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THE IMPACT OF URBANIZATION ON TROPICAL WATERSHED HYDROLOGY IN WUSHISHI USING REMOTE SENSING TECHNIQUES

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ABSTRACT

Future population growth and the corresponding increase in development in the Wushishi. Watersheds are widely recognized as major threats to the integrity of watersheds worldwide. The potential impacts associated with the expansion of developed land, and specifically with increasing amounts of impervious surfaces – rooftops, sidewalks, roads, and parking lots -may include significant changes in water quantity, degradation in water quality, and habitat loss. Because asphalt, concrete, stone, and other impenetrable materials effectively seal the ground surface, water is repelled and is prevented from infiltrating soils. Instead, storm water runoff flows directly into our surface waters, depositing metals, excess nutrients, organics, and other pollutants into the receiving bodies. In addition to these environmental impacts, increasing levels of imperviousness can dramatically alter our landscapes, as forested and other natural settings are converted to urban/suburban uses. The primary goals of this project were to provide an accurate, current description of the extent of impervious surface coverage in this region, as well as an estimate of change in the amount of "imperviousness" over a 14 year period (from 1987 to 2009). A detailed Characterization of the watershed was also conducted. Geospatial technologies provide effective tools to map and quantify impervious surfaces, and to monitor changes over time. Moderate resolution Land sat Thematic Mapper (TM) satellite Imagery, as well as an image processing GIS software, was utilized to estimate amounts of Imperviousness at relatively modest cost, thereby providing a mechanism for subsequently Measuring "imperviousness" at frequent, repeated intervals. Resource managers and other Professionals may effectively utilize the resulting data as they develop watershed Management plans and tools.

INTRODUCTION

The term watershed refers to the geographic boundaries of a particular water body, its ecosystem and the land that drains into it. A watershed also includes groundwater aquifers that discharge to and receive discharge from streams, wetlands, ponds and lakes. Large watersheds are sometimes referred to as river basins. Simply put, a watershed is all the land area that drains to a given body of water. We all live in a watershed and are part of the watershed community just like animals, birds, and fish are also living in water shed. We influence what happens in our watershed, good or bad, by how we treat the natural resources - the soil, water, air, plants, and animals. What happens in our small watershed also affects the larger watershed downstream (Anderson, 1976).

Depending on where we live, we cross quite a few brooks, creeks, runs, branches, gulches, arroyos, bayous, ditches, or channels as we drive to work each day. Each stream we cross is part of a massive network of streams that drain to the rivers and, ultimately, to the sea. Each stream has its own watershed that circumscribes all of the land that drains to the point where we cross it. Collectively, these small watersheds provide critical natural services that sustain or enrich our daily lives: they supply our drinking water, critical habitat for plants and animals, areas of natural beauty, and urbanization, the conversion of other types of land to uses associated with the growth of population and economy, is a significant land-use and land-cover change especially in recent human history.

Urbanization often has more severe hydrologic effects than other man-made agents of change, as watershed vegetation are replaced with impervious surfaces in the form of paved roads and parking lots. The expansion of Impervious cover is intricately correlated with water conditions and so is an indicator of overall ecosystem health and water quality; in that it influences hydrology (e.g., an increase in imperviousness is directly related to increase in the volume and velocity of runoff), stream habitat (e.g., the hydrological impacts of increased imperviousness lead to increased stream bank erosion, loss of riparian habitat, and

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degradation of in-stream habitat), chemical water quality (e.g., increases in imperviousness and runoff directly affect the transport of non-point source pollutants including pathogens, nutrients, toxic contaminants, and sediment), and biological water-quality (e.g., all the above changes have an adverse impact on the diversity of in-stream fauna) (Schueler, 1994; Arnold and Gibbons, 1996).
These effects are compounded by channelization of small streams and use of storm sewers designed for rapid downstream transport of drainage waters, both of which are intended as flood control measures but in fact can contribute to rapid water rise and flooding downstream, often still within the urban area. There is a direct relationship between urbanization (i.e. % watershed imperviousness) and the number of bank full flows occurring annually (Leopold 1968).

PROBLEM STATEMENT

Urban areas in the Wushishi watershed have greatly expanded over the past 10 years such that if current trends continue, they may expand by more than 10% over the coming 10 years. The conversion of forests and farmlands to urban land uses poses a threat to terrestrial and aquatic habitats, air and water quality, and the economic sustainability of the region. This rapid pace of land development has exerted great pressures on water resources such that in certain areas has caused environmental problems due to increased runoff of sediment associated with clearing of forest and natural vegetation and urbanization resulting in surface water pollution from point and non-point sources pollution, underground water pollution, and silting of reservoirs. Regardless of region, the underlying cause of threats to watershed quality and health is usually the same: watershed development. Current or future watershed development has been implicated as a prime threat to the current biodiversity in the region. This threat is magnified if future development is poorly planned, dispersed and fragmented; characteristics typically associated with urban sprawl.

AIM AND OBJECTIVES

The aim of this research work will be to determine the tropical water shed hydrology of wushishi area and the natural vegetation in the study area. The following below are the objectives.

- To create a land use, land pattern of the study area using different satellite way of three different seasons.
- To show the land use changing's in the study area.
- To show how the organization affect natural vegetation and to recommend the possible solution.

JUSTIFICATION

Urban environmental problems are threats to people's present or future well-being, resulting from human-induced damage to the physical environment, originating in or borne into urban areas. And when environmentalists talk of the benefits of environmental improvement, they are usually referring to improvements to people's quality of life that can come from addressing these problems.
This great challenge of managing our ecological resources in sustainable ways has necessitated the use of Geospatial technologies that provide comprehensive, synoptic, multi resolution and multi temporal coverage of large areas in real time and at frequent intervals that is vital for continuous surveillance of the watershed areas. Therefore understanding the degree and location of impervious surfaces and limiting the amount of impervious surface in a watershed is an important component of overall watershed management. Natural resource and land use managers need to be able to determine the existing percent imperviousness for an area in order to develop appropriate watershed management and/or Non-Point Source (NPS) mitigation plans and to understand the link between water quality and impervious surfaces (Hood, 2003).

DESCRIPTION OF DATA AND METHOD OF ANALYSIS

DATA COLLECTION

Four moderate resolution Landsat imageries is acquired for this study from Global Land Cover Facility (GLCF) website. This will include Landsat Imagery of 1994, Land TM of 2000, and Nigeria Sat 1 2007 covering the study area (Wushishi). Each image was imported into the IMAGINE (.img) file type from tiff format for further processing. Population figure was collected from National Population Commission.

DESCRIPTION OF DATA

The four sets of data used for this research are Landsat Imagery covering the Study area at a scale of 1:2500, spatial resolution 30m, with spectral bands of 7, and with swath width of 185km. Landsat Enhanced Thematic Mapper (ETM) was also obtained from Global Land Cover Facility on the internet. The Landsat ETM satellite has seven (7) bands like the Landsat TM but carries an additional panchromatic band. Landsat

ETM has a spatial resolution of 30m and the panchromatic band has a 15m spatial resolution. The ETM has a temporal resolution of 16 days.

Table 1.1: The Wavebands of land sat ETM

BANDS	WAVELENGTH (UM)	SPECTRAL LOCATION
1	0.45 0.52	Blue
2	0.52 0.60	Green
3	0.63 0.69	Red
4	0.76 0.90	NR
5	1.55 1.25	MR
6	10.4 12.5	Far
7	2.08 2.35	IR
8	0.52 0.90	panchromatic

REFERENCING

Handling spatial information requires the establishment of a *spatial reference system* to which all spatial measurements must relate. The primary function of the map is to portray accurately real-world features that occur on the curved surface of the earth. Geographic referencing, which is sometimes simply called *geo-referencing,* is defined as the representation of the location of real world features within the spatial framework by which the positions of real-world features are measured, computed, recorded and analyzed. In practice, geo-referencing can be seen as a series of concepts and techniques that progressively transform measurements carried out on the irregular surface of the earth to the flat surface of a map, and make it easily and readily measurable on this flat surface by means of a coordinate system. Map data are different from all other forms of data by this characteristic of geo-referencing and, the ability to manipulate and analyze geo-referenced spatial data is what distinguishes GIS from CAD and other types of computer graphics systems.

IMAGE ENHANCEMENT

Regardless of the extent of digital intervention, visual analysis invariably plays a very strong role in all aspects of remote sensing. While the range of image enhancement is broad; as earlier mentioned, filtering and contrast stretch where the major image enhancement techniques performed on the image in other to remove haze and cloud.

SOFTWARE USED

Basically, five software's were used for this project viz;

(a) Arc View 3.2a – this was used for displaying and subsequent processing and enhancement of t image. It was also used for the carving out of Minna region from the whole Niger State imagery using both t admin and local government maps.

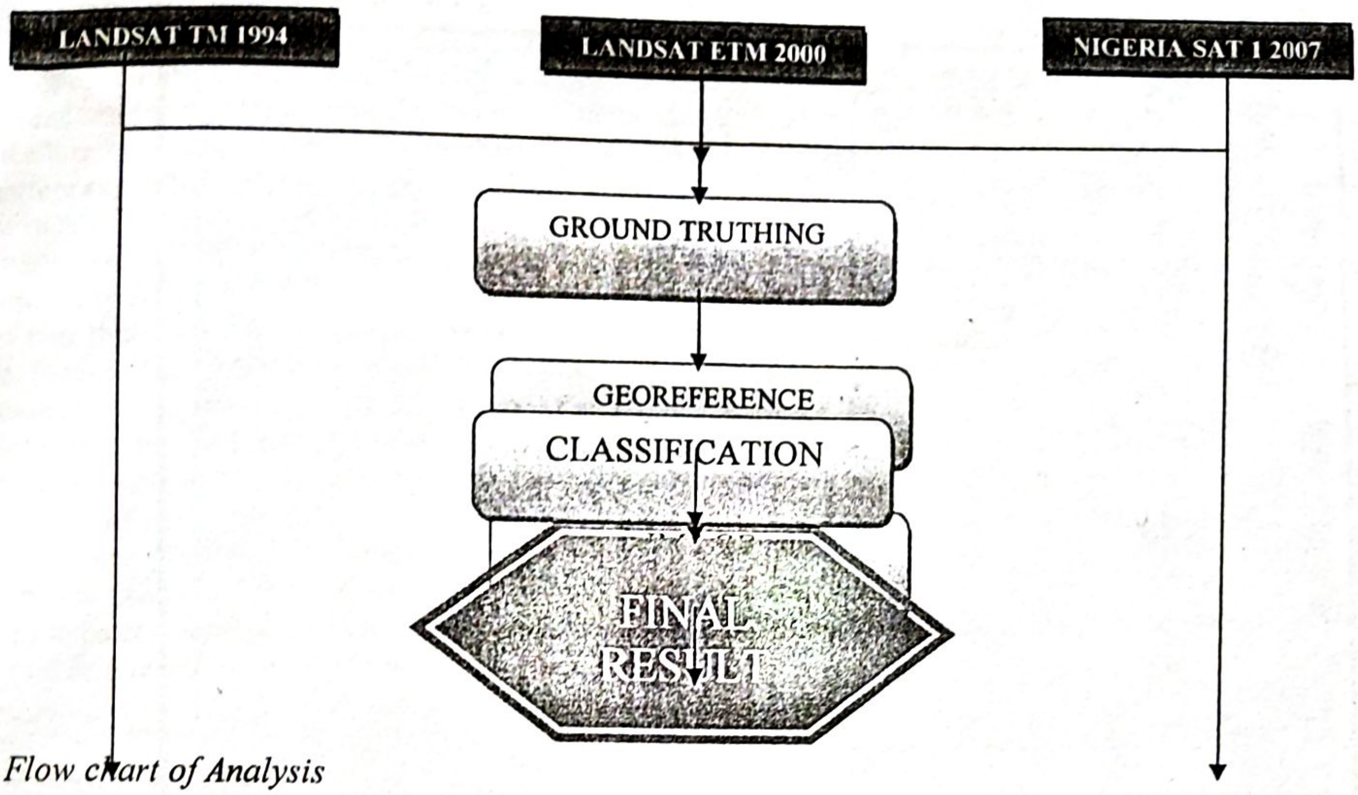
(b) ArcGIS – This was also used to compliment the display and processing of the data

(c) Idrisi32 – This was used for the development of land use land cover classes and subsequently for chan detection analysis of the study area.

(d) Microsoft word – was used basically for the presentation of the research.

(e) Microsoft Excel was used in producing the bar graph.

METHOD OF ANALYSIS



Flow chart of Analysis

PRESENTATION AND DISCUSSION OF RESULT

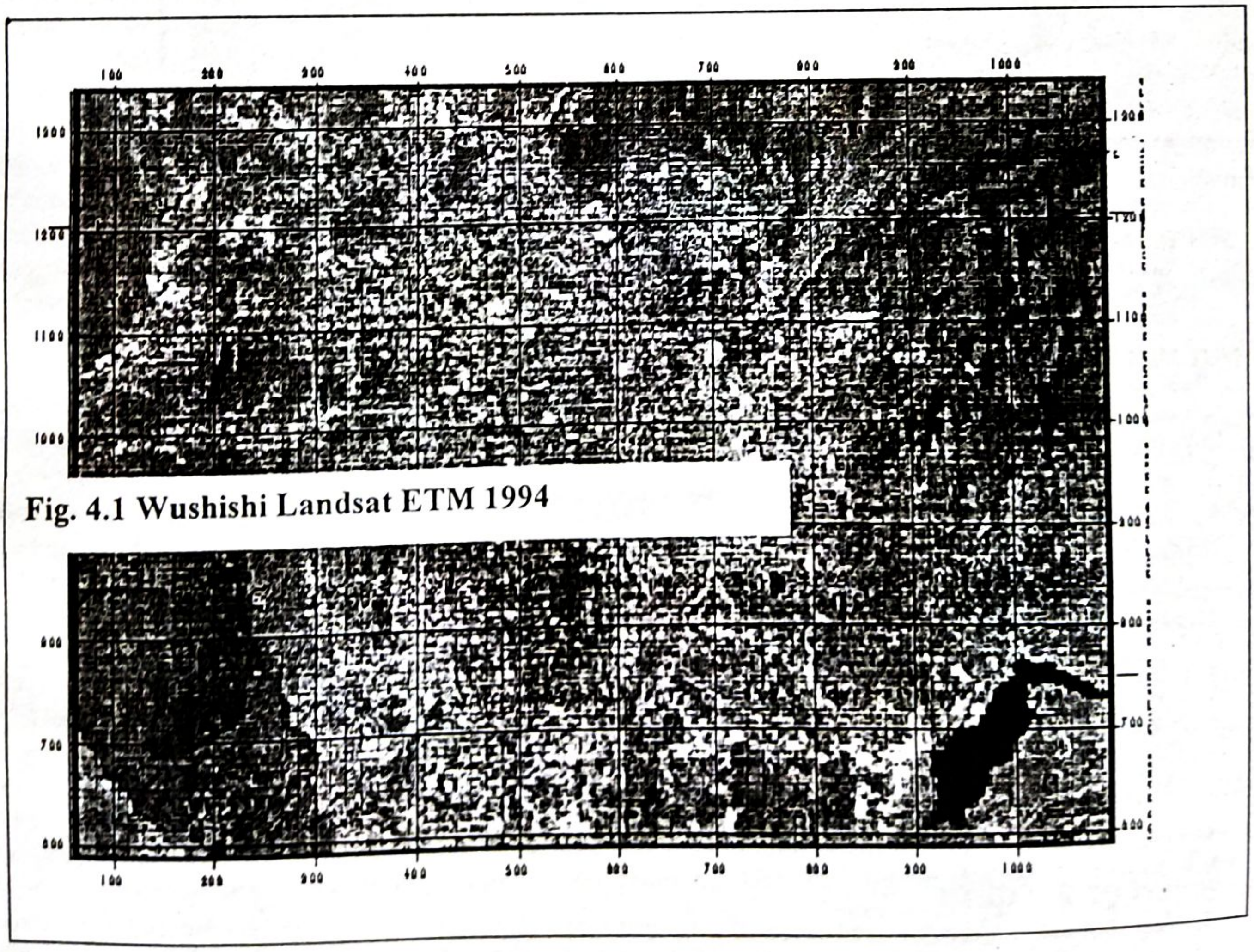


Fig. 4.1 Wushishi Landsat ETM 1994

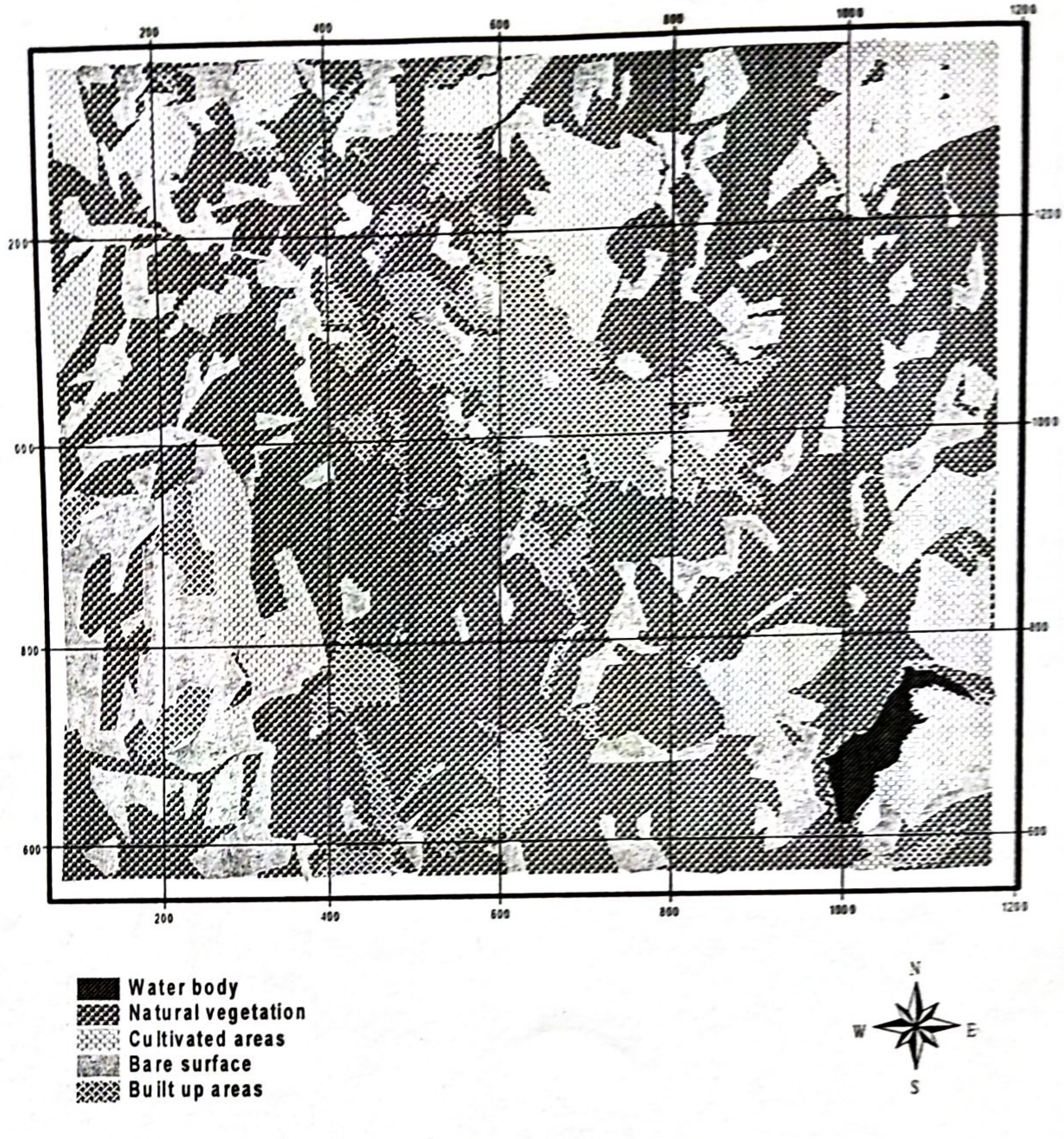


Fig. 4.2: Vector map of Wushishi, 1994

CHANGES IN DIFFERENT LANDUSE CATEGORY

LANDUSE	1994	2000	2007
Farmland	56.4	39.6	31.2
Intercity Built-up	24.73	34.2	36.1
Wet Vegetated land	12.24	8.24	6.74
Water body	25.37	16.37	15.37
Unclassified	1.35	2.35	2.35
Total	100	100	100

DISCUSSION OF RESULTS

Due to the fact that satellite image used were of different types slight problems were encountered. The scale of the 1994 Landsat Imagery and Landsat ETM Imagery of 2000 were of a better resolution the landuse categories that were mapped out, were more generalised than that of 1994 and 2007, road were too small to mapped out, or were not identified on the Image., so it is difficult to say exactly how much of such changes within the study area. In other words due to the difference in scale, errors are likely to arise on the landuse change map. Errors may have also come from the technique used in calculating the area coverage for each landuse category. However, the landuse map produced provides adequate information of the general landuse of the area as well as gives an idea of the rate of development.

Wushishi, which was once very sparsely populated and considered as rural, has changed significantly. As mentioned earlier, this is basically due to the general increase in population. There is likely going to be crowdedness brought by compactness in Wushishi come 2015. This situation will have negative implications in the area because of the associated problems of crowdedness like crime and easy spread of diseases. It is therefore suggested that encouragement should be given to people to build towards the outskirts through the provision of incentives and forces of attraction that are available at the city center in these areas. Indeed, between the period of 1994 and 2000, there has been a reduction in the spatial expansion of Wushishi compared to the period of 2007. There is a possibility of continual reduction in this state over the next 14yrs. This may therefore suggest that the city has reduced in producing functions that attracted migration into the area. Indeed, there have been many defunct industries within this period. Natural vegetation has been steady in reduction between 2000 and 2007 and in deed; this may likely be the trend 2007/2015. It will be in the good of the State and indeed, the Nation as a whole if the moderate reduction in bare surface land observed in-between 1994 and 2000 which is also projected by 2015 is upheld. Also, land absorption coefficient being a measure of consumption of new possible changes by each unit increase in urban population which was high between 1994 and 2000, reduced between 1994 and 2007. This therefore, observes that the rate at which new lands are acquired for development is low. This may also be the trend in 2007/2015 as there seems to be concentration of development at the city center rather than expanding towards the outskirts. This may be as a result of people's reluctance to move away from the center of activities to the outskirts of the city.

SUMMARY AND FINDINGS

Future population growth and the corresponding increase in development in the Wushishi Watershed are widely recognized as major threats to the integrity of watersheds worldwide.

The potential impacts associated with the expansion of developed land, and specifically with increasing amounts of impervious surfaces – rooftops, sidewalks, roads, and parking lots - may include significant changes in water quantity, degradation in water quality, and habitat loss. Because asphalt, concrete, stone, and other impenetrable materials effectively seal the ground surface, water is repelled and is prevented from infiltrating soils. Instead, storm water runoff flows directly into our surface waters, depositing metals, excess nutrients, organics, and other pollutants into the receiving bodies. In addition to these environmental impacts, increasing levels of imperviousness can dramatically alter our landscapes, as forested and other natural settings are converted to urban/suburban uses.

The primary goals of this project were to provide an accurate, current description of the extent of impervious surface coverage in this region, as well as an estimate of change in the amount of "imperviousness" over a 14 year period (from 1987 to 2001). A detailed characterization of the watershed was also conducted.

Geospatial technologies provide effective tools to map and quantify impervious surfaces, and to monitor changes over time. Moderate resolution Landsat Thematic Mapper (TM) satellite imagery, as well as an image processing GIS software, was utilized to estimate amounts of imperviousness at relatively modest cost, thereby providing a mechanism for subsequently measuring "imperviousness" at frequent, repeated intervals. Resource managers and other professionals may effectively utilize the resulting data as they develop watershed management plans and tools.

From the study, it was observed that the impervious surface percentage of the Wushishi watershed had decrease over the fourteen-year period between 1987 and 2001 by 13.68%. As already earlier mentioned, although this value falls above the threshold of an impacted watershed, a decrease in impervious percentage in the watershed over the duration of study is an indication that the watershed is progressively recovering from its degraded state. Other findings include the number and area extent and catchment center of the watershed that has been detailed in Appendix B - a maximum catchment area and perimeter of 559968.76m2,

and 3654.42m2 respectively. A total of 447 catchments were extracted and characterized.

Furthermore, 447 drainages were also extracted as detailed in Appendix A – a maximum drainage length and Sinuosity of 993m and 1.414 respectively. A maximum Strahler and Shreve drainage order of 4 and 47 respectively.

CONCLUSION

This project showcases the enormous potential of remote sensing, GIS as well as allied geospatial techniques in studying urban related environmental problems at a watershed scale.

The main aim of the project was to develop a methodology for evaluating or assessing the impact or consequence of urbanization on the overall health of a watershed; and the Wushishi watershed of Kogi State, Kadunaia was the selected study area. Imperviousness was employed as the most effective index of assessing the health of a watershed in this project.

The first phase of this project involved the characterization of the watershed with the principal objective of extracting detailed hydrological parameters that are indicative of the morphology and hydrological interchange of the study area. By so doing, a number of hydrorelated parameters such as the catchment area and perimeter, drainage network number and order classified according to Strahler and Shreve, drainage flow length and sinuosity and catchment centre as well as the Watershed elevation and slope were extracted.

A second phase in this project work explored the possibility generating a percentage imperviousness index for the Wushishi watershed performed on a watershed scale. Standard methodologies as adopted from similar researches in other parts of the world formed the basis for this phase of the project. A multi temporal Landsat 7 satellite imagery was used to classify the land use and land cover of the study area; impervious coefficients that were also adopted from such foreign researches but modified to conform to the Wushishi Watershed environment were also utilized. These values were used to generate an impervious percentage attribute map of the classified land use land cover map of the Wushishi Watershed. From these, a histogram which contained the percentage imperviousness of the Wushishi Watershed for both dates were derived indicated as the mean pixel value of the histogram of the attribute map.

The principal finding of this project was that though the 'built-up' area class and percentage as highlighted in figure 4.12 increased from the first to the second date, which is an indication of an urbanizing environment, the health of the watershed was rather found to have improved as indicated by reduction in the overall impervious percentage derived for each date of the classified Landsat satellite imagery (i.e. from 45.79% – 32.11%). This is an absolute contradiction to the finding of similar researches conducted in other environments; where overall health of a watershed was found to deteriorate with increasing urbanization. The researcher attributes contradiction to any and both of the following:

- The satellite imageries used for the supervised classification might have been acquires in years with highly contrasting climatic regimes resulting in an increased vegetation of the study area as one moved from the first to the second date.
- The percentage of the 'built-up' land use class of the study area was too small (17.56% and 20.70% for 1987 and 2001 respectively) to allow for the assessment of impacts due solely to urbanization of the watershed thereby minimizing the influence from other land cover classes.

RECOMMENDATIONS

The following are the recommendations resulting from the findings of this project work.

- To achieve a more representative result that typifies the actual impact of urbanization on a watershed especially within the tropics, such studies should be conducted on a sub-water shed or catchment scale. This apparently implies the use of higher quality satellite imageries and ancillary data from which more land uses land cover classes could be extracted.
- Satellite imageries and other ancillary data should be collected for years with uniform climatic regime so that effects associated which varying climatic regimes for one year to another could be reduced. A better approach could be to develop a methodology that minimizes such climatic variation to the barest minimum for subsequent similar projects.
- Kaduna Environmentalists should adopt and increase the use of geospatial techniques in other aspects of environmental studies to be able to achieve results that are empirically verifiable and also with a high level of reliability.

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