination

Most Earth Observation Satellites record various spectral bands. These bands can be combined with one another to enable greater visibility for specific land feature. These combinations require a basic understanding of wavelength of each band and the colour they reflect when they meet each specific feature. This is because various land features display a variety of colours on the visible spectrum. The band combination adopted for this project was the 4.3.2 combination as shown in figure 2 below. This combination is conventional considered to produce a false or composite colour. Vegetation here appears to be in shades of red, while urban settlements appears in the cyan blue color. Soils vary from dark browns while coniferous trees appear in the clolour of dark to light brown. Water body appears in blue.

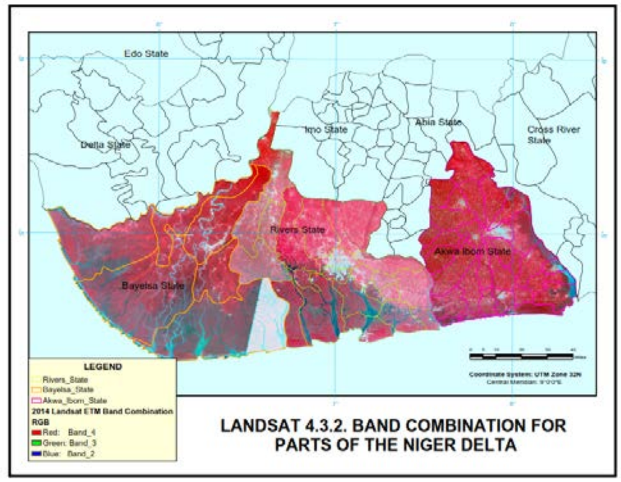

Fig.2. Landsat 4, 3, 2, Band Combination for Parts of the Nigeria

2.2 Image Classification

This can be described as the extraction of differentiated classes or themes, land use and land cover categories, from raw remotely sensed digital satellite data (Gorham, 1999). The development and creation process of the 2014 land use and land cover map for parts of the Niger Delta is based on the fundamentals listed below. In this research the term land use and land cover is combined as one entity for the description of the landscape within the area of study. It should be noted that while land use and land cover are recognized as separate entities (Meyer, 1995), they have been combined in this study in order to conform with the level of detail employed. Also, finer levels of inquiry would most likely need to use separate measures of land use and land cover and/or to use more detailed levels of the classification scheme.

A multilevel, hierarchical land use classification was derived from the author's as prior knowledge of the study area and is roughly based upon an Anderson level II classification (Anderson et al, 1976). For the scope of this study, 5 level I catego-

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ries and 8 level II categories compose the hierarchical land use and land cover classification employed in this project. (Table 1.0) Level I and level II land use and land cover categories were broadly categorized purposely in order to minimize confusion between land cover classes that experienced change over the time period considered in this study.

3.0 Results and Discussion

The land use/ land cover mapping in parts of the Niger Delta under consideration shows a cluster of urban settlement at the center of each of the three states. Clusters Settlements is an indicator of organized human habitation within which economic activities, transportation systems, communication media, political, administrative and educational facilities around which development revolves in the area. This study identified 13 significant settlement clusters ranging from 63.5 Sq. Km to 581 Sq. Km with the largest occurring in Port Harcourt, Rivers State. These cluster settlement are areas of thick habitation. 6 clusters are within Akwa Ibom State, 4 in Rivers State and 3 in Bayelsa.

TABLE 1
Landuse and Landcover Classification Category
(Anderson et al,1976)

Category No.	Level 1	Level 2
1.	Urban Areas	11. Low Intensity 12. Moderate Intensity 13. High Intensity
2.	Agricultural Land	21. Cropland and Pastures 22. Orchards, Grooves, etc.
3.	Forest Land	31. Deciduous Forestland 32. Evergreen Forestland 33. Mixed Forestland
4.	Water Body	41. Streams and Canal 52. Lakes 53. Reservoirs

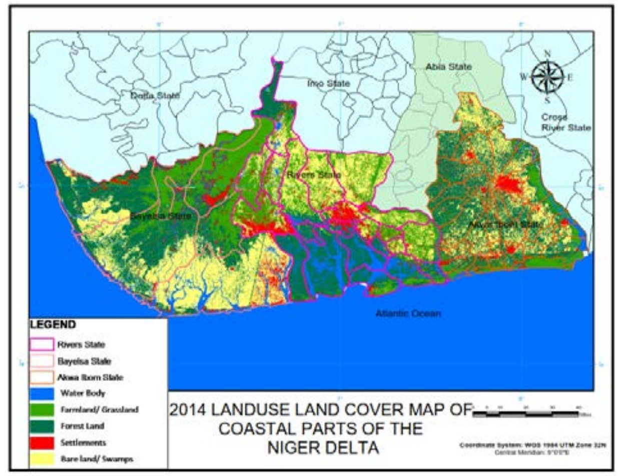

Fig.3. 2014 Landuse Landcover Map of Coastal Parts of the NigerDelta

The urban clusters identified in Akwa Ibom State are: Uyo Settlement Clusters, Abak Settlement Cluster, Ikot Ekpene Settlement Cluster, Ikot Abasi Settlement Cluster, Eket Settlement Cluster, and Oron Settlement Cluster. These are areas of dense cluster settlement and seeming infrastructural development. Uyo Settlement Cluster is within 166.3 Sq. Km, Abak is 27.7 Sq. Km, Ikot Abasi is 39.26 Sq. Km, Eket Settlement Clusters is 36.8 Sq.Km. Oron Settlement Cluster is within 18.5 Sq. Km. and Ikot Ekpene Cluster is within 27.8 Sq. Km.

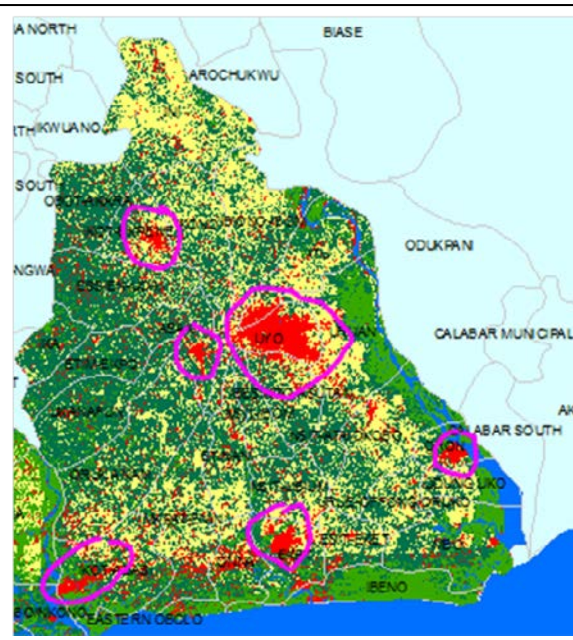

Fig.4. Sheet showing urban settlement clusters in Awa Ibom State

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The urban settlement clusters in Rivers State are: Port Harcourt/ Obio Akpor Settlement Cluster, Abua/ Odua Settlement Cluster, Bonny Settlement Cluster, and Ogba/Egbema/Ndoni Cluster. These settlement cluster around an area coverage of 581Sq. Km for Port Harcourt/Obio Akpor, 63.5 Sq. Km for Abua/Odua Settlement Cluster, 135.2 Sq. Km. for Bonny Settlement Cluster, and 105 Sq. Km for Ogba/Egbema/Ndoni Cluster.

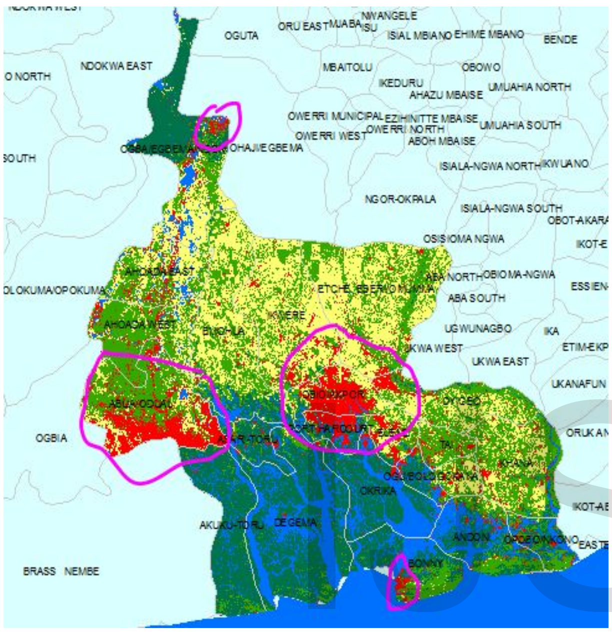

Fig.5. Sheet showing urban settlement clusters in Rivers State

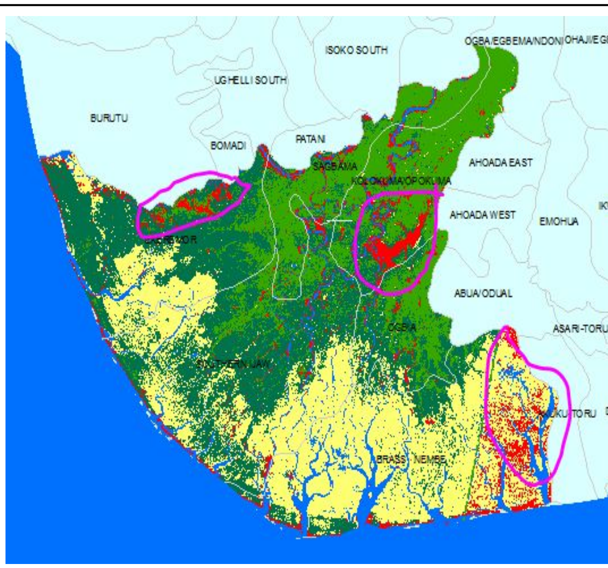

Fig.6. Sheet showing urban settlement clusters in Bayelsa State

TABLE 2
LANDUSE AND LANDCOVER DISTRIBUTION IN PARTS OF NIGER DELTA

S/N	Land Use and Land Cover	Area (Sq.Km)	Coverage %
1.	Water body	1301.55	15.43
2.	Farmland/Grassland	2145.129	25.42
3.	Forestland	1140.844	13.52
4.	Urban Centers	2016.023	23.89
5.	Bareland/swamps	1834.277	21.74

3.2 Comparative Assessment of Land Use Variation For Natural Resources Potentials

Figures 7 and 8 below shows the percentage distribution of Land use characteristics within the some of the states in the study area. This indicates that Bayelsa has the highest contribution of Water body/Resources with a percentage of 66.19%, while Rivers State is followed with 17.72% and Akwa Ibom State with 16.10%. Among the three states covered wthin my study area, Rivers has the highest forest resources taking aa percentage of 42.22%, followed by Bayelsa State with a percentage of 30.44 and 27.34 % from Akwa Ibom State.

Rivers state also has the highest potential for agricultural production with an estimated percentage of 47.20 of the farmland and grassland considered in the study area (Akwa Ibom, Bayelsa and Rivers State).

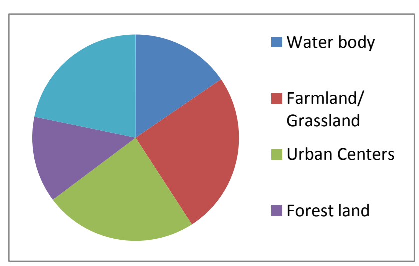

Fig.7. Pie Chart showing areal coverage of Landcover and Landuse in parts of the Niger Delta in Rivers State

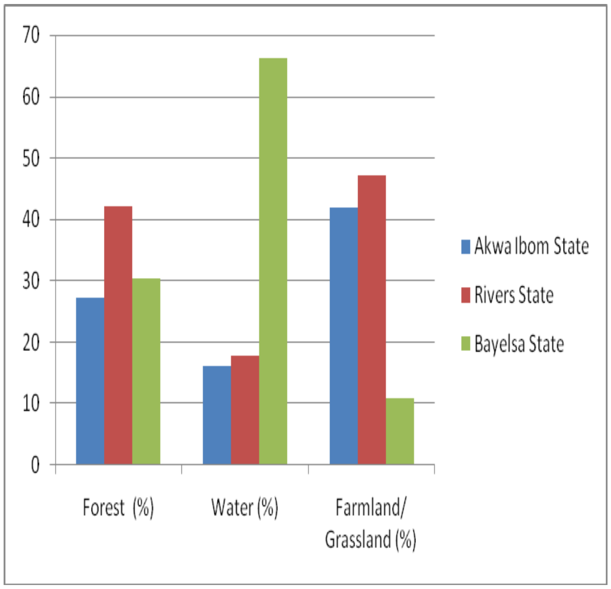

Fig.8.Histogram showing Landuse distribution coverage with the stud area

4.0 Conclusion and Recommendation

This study shows that small splinter clusters are springing up and expanding in Akwa Ibom State, while existing cluster development centers in Rivers and Bayelsa State are increasing by the day instead of dvelopment of new cluster development centers. This will inhibit urban renewal in areas without splinter clusters and create undues pressurs on the existing water and forest resources within rivers state. Government Agencies in Rivers and Bayelsa State need to conciously adopt development projects that will decentralize settlement efforts and reduce the pressure on existing resources within the states. Furthermore, this study has revealed the potentials for income generation in forest resources in Rivers State, and water resources Development in Bayelsa. There is also a potentials for livestock grazing development and crop production in Rivers State while Akwa Ibom state has a highest potentials for crop production.

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