Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.11, 2014 www.iiste.org

Assessing Web Compliance of Base Map using the Open Street Map: The Case of Adamawa State, Nigeria

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Abstract
The focus of this study is on assessing the reliability of base maps for web compliance with specific interest in its compatibility with the Open Street Map. Base maps are reference maps used in a particular jurisdiction to which all mapping projects are referred. The Open Street Map is an online open source editable map of the globe available to GIS users. The study applied the use of the open street map to Adamawa state in Nigeria. The analogue map of the state was obtained, scanned, geo-referenced and digitized on the ArcGIS 10.1; this was then added to the open street map of the WGS 1984 Universal Transverse Mercator, auxiliary sphere. It was observed that the digitized map did not synchronize with that displayed by the open street map which prompted for editing. Two maps were then obtained, the first is the originally digitized map and the second is the edited map based on the open street map standard. The result showed two similar but different shaped and sized maps. The study recommends the use of the open street map as a referencing standard frame for the states currently undergoing digital spatial information transformation in order to maintain uniformity of standard in the country.
Keywords: web compliance, base map, OSM, Adamawa state

1. INTRODUCTION

The advances in web-technology and the already embraced field of Geoinformatics have provided the convenience that makes digital spatial information (SI) more informative and lucrative. The Open Street Map (OSM) of the Universal Transverse Mercator (UTM) auxiliary sphere currently provide online open source data to GIS users, all with the aim of information dissemination through the use, reuse and sharing of SI. The necessity for having a framework for documenting and sharing of this information therefore becomes inevitable. The vision of Al Gore's 'digital earth' is also becoming a reality, that is, having an interconnected three dimensional spatially referenced planet where digital knowledge can easily be drawn from the pool of globally connected archives (Ehlers, 2008, Craglia et al., 2012). In order to achieve this global connection, it is expected that the spatial information infrastructure (SII) must be put in place, which readily disseminate reliable spatial data (SD) based on acceptable standard. Most of these SDs are provided for by the volunteered geographic information (VGI) termed as 'social networking and user-generated web content' (Goodchild & Glennon, 2010). The VGI is not new in the current dispensation of the world of geoinformatics, but in the 'developing GIS' (mostly found in developing countries) where spatial data transformation from one coordinate system to another is still taking place, it may mean something else (Tumba &Ahmad, 2014). This calls for a proper assessment of the georeferenced maps being used as reference-base map; this is because the output of georeferenced data is directly a function of the base map used. In line with modern technology, and the so much shout about the world being a global village and the quest for a 'digital earth' the expectation is that each county map is supposed to be web compliant. This means a dot on the national map signifies a dot (X, Y) on the widely accepted WGS 1984 web Mercator auxiliary sphere, by adopting this system, it also solves the problem of using similar but different shapes of maps for the country or region. The Open Street Map (OSM) is currently accepted and used to have a free and editable map of the world; it is the creation of ESRI in collaboration and partnership with other software bodies. OSM map provide ArcGIS desktop (versions from 9.3 upwards) users with online service.

One of the pressing problems of national SDIs is the issue of fundamental datasets which provides the spatial object location, and its attendant characteristics. The basics of launching a successful national spatial data infrastructure (NSDI) leading to regional and global SDI is the issue of a reliable basic fundamental dataset at the local-state levels, the first of which must be the base map of the state including its local governments. In line with providing SI consistent with International Organization for Standardization (ISO) and the world wide web consortium (W3C), the map used must be consistent, this is because one of the goals of the global spatial data infrastructure (GSDI) is a spatial information interoperability towards having a spatially enabled society for the envisaged 'digital earth'. Developing countries are most bedeviled with these problems of inconsistencies, Nigerian is no exception, and so also with its states. The web map of Adamawa state accessed on WGS 1984 Web Mercator auxiliary sphere for open street map shows similar but different shaped map from that used by the state, this means the size and shapes of areas would also be different. Taking into cognizance that different projection systems might have been used, this constitutes problems as the administrative map used for running the state is in clear contrast to the web standards. This research intends to investigate web compliance of the state administrative map for enhancing spatial interoperability for effective exchange and sharing of spatial information.

In this paper, we intend to assess Adamawa state base map (administrative map) towards web based compliance on the OSM in order to maintain accuracy, standard and reliability. The objective would be; the need to achieve standard requirements for spatial data interoperability for the state, country and the entire geospatial community. The intention would be to have a map whose coordinates are uniform and reliable, with a single map standard whose shape and size are the same, on the same reference system for spatial planning in the state and for Geoinformation users in general.

1.4 Study Area

Adamawa is one of the 36 states of the federating units of Nigeria, created in 1991 on the 27th August, by the then military regime. It was carved out of the defunct Gongola state which was dissolved after a life span of 15 years. At the Nation's regional level, it is one of the 6 states of the former (and still) North Eastern region. It is located between latitude 8° N, 11°N and Longitude 11.5°E, 13.5°E. Adamawa state is bounded by the Cameroun Republic to the East, Gombe state to the West and Borno and Taraba states to the North and South respectively. It is in an estimated area of 39, 742, 12 sq. km which accounts for 4.4% of the total land mass of Nigeria, its projected population as per the 2006 population figure stands at 3,737,223. Geographically, Adamawa is a state traversed by mountainous land forms like the Mandara Mountains, Cameroun Mountains and the Adamawa hills, and Large Rivers, Benue, Gongola and Yadzarem.

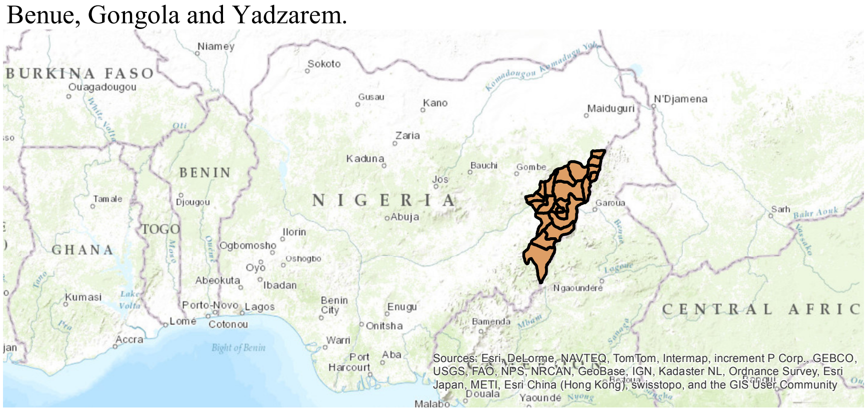


Figure 1: Map of Nigeria showing Adamawa state

1.4.1 Administration

Adamawa state is made up of 21 local government areas, with its state capital at Yola. The 21 local government areas are; Demsa, Ganye, Gombi, Guyuk, Girei, Fufore, Hong, Jada, Lamurde, Madagali, Maiha, Mayo-belwa, Michika, Mubi North, Mubi South, Numan, Shelleng, Song, Toungo, Yola North and Yola South.

2. Overview of Web Mapping and Digital Earth

The advances made in information technology as a result of the internet and mobile electronic technology have continuously changed the direction and concept of modern SI. The introduction of web mapping has changed the top-down approach formally enjoyed by governments, scientific domain and the private sector (de By & Georgiadou, 2013). The new concept has now assumed the bottom-up approach where information from individuals or bodies now serve the top in what is termed 'volunteered geographic information' (VGI) (Goodchild & Glennon, 2010). VGI is a term used to describe individuals who, taking the advantage provided by the open-source mapping tools and opportunities, provide geospatial information for web and other users in line with the vision of the digital earth (Guo et al., 2009), some authors call it crowdsourcing geographic knowledge (CGK) (Tulloch, 2014). Perhaps, the complex and dynamic nature of contemporary SI and its attendant cost implication could serve as the reason of this diversification in the bottom-up approach (Lu et al., 2013). This complication and dynamism according to research can be minimized by introducing the concept of World Wide Hypermap (WWH) architecture and reducing the normal SDI interoperability problem through a Geospatial Service Web (GSW) (Masó et al., 2014, Gong et al., 2012). WWH is diverse heterogeneous service architecture. The above stated concepts form the basis of contemporary spatial information towards the digital earth notion and having a spatially enabled society.

2.1 The Concept of Digital Earth

According to Gao et al., (2009) digital earth is a mere expression of the real earth we live on and expresses it as modern way of describing and understanding the earth in the 21st century. It has also been expressed as the metaphor for the access and organization of digital information on a multi-scale representing the earth in three-dimension (Gao et al., 2009, Guo et al., 2009). The notion of digital earth stated by Al Gore has long generated interest in a cooperative study of the planet and its vast resources with the provision for sustainability and management of these resources as a priority (Foresman, 2008). Today, so many researches are being carried out in various domains by researchers, all with the quest for digital earth compliance towards easy access, sharing and exchange of globally distributed unambiguous SI that translates into 'a mark on the globe' with global effects (Bernard et al., 2013, Zhan et al., 2013).

The application of an innovative digital earth living lab, with people driven orientation to support bottom-up approach is being advocated (Schade & Granell, 2013) through cooperative and public participation in spatial information technologies (Brovelli et al., 2014).

The increasing volumes of SD as a result of breakthrough developments in SI technologies have made Geoinformation a business which should be properly managed (Sidda et al., 2012). Some analysis made on digital earth from the 1999 declaration to 2009 call for some thoughts about its future direction (Guo et al., 2010) and expressed fear about it, reaching the saturation stage.

2.2 Web Mapping

The significant impact of the world-wide-web has brought about the increased number of different geographic services from different source providers like Google, Microsoft and so on (Vaccari, 2009). Web mapping is increasingly becoming the driving engine to modern rich-spatial information age for information dissemination in order to address multidisciplinary issues (Singh & Singh, 2014), this is as a result of advances made in web-based technologies which hitherto had been slowed by low bandwidth and slow internet services (Delfos et al., 2013). Perhaps the geospatial community is progressing into the much expected era of geo-sensor (Craglia et al., 2008) and seemingly realizable generation of web and wireless geospatial information systems (Di Martino et al., 2013). Web map and web mapping transcend ordinary web cartography; it is both about providing SI services and consumption of the derived information. Web mapping is a new technology that is still undergoing development with challenges of quality, usability, legal constraints and its social gains. Contemporary issues in the web mapping show it has moved fast in technology as there are so many researches in sensor web technologies(Chen et al., 2013, De Longueville et al., 2010). The sensor Web may be defined as an infrastructure, which enables an interoperability and usage of sensor resources by enabling their discovery and access. Sensor web technologies involve the production and availability of spatiotemporal geospatial information that are real-time accessible using online modelling tools (Chen et al., 2013, Evans & Sabel, 2012). Recent trends in the World Wide Web have shown it has undergone and is still undergoing technological improvements in its transfer protocols; example, the Web 2.0 and the Representational State Transfer (REST) (Mazzetti et al., 2009). These technologies have led to the contemporary era of spatiotemporal information which reduces cost and time that is involved in information dissemination through in-situ and remote provision of SI for monitoring (Yuan & Raubal, 2014, Zyl et al., 2009). It is quite possible to automatically generate enlarged congested areas of interest due to advances in web technologies (Ti & Li, 2014).

2.3 Web Mapping and the Open Street Map (OSM)

Web maps are of different classes or types; the concern of this study however is with the analytical web map which deals with GIS services. The SD used for analytical web map may be a static one, which may, in a simple lay man's language be an analogue data converted into semi-analogue raster data. This geospatial data delivery is normally tested for their efficiency on the open geosource consortium (OGC) (Giuliani et al., 2013).

Modern web map services are provided by the WGS 1984 Web Mercator projection (auxiliary sphere). The web Mercator projection is a projection based on the parameters of an ellipsoid, the auxiliary uses sphere as the basis of its projection which is conformal in nature (Exchange, 2013). According to the Exchange; "*conformal means the maps will show familiar objects with their correct shapes"*, sizes and bearings are therefore maintained.

The WGS 1984 Web Mercator Auxiliary Sphere (WMAS) presents an editable accepted Open Street Map (OSM) via the web's open source for geospatial information users. The OSM is a collaborative mapping project that has received support from voluntary participant who contribute data through the VGI (Jokar Arsanjani et al., 2013). It has the advantage of maintaining the size and shape of the land area under investigation and offers interactive analysis and visualization (Khan et al., 2011). OSM encourages the application of location based services (Jang et al., 2014). Modern online web mappings are done using the OSM; these however constitute problem to the developing countries due to absence or limited access to the desired geodata (Neis et al., 2013).

3. Nigeria Geospatial Information

As at 2003, reports had it that about 23 African countries had initiated a National Spatial Data Infrastructure (NSDI) (Ogundele & Agbaje, 2009) program with a few of them already at the implementation stage, of which one of them is Nigeria. The history of the contemporary geographic information system in Nigeria can be traced to the establishment of the National Geo-spatial Data Infrastructure (NGDI). In 2002, a committee was established to draft a national GI policy with the mandate to provide fundamental dataset, users' survey requirements and analysis, and capacity building. This move was followed by the establishment of subcommittees, six of them in number, they are; geospatial data set, standards, Legal issues, Capacity Building and Awareness, clearing house and metadata, Sustainability and funding. The National Space Research

Development Agency (NASRDA) is the parent federal government body in charge of coordinating the activities of research organizations under it like the National Centre Remote Sensing (NCRS), Jos, Centre for Geodesy and Geo-dynamics, Toro, and the Centre for Space Science Technology Education (CSSTE), and also enjoys support from (RECTAS) the Regional Center for Training in Aerospace Survey (RECTAS, 2013).

The objectives of these bodies are for research, coordinating and provision of Geo-referenced spatial data for mapping of Nigeria and her endowed resources, towards sustainable SI management. The launching of Nigeria communication satellite 1 and 2 in 2007 and 2012 respectively has given impetus to the bid for the spatial information quest of the country; the derived spatial information is supposedly meant for effective communication and monitoring of the environment and other natural and artificial resources.

3.1 The Abuja Geographic Information System

Nigeria's federal capital territory, Abuja, is estimated to be on a land approximately 7,315 sq. km, the relocation of the federal capital from Lagos to Abuja therefore, provided enough space for modern city development and initiatives, and more so for national security and other strategic purposes (Adeoye, 2008), thus releasing the pressure on Lagos which had hitherto choked up.

In line with the growth of, and the growing demands of the federal capital city, increase in population due to rural-urban migration and population increase due to relocation, the federal government in 2003 established the Abuja Geographic Information System (AGIS) to manage land and land related dealings in Abuja. Aware of the fact that most developing countries are faced with the problem of having to manage SI in analogue formats, the mandate of AGIS was to provide digital land information for the federal capital territory, the purpose of which is for cadastres, valuation for tax and general land inventories. This is aimed to integrate the administration of land and housing and infrastructural development in the federal capital territory (Akingbade, 2012, Agunbiade, 2012). The federal capital development authority (FCDA) has been up to the challenge in maintaining the master plan of Abuja through revocation and demolition of illegally acquired and illegally designed plots/buildings, the aims of which is to provide enhanced services and relevant SI to support and provide spatially enabled environment.

3.2 States' Geographic Information Systems

It has long been the tradition in Nigeria that general survey and the registration of the surveyed land had been the exclusive preserve of the State Ministry of Land and Survey. Each of the 36 states of the federation has a Ministry that takes care of the land and its survey interest, the autonomous nature of the states allow them to operate under different names and traditional. Of late, however, the pressing demand for proper documentation, the increase in volumes of analogue record keeping and the endless litigation as a result of these pressures have forced the state governments to look inwards. Current trends in the 36 states of the federation are that each state now has a SI System, leading to the formation of various GIS in line with the motives of AGIS, which are at various levels of implementation. The motivation and vision for these moves are all geared towards e-government (Ashaye, 2012). This is true in view of the fact that SI production at the local level could be a more effective option than the top-down approach, as seen in the municipal and provisional SDI studies in South Africa (Smit et al., 2013), however developing countries are always saddled with the problem of lack of functional policies on GIS (Nagayama et al., 2010).

3.3 Adamawa Geographic Information System

Each state of the federation in Nigeria is saddled with the responsibility of establishing her own geographic information 'house' or outfit to cater for the production and provision of spatial data, necessary for the management of SI within the state. In compliance with the federal government's directive each state ministry of land and survey has a GIS aimed at providing the teeming population with information about their land parcels.

The SI provided is presumably supposed to be used for policy formulation, decision making, economic planning and management, the Adamawa Geographic Information System (ADGIS) is one of such states' GIS that were purposely established tocater for decision-support and planning needs of the state (Tumba & Ahmad, 2014). It is established with the mandate to transform the existing methods of geospatial information gathering, processing and documentation of survey data in the state. The cardinal focus of which is the digitization of all spatial data from the existing analogue formats, it aims to create a spatial database from which digital information can easily be obtained about any interest in land in the state. The structure on the ground so far, shows that ADGIS is on course for SI transformation of the state. However, what needs to be investigated is the level to which it has performed, what it has done, what needs to be done and needs assessment for job performance.

4. Methodology

The first primary data for this study is the base map of the state used as the official map for all spatial transactions in the state, obtained from the Ministry of Land and Survey. The second stage involved the extraction of the coordinates of some identifiable points and or places on the Adamawa state map obtained from the ArcGIS Explorer for desktop. The third stage was the entering of the coordinates of the local governments' headquarters unto the Excel spreadsheet, which were earlier extracted along with some other points.

4.1 Procedure

First, the analogue administrative map used as base map was scanned; this is the first stage of digital conversion, where the map now assumes a raster format. The second stage was exporting the map to the Arc map environment of the ArcGIS 10.1, the extracted coordinates from the ArcGIS Explorer for the local government headquarters and other points of interest were used for geo-referencing.

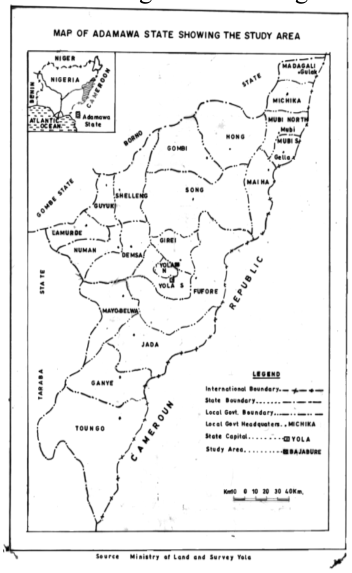
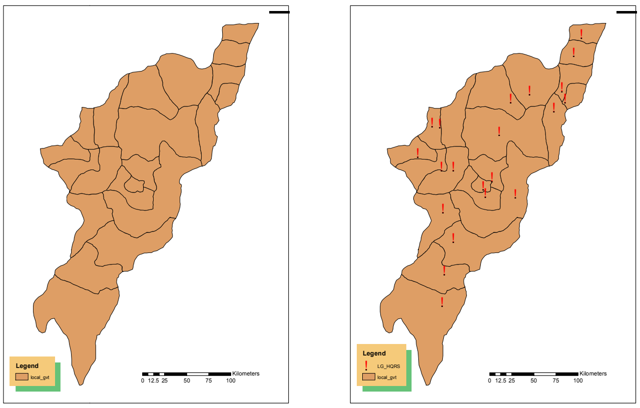


Figure 3: Analogue map of Adamawa state obtained from the Ministry of Land and Survey, Yola

In order to avoid a digitizing problem, enough number of coordinate points is required. The third stage was the creation of the geo database in the Arc Catalog, from which a feature dataset was created; the feature data set enables the creation of a number of feature classes. In this particular case, the feature data set created was named 'Local Government', that is, representing the local government areas that make up Adamawa State. Under it, feature classes of local government headquarters, 'roadA', 'roadB' and 'roadC' were created. The local governments were then digitized, that is, one class for all the 21 local governments (figure 4). Local government headquarters were then imported as points from the excel spreadsheets to shapefile, and converted to point map, this point map was then exported and added to the data frame (figure 5)



(a) (b)

Figures 4: The digitized base map of Adamawa state shown in (a), while the (b) shows the added local government headquarters point map to the digitized base map

Online editing was done by superimposing the Adamawa state map on the Open Street Map (OSM). The boundaries of the base map as appeared on the OSM were carefully followed and traced with the cursor, trunk 'A' roads were traced as roadA, trunk 'B' roads traced as roadB and trunk 'C' roads traced as roadC. For practical editing, the 'symbology' of the base map was changed to 'hollow' so that the digitized map is seen as in figure 5 below.

The Nigeria digital map was also obtained by creating its class under the Adamawa local government feature dataset. It is necessary to create enough feature classes to serve as an in-situ check on the web for accuracy. The idea is if the 'whole' is accurately surveyed, then, errors within the parts can be drastically minimized.

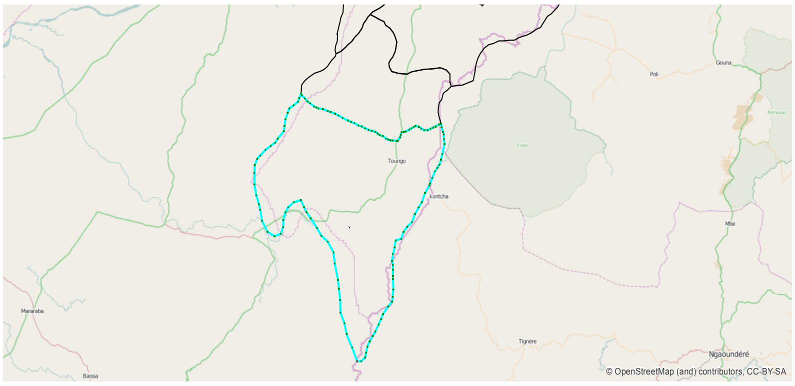
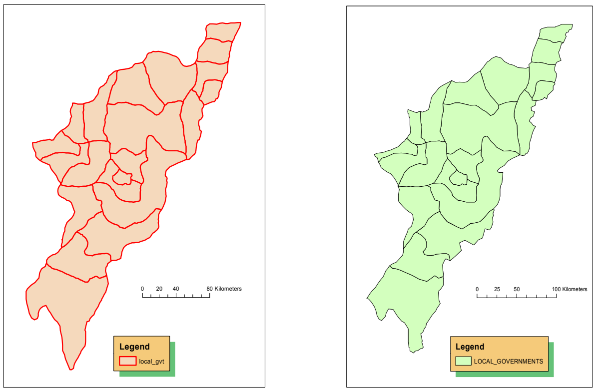


Figure 5: Editor Tool points shown in light green

5. Results

The result of the digitizing and editing of the Adamawa state base map on the ArcGIS 10.1 and OSM respectively is shown in figures 6a and 6b; two identical but different shaped maps are presented. Figure 6a shows the original shape of the base map used as digitized on the ArcGIS 10.1, while figure 6b shows the edited version of the base map synchronized with the OSM. It is clearly seen that the two maps look identical, appearing similarly shaped, when critically observed, the southernmost part of the map and some portion of the North Western part of the map have different shapes.



(a) (b)

Figure 6: The digitized base map is sown in (a), while the OSM synchronized (edited) map is shown in (b)

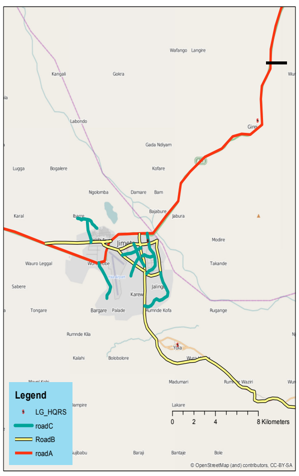


Figure 7: Digitized OSM road network for trunks A, B and C roads in Adamawa state

Test for location accuracy was carried out on the two maps to assess its reliability; this was done by

Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.11, 2014

superimposing the OSM edited map (figure 5b) on the originally digitized base map (figure 5a) and the road network (figure 7). This showed the change in size and shape indicative of the decrease or increase in the area of the state (figure 8).

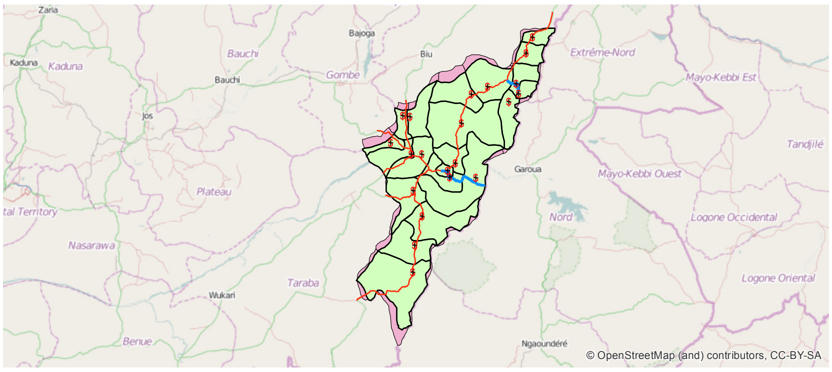


Figure 8: OSM edited map superimposed on digitized original map

The uncovered pink color indicates the extent to which the Adamawa state map has been blown out of proportion compared with that of the OSM.

6. Discussion

The result obtained above shows clearly that the question of the accuracy, standard and reliability of the base map used by Adamawa state for spatial information reference can be conveniently challenged by this study based on the OSM standard. The increase in the shape of any spatial object in whichever direction is tantamount to increase or change in the coordinates of the spatial object. It can be clearly seen in figure 8 that there is a disproportionate increase in the size of the southernmost part of the state (Toungo). Significant encroachments into neighboring states of Gombe and Borno also occurred on the North Western part of the state (Lamurde, Guyuk, Shelleng, Gombi and Hong).

The issue of boundary disputes among the three states is however played down, because it is an internal issue. The Eastern part does not show any significant boundary alignment problem, perhaps, because it is an international boundary between Nigeria and the Republic of Cameroun.

5.1 Suggested Model

The maintenance of standard for map exchange and sharing, either in the analogue or digital formats is an imperative factor in spatial interoperability. Spatial information interoperability is very vital for modern spatial information management, especially in the developing SDIs like Nigeria. The opportunities provided by the OSM should be exploited and adopted. This is very imperative at this critical point in time that the ADGIS is undergoing digital conversion and transformation of spatial data in the state. This would afford to provide the same reference frame with other states currently undergoing similar transformation, where checks could be made on a larger Nigeria map (Figure 9) for boundary excesses.

The ADGIS should as matter of priority establish a Web Compliance department to handle issues of digital data in compliance with OSM.

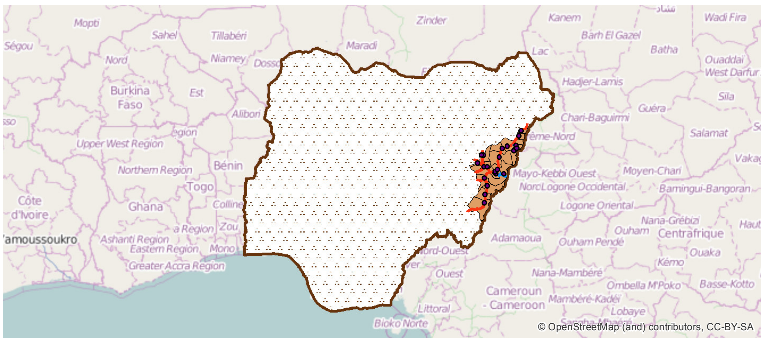


Figure 9: Map of Adamawa State on a larger Nigeria OSM

7. Conclusion

This study highlights on the assessment of the reliability of base maps for web compliance used for spatial information management in various jurisdiction based on the OSM standards. The case of Adamawa state in

Nigeria was the highlight of the study. Contemporary issues in spatial information technology as it relates to OSM form the basis for discussion, and highlight the current importance given to the OSM friendly environment. It stressed its importance in quest for the fulfilment of the vision of the digital earth notion started by Al Gore in 1998. The study applied the notion of the OSM to Adamawa state in Nigeria as its case, its importance relates to the current move in the country, both at the nation and states levels for functional spatial information management systems to cater for growing needs of the people for the documentation of land and its related resources. In this study, the analogue map of Adamawa state, which is the base map for all administrative dealings with regards to spatial data management was scanned, georeferenced and digitized on the ArcGIS 10.1. Local government headquarters and road network were used as tie points to check for in-situ on the digitized map. To ascertain its web compliance, the digitized map was added or superimposed on the OSM of the WGS 1984 Universal Transverse Mercator web auxiliary sphere. Editing to obtain the original size and shape based on the OSM was done on the web. Two similar but differently sized and shaped maps were obtained, these are, the digitized original map and the OSM synchronized map. It was discovered that the size and shape of the map used as the base map for the state was in glare contrast to the OSM. In order to curtail these differences and to maintain standard across the states, it is suggested that the OSM standard should be adopted as a model for transformation.

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