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Research article

MAPPING AND ASSESSMENT OF FACILITIES USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM (GIS) TECHNIQUES IN LANGTANG NORTH L.G.A. OF PLATEAU STATE, NIGERIA.

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Abstract

The concept of digital mapping is a well-known technique that has brought a lot of changes in the cartographic industry today. This project produced a digital map of the existing and proposed facilities / utility services in Langtang North metropolis of plateau state. A spatial database of these facilities and utility services was also created using ESRI'S ARCMAP 10 Software. The Ikonos satellite image served as a base map showing all the facilities that were visible and could be recognized. Various layers of the segment maps were obtained. These were the Road network, River and main Water pipeline. Other facilities were mapped as point maps they are: Telecommunication masts, Boreholes, Transformer stations, Petrol and Gas filling stations, Health care institutions and Recreational centers. Some facilities services required upgrading and expansion, The Borehole located in Tabbat central and the Ponzhi Tarok palace motorized borehole. The NTA/ TV community station located at Zangzat, the MTEL/ NITEL in Tabbat and the Langtang Mini stadium needed upgrading and expansion as a result of the deplorable state of facilities presently. The transformer located at the hospital junction is not meeting the required service delivery because of the problem of overload. Adequate recommendations were also made based on the study results.

Key words: facilities mapping (FM), GIS, utilities.

1.0 Introduction

Facilities Mapping (FM) is the process of digitally identifying and mapping facilities infrastructure with the explicit goal to improve operational management and planning tasks such as dispatching, inventorying, and maintenance (EWG, 2010). Some examples of facilities include utilities (i.e. gas, water, telephone, and electricity), airport siting, and transportation planning. Facilities as used in this paper, however, refer to all man-made structures or other improvements whose function, size, service area, or uniqueness give them the potential to improve the well-being of the people without disruption of vital socioeconomic activities.

Decision makers require timely, reliable information regarding the availability and state of facilities in their domain. Not only will they require quality baseline information on the way the facility are functioning, there is also need to get regular updates from time to time so as to be able to monitor funds expended on the facilities. The ability to generate futuristic models of these facilities in order to have a clear vision of what expenditures are expected to achieve, and also to analyze the effect of various environmental factors on these facilities, in order to anticipate impending problems; are some of the desires of decision makers that were formerly viewed as being in the realm of science fiction.

The GIS has now become known for being an efficient and powerful decision making tool capable of handling the different scenarios stated in the preceding paragraph (Kaundinya & Bagati, 1998; Rita Davies, 2010). The spatial resolution of satellite data used with the GIS had continued to improve significantly over the years. In the early nineties SPOT‘s panchromatic band (10m) used to be the ultimate. Since then, SpaceImaging in 1999 launched IKONOS with a panchromatic band of 1m. By 2003 ORBIMAGE launch Orb-View, which also had a panchromatic band of 1m. Two years after IKONOS, DigitalGlobe launched QuickBird with a panchromatic band of 0.6m. With Geoeye’s plans to launch yet another satellite with a resolution of 0.4m (Jensen, 2007), the sky is the limit for satellite technology. It is this kind of significant improvements in the spatial resolutions of satellite images that have made it possible for the GIS to provide needed information with a remarkable degree of details.

Unfortunately, in Nigeria, lip service is still being paid to GIS based facility mapping. Majority of government agencies still rely on ground surveys and analogue maps. In the few cases where facility maps were created using the GIS e.g. in the case of Musa & Tukur, 2006, once the maps were printed, the function of computers reverted back to word processing. The only evidence that such a project had ever been carried out, are the map albums decorating some of the offices. It therefore didn’t come as a surprise when it was discovered that many of the government agencies in the study area were in possession of analogue maps that were in deplorable state. Some of them were so bad that they could not be traced. The Plateau State Ministry of Survey and Planning, was expected to be at the forefront of other government agencies in the use of digital mapping techniques. However, they were found instead to be using ground surveys techniques and analogue maps. The only available information on water facilities now is a sketch plan of water pipeline network of Langtang which was produced by a construction company -Julius Berger Nigeria plc in 1982 when the Langtang dam was first constructed. The electricity company of Nigeria (Power Holdings Cooperation of Nigeria - PHCN) claims to have a plan showing the electricity distribution network of the study area. Unfortunately, this map cannot be

located. The loss cannot be unconnected with the way the maps were stored. Maps on other facilities like education and health can at best be described as glorified sketches with no meaningful information decipherable in them. It is the desire to address such problems and also to demonstrate the effectiveness of facilities mapping that this paper intends to:

- Show the locations of these facilities/ utility services on a digital map.
- Identify facilities that may require upgrading and expansion.
- Carry out an assessment of facilities/ utility services in the metropolis.

Different kind of facilities have been successfully mapped digitally in a time effective and cost efficient manner. Analyses made from such maps have helped in proper planning and management of the facility. Abbas et al (2012) investigated the spatial distribution of healthcare centres in Chikum local government area of Kaduna State Nigeria using the GIS and GPS. The study then used the WHO criteria for the location of health care centres in developing countries, to propose nine new sites for the location of new health care centres to adequately cover the health needs of the people of the study area. Similar health facility mapping has been carried out also in India (Gambhir & Rodnuguez, 2013) and Nepal (DHS, 2010). Other facilities that have been successfully mapped include cultural facilities (Rita Davies, 2010); Oil and Gas Pipeline **(**PRLog, 2009); refuse disposal facilities (Musa, 2012) and telecommunications (Edan et al, 2013).

2.0 Study Area

Plateau state is one of the 31 administrative units covering Nigeria. Langtang north LGA is located in lowland region of Plateau state. Langtang north is one of the 17 Local Government Areas of Plateau State, it is located in the southern zone of the state it lies between the 9^0 06' 16.33'' and 9^0 10' 33.78'' N latitudes and 9° 45' 18.70" and 9^0 49' 40.35" E longitudes and it spreads over an area of 2,476 km². It is situated close to the mountain range from the Jos Highland on the west. Langtang north LGA has an altitude range of 500 to 1000m above mean sea level, the climate is semi-arid with maximum rainfall in the month of August (296 mm), October to December are dry. While the hottest months are March and April with temperatures reaching 38°C, the coolest time is at the end of December and early January, when temperatures fall to 18°C. In 1991, the total population of Langtang north was nearly 98,876 people, which kept on increasing slowly having a rise in population as recorded in the most recent time's 2006 census as 111,148 people. In Langtang north about 79.5% of households have electricity connections and 53.4% water facilities (Economic Survey of Plateau, 2000).Bounded by Kanke , Mikang, Wase, and Langtang south GAs in the north, west, east and south respectively. Langtang north LGA is predominated by the indigenes known as Taroh.

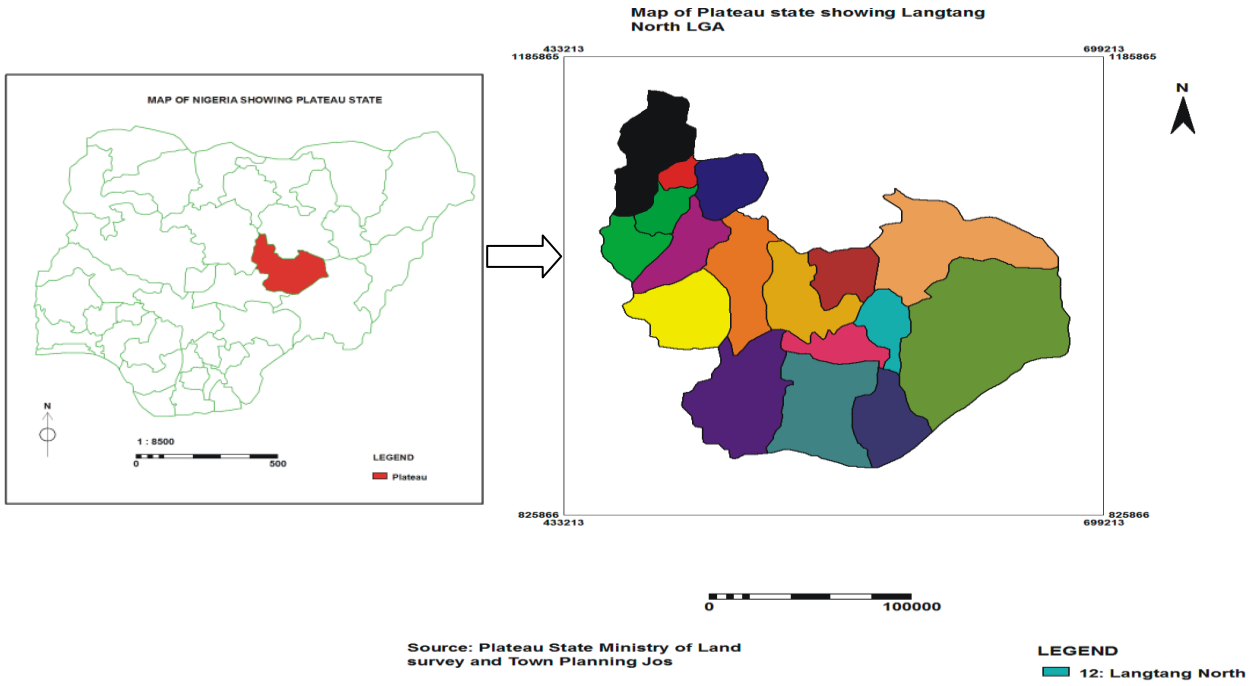

Figure 1: Map of Plateau state showing Langtang North LGA

3.0 Methodology

3.1 Materials

The hardware used consisted of a Toshiba Laptop computer with 2.00 GB of RAM and 320 GB HARD disk; a Garmin Hand held Global positioning system (Etrex HCx series) and Hewlett Packard 710c desk jet printer. Four different software packages were also used - ITC's ILWIS 3.3, ESRI's ArcMap 10, Microsoft Excel 2010 and Corel Corporation's CorelDraw x3.

The data used include data obtained from the GPS and IKONOS satellite image (1m spatial resolution) acquired in October 2010. Analog map of Plateau state showing the local government areas were also used to depict the study area.

3.2 Mapping the Facilities:

Mapping and assessment of facilities used the tripartite technologies of Remote Sensing, GIS and GPS. Figure 2 describes the general frame work of the methodology.

Most of the facilities mapped were extracted from the IKONOS image of study area. The IKONOS satellite image was first printed in A3 paper and taken to the field for ground truthing. Objects too small to be identified by the image were picked by the GPS. The IKONOS image was imported into the GIS. Each of the

facilities was digitized into separate vector layers. The facilities mapped include road network, rivers, water pipelines, filling stations, healthcare institutions, educational institutions, boreholes, transformers, communication masts and recreational centres. For each layer of spatial data, related attribute tables were linked to it to capture all attribute data in an efficient manner. Attribute data included the state of disrepair of such facilities and the year of last renovation. This was done with the aim of later isolating facilities performing at optimal level from those that are not at optimal performance.

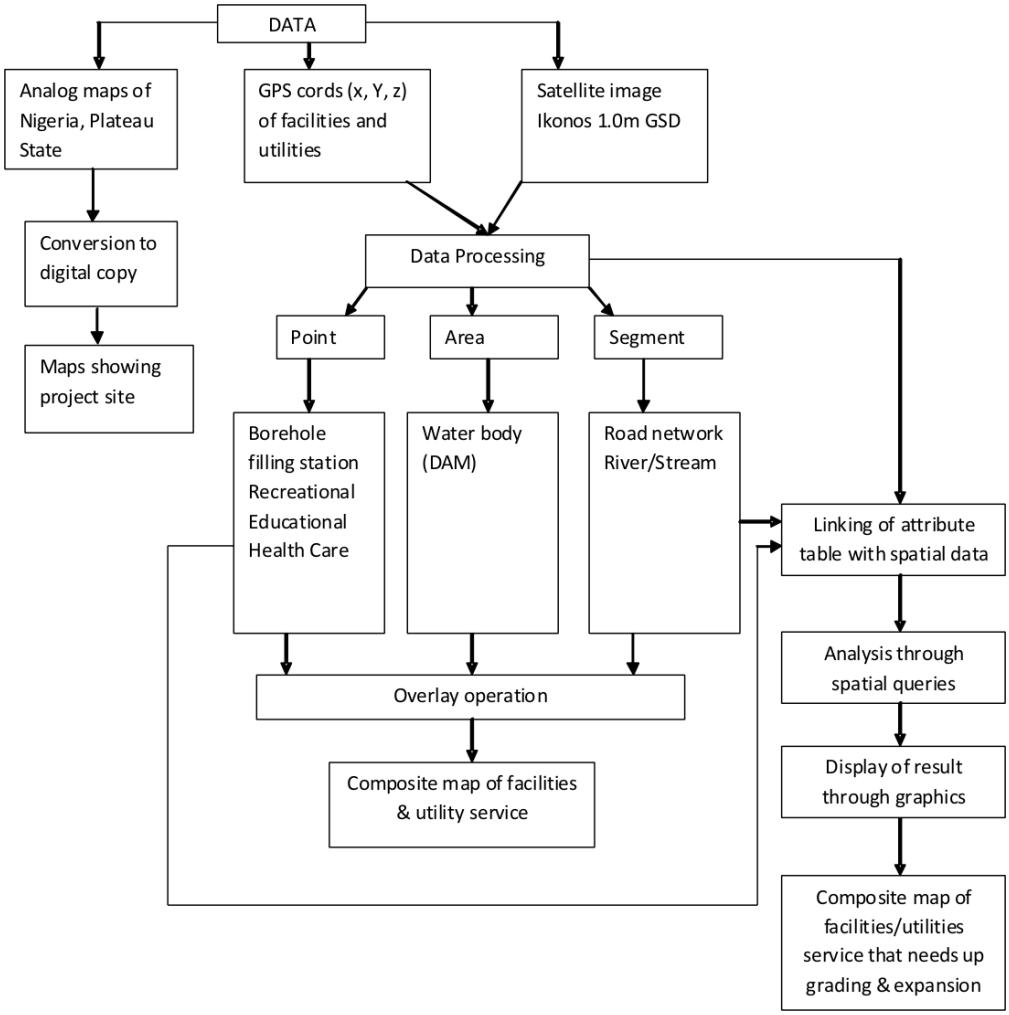

Figure 2: Framework of methodology in form of flow chart.

3.3 Identification & Assessment of Degraded Facilities:

With the help of relevant queries, facilities that require upgrading and renovation were isolated from other facilities. Some of the specific queries made include:

- Show all boreholes that are not functioning.
- Show recreational facilities with restaurant services.
- Show all the non-functioning telecom masts.

The queried facilities were overlaid on the satellite image in order to make comparisons between the queried facilities and other features in the satellite image Fig 3. Analysis included comparing both facilities in disrepair and optimal facilities with the number of houses it's expected to serve. This kind of comparison revealed facilities that also required expansion. In other cases, like in the case of boreholes and water pipeline, service area analysis were conducted in order to ascertain buildings that fall within and those that fall outside service areas of the facility. In areas where upgrading and expansion is considered necessary, the costs of such expansion, in terms of number of houses that will have to be destroyed, were analyzed.

4.0 Results and discussion:

The added flexibility that the GIS gives a user so as to be able to query and manipulate the digital map in such a way as to display information based on its associated attribute data has again been demonstrated in this paper Fig 4 & Fig 5. The results of spatial queries revealed the facilities needing upgrading. Examples of such facilities include some of the hand pump boreholes located in Tabbat Kogi which are currently not functioning. Some of the telecommunication masts are also not functioning. The Langtang mini stadium is one of the numerous recreational centres for sporting activities.

An assessment of the water pipeline network against the backdrop of the satellite image clearly shows that the water pipeline requires expansion Fig 6. This is because a lot of development had taken place since the water pipeline was laid in 1982. The main arterial water pipelines in the city are made of 300 mm diameter steel pipelines and are split into only two branches. One branch has its source at the pumping station Zangzat and runs along the major road known as Solomon Lar way to terminate at one of the most populated ward in the metropolis – Pajat. Pajat itself has expanded well beyond the termination point of this pipeline, thus rendering a great number of people left without pipe borne water. The other arterial branch was laid from Police station junction through Datyem Street, Stadium Rd and terminates at the end of Igbinedion Street in pajat ward linking Wase road. Another was laid along J.T Useini Street to terminate at Aliyu Kama road. From these arterial pipelines, 50mm water pipes are used to convey pipe borne water into the various houses. Spatial analysis conducted revealed that these secondary pipelines have to traverse very long distances before water could be delivered to some houses. In some instances distances could reach 500m or more. Since the 50mm pipes are not designed for these types of long distances, it is not surprising that the pipes get frequently broken and in some cases blocked, thus cutting off water supply completely. Where they function properly, the share number of people depending on the pipe does not match the quantity of water flowing from it, causing a lot of hardship. This is the situation experienced in places like new market road, Eastern bye pass, Western bye pass, Hospital road and Wase road.

To avoid this type of scenario, the best solution is a proper design of the water pipeline network using a three tier system consisting of the arterial pipes, the secondary pipes and the tertiary pipes. The present arterial pipes should be extended to the outskirts of the city. The secondary pipes should consists of pipes much bigger than the 50mm pipes presently available, preferably 200mm pipes, while the tertiary pipes should consist of the present 50mm pipes. The network design should ensure that the secondary pipes reach areas that are presently

not serviced by the arterial pipes. If the design is properly done, none of the tertiary pipes should be more than 50m.

There is no doubt that the study area has a well developed network of roads Fig 7 However, the unseen problem therein is the condition of the roads. For instance, Stadium road is in such a deplorable state that farming activities has taken over from where the road used to be. Rather than follow Stadium road, motorists now follow Hospital road thereby overloading the latter with traffic. Other roads that were noted to require expansion and upgrade if smooth flowing traffic is desirable are Hospital Rd, Eastern Bye-Pass, J.T. Useini Street and Western Bye-Pass. The ability to document the varying conditions of these roads and rank them into various levels of deterioration, without unnecessarily overcrowding the facility map with too much information was observed to be an added advantage when working with the GIS. This will allow policy makers prioritize resources for repair and maintenance in an unbiased manner. However, the ability to perform network analysis on any of the facility networks (roads, pipeline, and power lines e.tc.) has made it an indispensible tool for planning and management.

The digital map revealed that most of the educational institutions in the metropolis are privately owned. Very few public schools were seen scattered about the study area Fig 8. This result actually tallied with the reality on ground. Despite the few numbers of public schools, it is interesting to note that most of the educational institutions needing renovation are publicly owned. Though government had tried in the past couple of years to renovate the class rooms and provide toilet facilities, the general picture displayed in the facilities map, exposed government's inadequacy and uncovered the magnitude of energy and resources that is still needed to bring the public schools back to desirable level.

Other facilities worthy of note include health care facilities and bore holes. The only available public health care services are the General hospital and the primary health care center. On the other hand nine private health centers are available. In terms of infrastructural development, it is acceptable to give the public health care centers credit because of the improvements in health care services delivery. In the metropolis, about 98% of the boreholes are hand pumps and 2% are motorized Fig 9. This generally slows down efficient service delivery and makes it inefficient. Most of these hand pumps are always over used due to population pressure. This has resulted in cases of breakdown of the pumps and drying up of water in the boreholes. This has been the practice in some areas of the metropolis like Yangang along Keffi Street, Tabbat behind NITEL and Tabbat (General hospital).

5.0 Conclusion

The need to get updated, accurate information about facilities in a metropolis has made facility mapping a sine qua non to the efficient development of urban facilities. This paper used remote sensing (RS), geographic information system (GIS) and global positioning system (GPS) technologies to created digital maps of the facilities in the study area. The remote sensing data eliminated the drudgery associated with carrying out ground survey. The cartographic superiority of the GIS over other methods of map design coupled with its analyzing power made it possible to document almost all needed information about the facilities including year of construction, state of disrepair etc. While remote sensing captured most of the details required, some were too

small to be captured. The GPS became very handy in such situation. It was observed that though most of the facilities were either obsolete, inadequate or in various states of disrepair, the facilities managed by government are worst. This brings to fore the question of government privatizing the facilities.

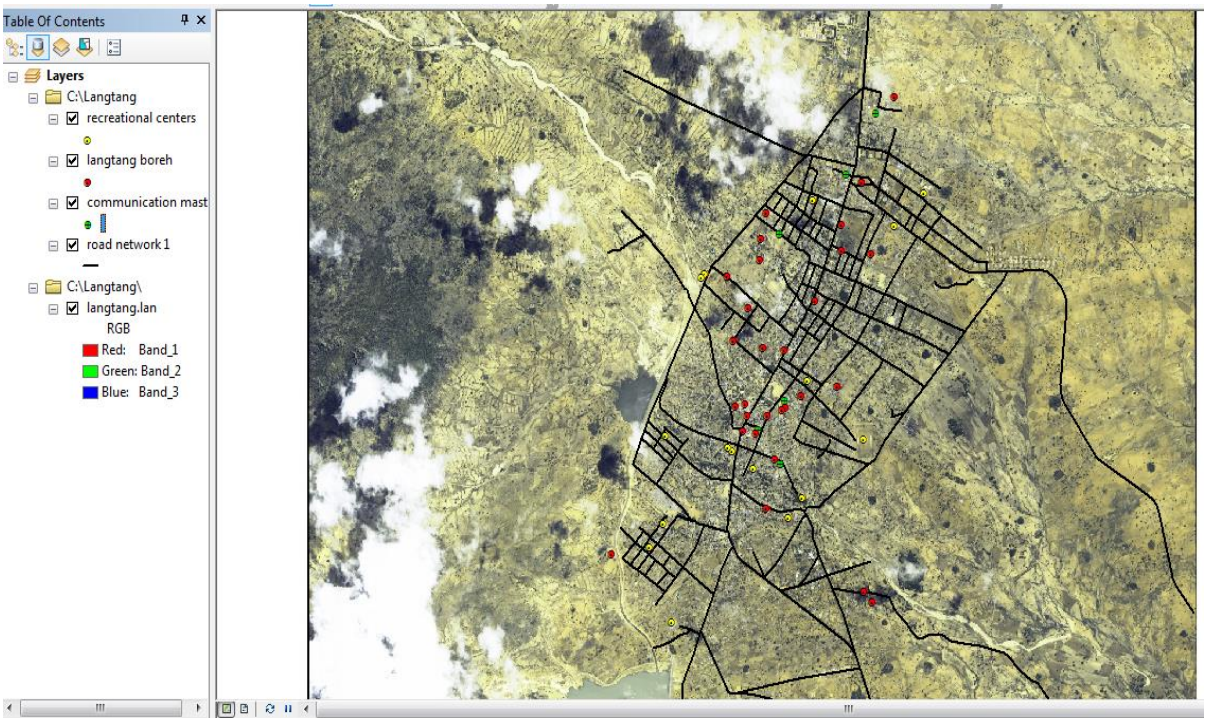

Fig. 3: Showing Boreholes, Recreational and Telecom facilities overlaid on Satellite image

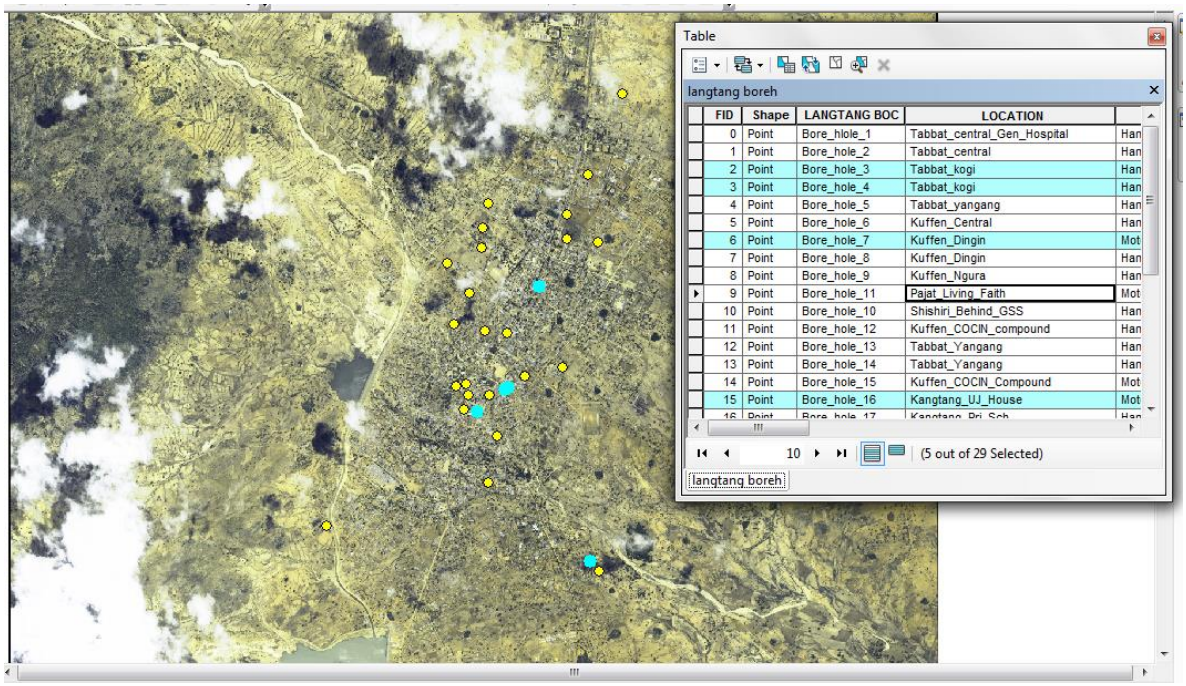

Fig. 4: Showing Query result on boreholes

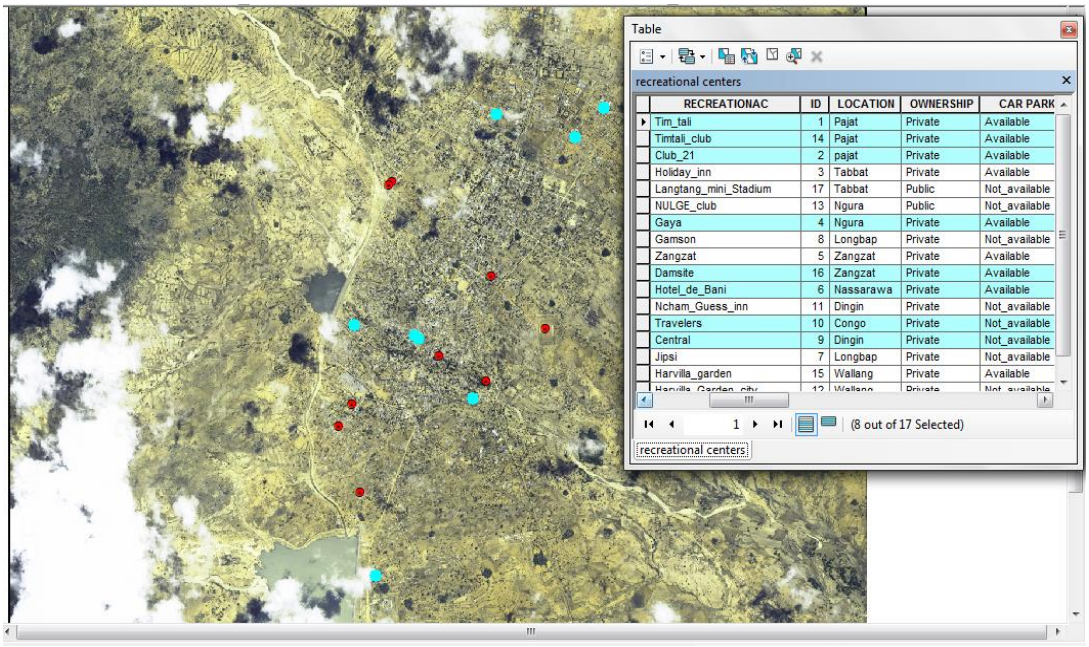

Fig. 5: Showing Query result on Recreational centers

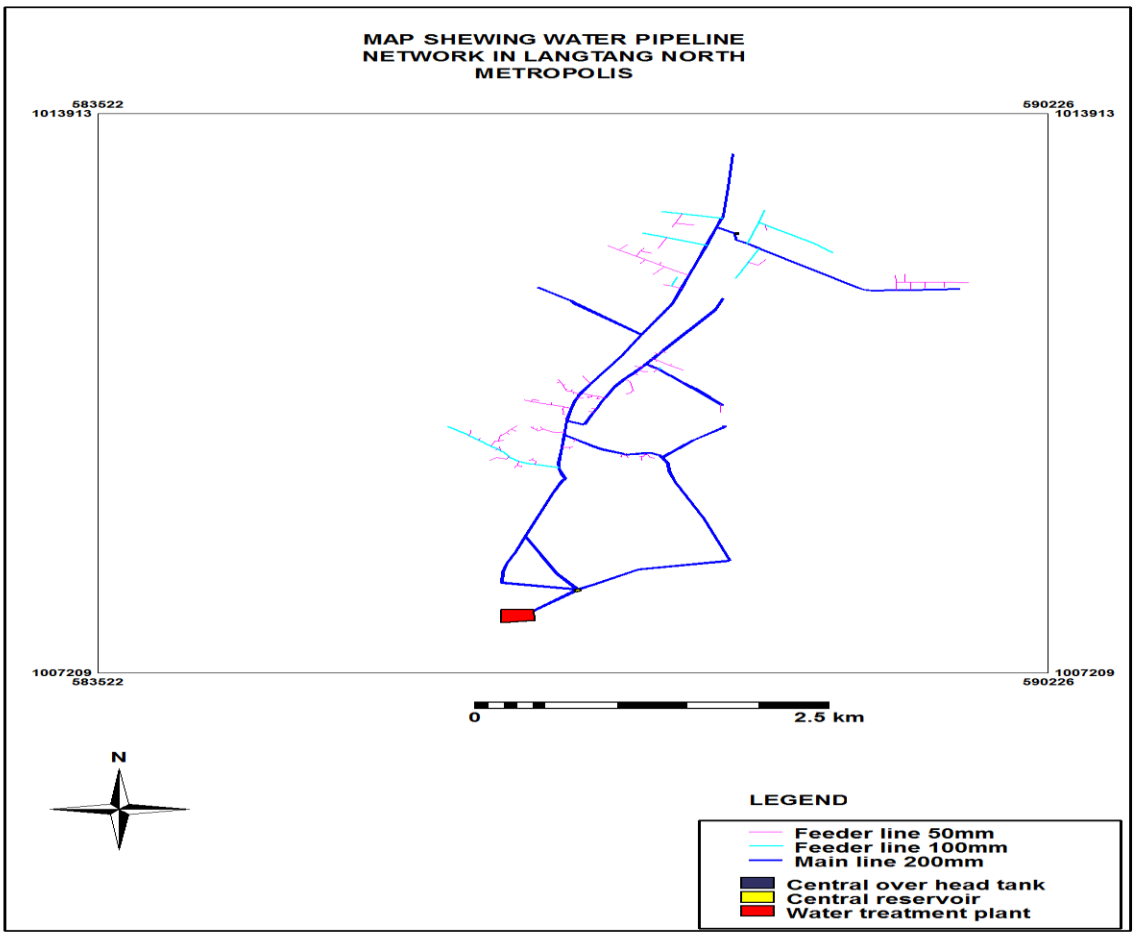

Fig. 6: Showing water pipeline network

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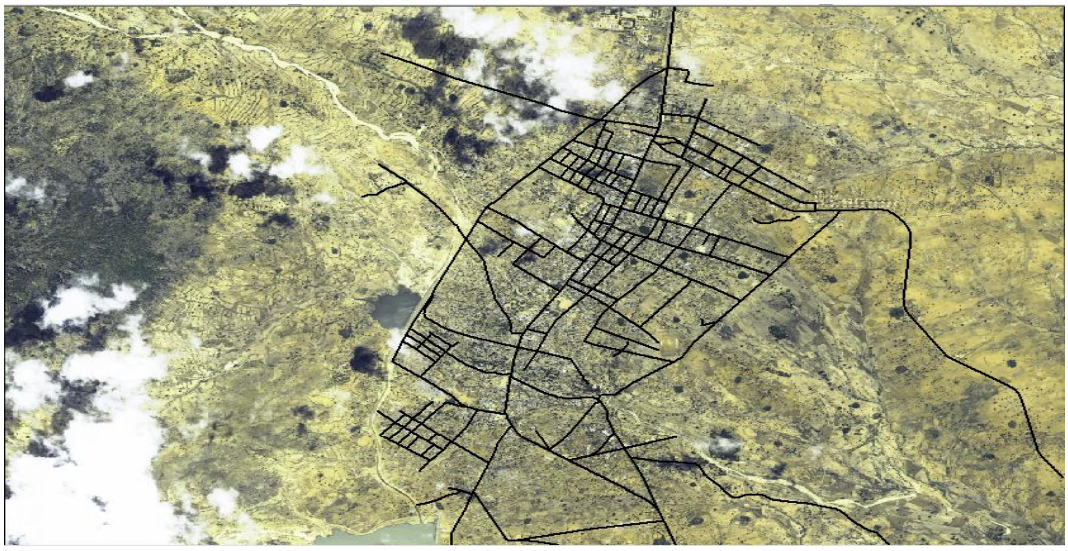


Fig. 7: Showing Road network

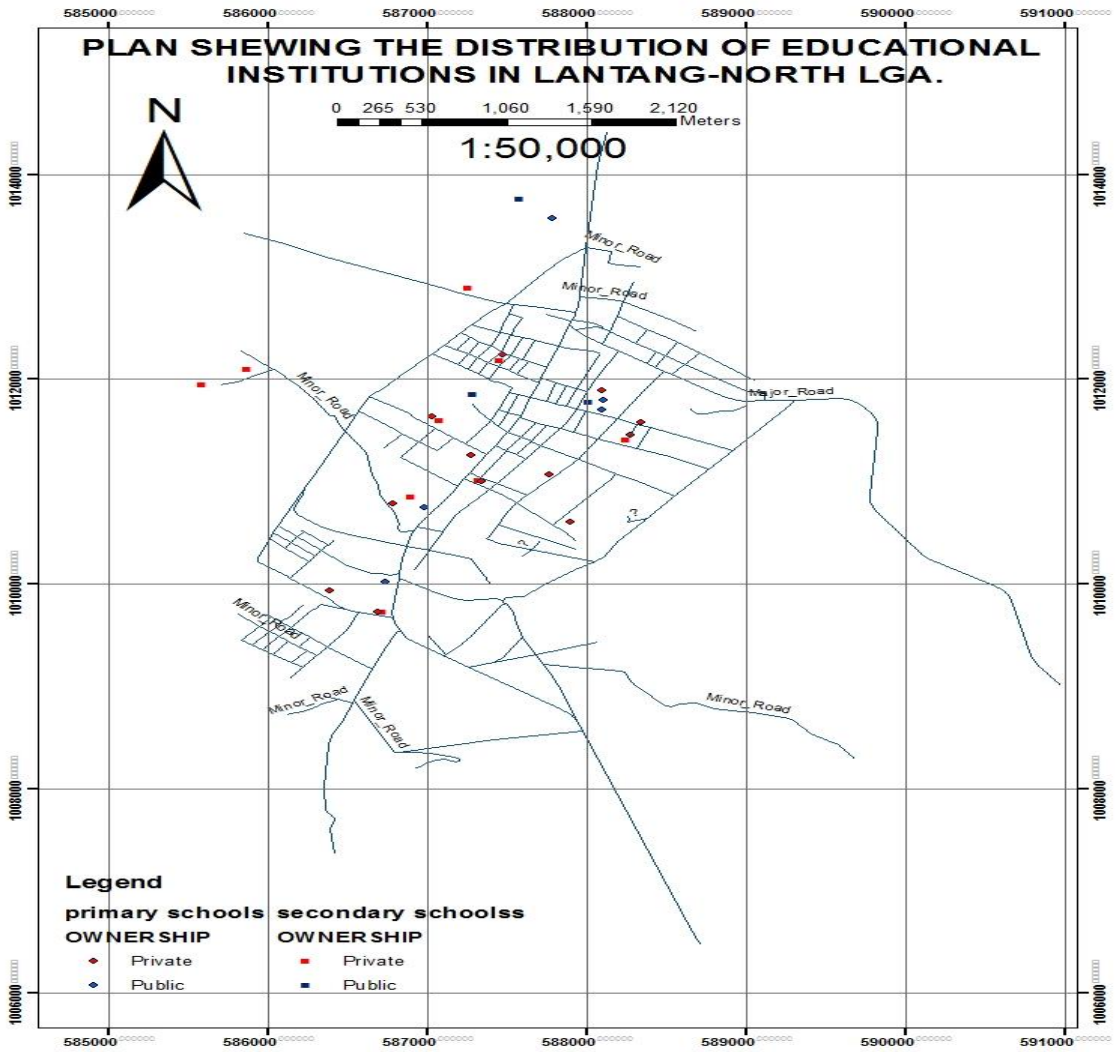
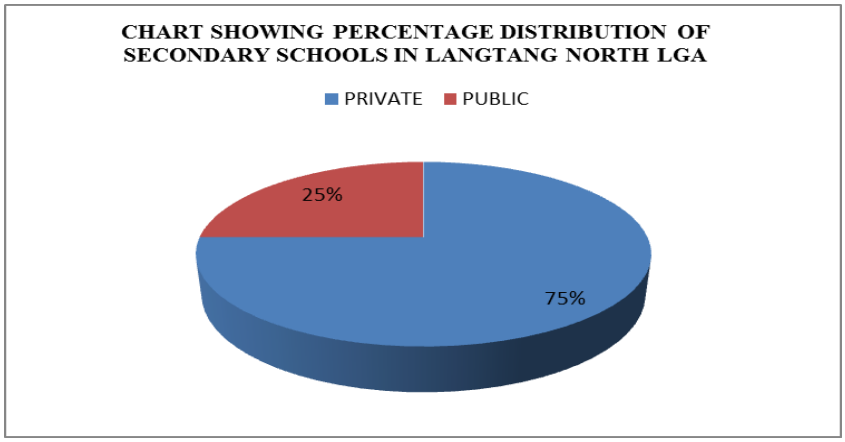
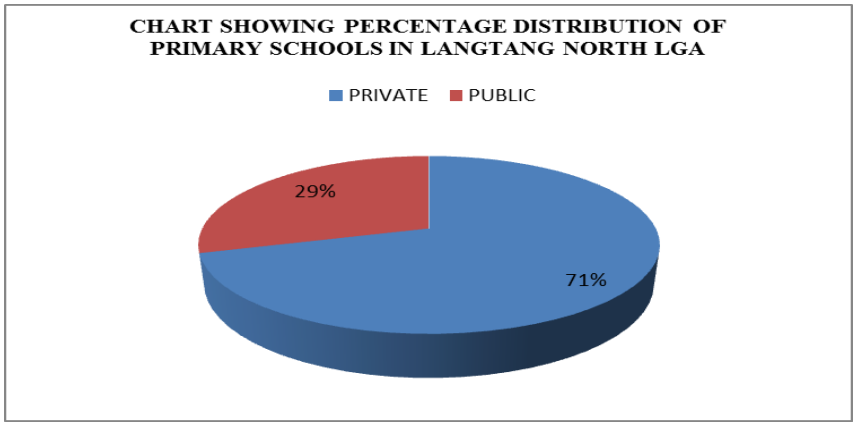


Fig. 8: showing the distribution of Educational institutions





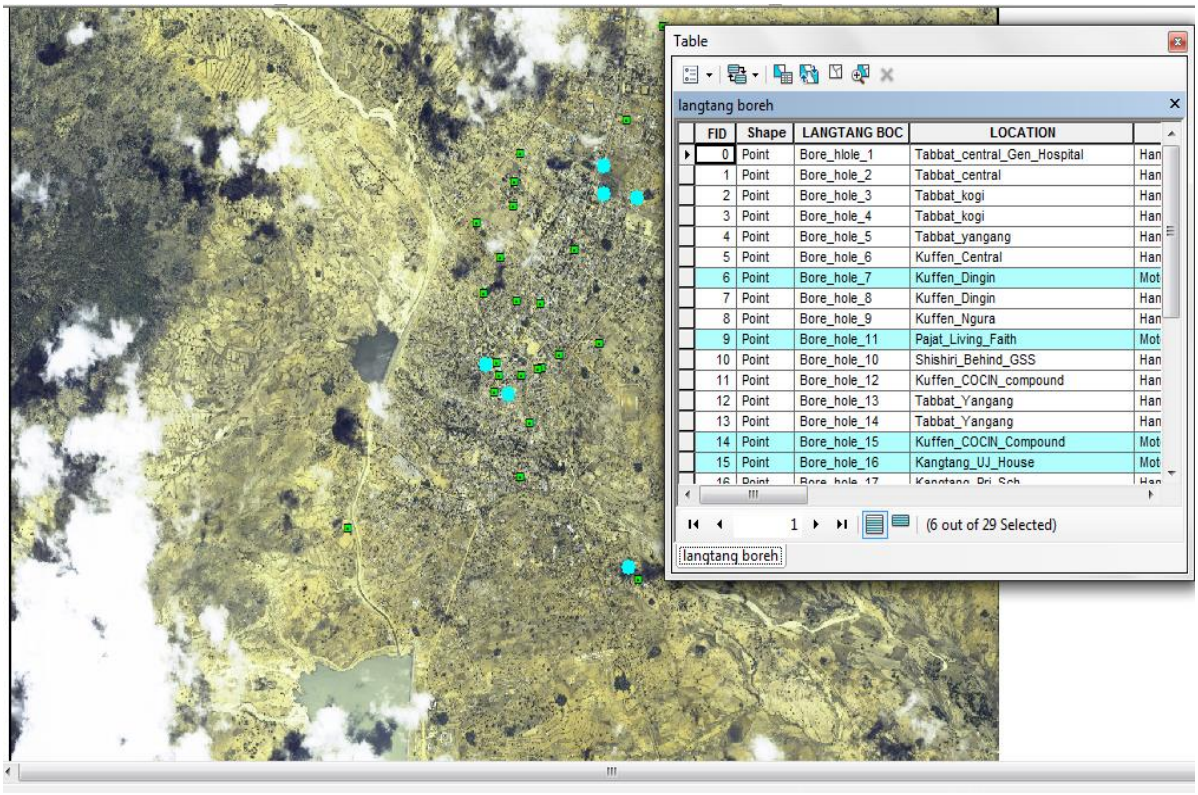


Fig. 9: Showing hand pump and motorized boreholes

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iv. Other relevant authorities that we could not mentioned

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