STUDY OF CHANGING RIVER COURSES AND ESTIMATION OF REDUCTION OF AVAILABLE LAND RESERVED FOR DEVELOPMENT IN LAE CITY OF PAPUA NEW GUINEA USING GIS AND REMOTE SENSING TECHNOLOGY.

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Change Detection, GIS, Lae city, Land availability, Remote Sensing, River shifting

ABSTRACT
Study of river course dynamism is very important in understanding the flow pattern characteristics of river, especially the erosion activity of the river, modification of flood plain, bank cutting, channel shifting, etc. They assist in identifying and estimating manmade as well as natural erosion by river. The study area 'Lae' city is a city that is surrounded by three major rivers. Thus the activity of rivers in shaping and altering the 'available land' of city is objective of the study. People are migrating into city for being employed or having a better living standard. They cater to the demand of expanding factories, business firms, industrial activity that are expanding with the passing time in Lae city. Remote sensing and GIS technology was used to identify and estimate how fast the available land in the city is being gnawed by 3 major rivers between year 2000 and 2012 and the implication to expansion of the city. The study was carried out for the understanding for Lae urban planners and Lae city council as major concern lies behind them to know how the river is migrating its paths and which way the city is to be expanded.
INTRODUCTION

Anthropogenic activities are greatly influenced by river course change implicating available land. Remote sensing and GIS can be effectively used to study riparian dynamism posing risk to the city’s expansion plan.

Lae city is the second largest industrial city in Papua New Guinea. Now a days the city is expanding at a vary brisk pace due to migration of people into the city, expanding of public institutions, industries and factories, commercial area, residential area etc... Thus expansion of city leads to considerable stress on the availability of land. Also the city has its vision or goal to achieve in objectives in enshrined in vision 2050 that is the city will be expanding and developed to the goal set by governing body. For the city to expand and develop, governing body has to know and be aware of what are some main natural features that can stop or limit the extension of the city. This can help them to make better 2050 vision plan. Today Governing bodies have to consider contingent plans knowing that, the city is located within three major rivers and these are Markham river, Bumbu river and Busu river. The expansion of city can be impaired by these rivers. That is as the city demands more land for development and expansion; the rivers are also and slowly eating away the available land. Thus this was the main focus of the study.

Remote sensing technologies are increasingly being used to analyze fluvial landforms and Processes [5]. Information on river morphology and changes over time is commonly needed for water resources planning and river management [6]. This information can be studied using recent and historical remotely sensed data [3]. Precise information on the quality, availability and capability of resources can be collected and analyzed by modern cartographic technologies utilizing satellite images, geographical information systems (GIS), global positioning systems (GPS) and light detection and ranging (LIDAR). Thus, satellite remote sensing and aerial photography can play an important role in generating information about river systems and their temporal changes through time and how those affect the surroundings.

A river is a natural water course, usually freshwater, flowing towards an ocean, a lake, a sea or another river [4]. Changing course of rivers is a natural phenomenon. Shifting of course by a river is a vital part that changes the shape and size of river bank and decreases the land availability [2]. Keeping this in mind, a change detection study was proposed to be carried out at Busu, Markham and Bumbu River to identify its course change and how it has affected the available land of the city.

Change detection study is a study that utilizes images or maps of different years for the same area. Through this study it is easy to identify and estimate the available land eroded or removed over time or available land that will be removed or erode by 3 major rivers. The result of study can bring about better understanding of river flowing pattern, changing of course and its impact. Thus from there, an assessment can be carried out to solve the issue. That is preventing land from eroding away and also to decide which way the city is to expand in order to realise 2050 vision of the Govt. of Papua New Guinea [1]. The study is of paramount importance because the Rivers are within the boundary of the City.

SIGNIFICANCE OF THE STUDY

This study is equally important as it will offer the option of using the capabilities of GIS and Remote Sensing to solve problem associated with river course changes and bank erosion at the study area and reduction of available land. The spatial analysis on the river course change and its impact on reducing the available land of the city would provide invaluable information and increase the understanding of how to carry out mitigation measures through understanding of the expansion of the city. GIS and remote Sensing application can help in understanding how fast or slow is the river bank is eroding and reducing the available land for development purpose. It provides answer as to why and how changes of channel occur and what preventive measure or method can be put forward to preserve land from eroding or to minimize the loss of land.

AIMS AND OBJECTIVE:

- To identify changes of 3 major river course over time
- To identify and estimate the impact of river course change towards reduction of available land of Lae city

STUDY AREA

The study area that was selected to carry out the research study was the city of Lae In the country Papua New Guinea that is located in 06042°S,147000°E and has the height above mean sea level of 8m. It is Papua New Guineas second largest city. The topography of the study area consists in 3 major rivers itself with its geomorphologic features, urban and built up area and agricultural areas. Thus the landscape of the study area is both flat and hilly. The length of the study area is approximately 12-15km and its width is approximately 14-16 km. The total area for study area is 10 229 hectare.
2. MATERIALS AND METHODS

2.1 INTRODUCTION

This is the main chapter that discussed the methodology that was applied during the research project. It contains the main points and ideas of the project and gives detailed description of the processes and procedure of appropriate data which was collected and how it was processed. Furthermore the purpose of this chapter was to highlight or discuss the types of materials, instruments, software and what actual data was used and what methodology was used to analyze and process the data that was collected in order to bring out the desired output for the better understanding of the situation of the study area. The main idea behind every processing of the data is to highlight and identify the course change of three major rivers and to calculate or find out how much available land of the city have eroded or removed between year 2000 and 2012. Hence we can put up a better idea how and in which direction city is to be expanded.

2.2 DATA USED AND ITS PROCEDURES

To do change detection study, several remote sensing data or base map produced or captured at different time is needed. For the case of this research study, the data used was, base map of Lae and Environs, 2000 at a scale of 1: 10 000. The map was produced from 1:10 000 scale orthophoto, 1: 25 000 topo map and 1:4000 scale cadastral plans and finally the map were updated from 1:10 000 scale aerial photo (flown Feb, 2000). The map was digitized to extract vector layers of Markham, Bumbu and Busu River and the surrounding land and built-up area that is for year 2000. The other data used for the study was LIDAR image (orthophoto) of Lae city captured in 2012 at 20cm spatial resolution. The study area was cropped and each and every individual features of the study area was digitized to create vector layer. The two types of data collected are of different years (2000 and 2012) that are of 10 years interval. The data was also acquired through Field visit and local interview with the questionnaires. These data was purposely used for verification and help in area calculation or help in identifying the available land eroded or removed. Example of types of questionnaire used was:

a) How often did you see this river changes its course?
b) From your point of view, is this particular river eroded or cut off any banks?
c) If the river is eroding the banks, are you going to relocate yourself? ( )
Table 2.2.1: Data Used

<table>
<thead>
<tr>
<th>data type</th>
<th>scale/resolution</th>
<th>source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base map of Lae and environs -2000</td>
<td>1: 10 000</td>
<td>Lae city council office</td>
</tr>
<tr>
<td>Orthophoto(LIDAR) data-2012</td>
<td>20cm spatial resolution</td>
<td>Lae city council office</td>
</tr>
<tr>
<td>Field visit and local interview with the questionnaires provided</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.3 GIS SOFTWARE USED AND ITS PROCEDURES APPLIED TO MANIPULATE AND PROCESS THE DATA

For the LIDAR data (Orthophoto) ArcGIS 10 was used to extract the study area and was converted to imagine format (img). The spatial reference was already made available with the data and that is Papua New Guinea Map Grid 1994 zone 55. MapInfo Professional 10.1 was used for the purpose of digitizing, the extracted study area in raster format (img) was open in MapInfo 10.1 for digitizing and again after digitizing the vector file from tab format was translated using universal translator in MapInfo 10.1 to shape files which was read able by ArcGIS 10. Thus ArcGIS 10 was used to do overlay and proximity analysis and produce a final output map with the results of impact.

Finally for Base map of Lae and environs -2000, the map was taken in digital format in MapInfo (tab) file format; the projection system was WGS 84 projection system UTM zone 55 southern hemispheres. The map was digitized using MapInfo 10.1. All the vector files are then translated to shape files using universal translator in MapInfo 10.1 where it is read able by ArcGIS 10 here the analysis (overlay and proximity) and mapping was carried out.

What was done is that, ArcGIS 10 was used to do union operation on vector files for each data set that was digitized. The combine union of each data set was overlaid to find out the changes that have occurred over time. How it was done to achieve the objectives is that, union operation using ArcGIS 10 was done first for the river network features and land use land cover for year 2000. On top of these the river network features for the year 2012 which was digitized was overlaid. There the rivers course change was found out and the estimation was done of how much available land for Lae city was removed or eroded between year 2000 and 2012. Field visit and local interview data taken was used to verify what was processed using the GIS software. This was all done using ArcGIS 10 software. Thus MapInfo was also used to help and confirm in proximity and overlay analysis that was done to find out the reduction of city’s available land.

The combined methodology that was followed /applied through the research study is shown in figure 2.3.1.

Figure 2.3.1  Methodology
3. RESULTS AND DISCUSSION

3.1. INTRODUCTION
The study has been carried out with the help of remote sensing data, Base Map, ArcGIS 10 software and MapInfo Professionals 10.1. The data were individually processed and analyzed in a GIS environment using the software mentioned. After overlapping those shape files, the changes of river course and its impact in reducing the available land of Lae city was identified. These were the main objectives that were put forward to achieve.

Through investigating and analyzing the activity of three major rivers surrounding Lae city with the help of present study and local interview, it was found out that Busu River is one of the fastest flowing river in PNG as well as world [7]. It cuts and erodes the bank at high rate and changes its course every time. The river is meandering at the northern part and braided at the southern part and meandering pattern and braiding pattern of river has its own effect in cutting and eroding the banks. Busu river flows in the north-east part of the city. It flows right near/ within the city. For the Markham River, it is not that fast but the river is so widely expended. It cuts and erodes at high rate when flooded. Likewise Busu River, it flows right near the city where the city is to expand. For the Bumbu River it is a narrow river and flows at medium speed. It cuts and erodes at high rate during flood. Since it is located right within the city and when there is a continuous rainfall, the river can make huge destruction to industries, public institution etc.. which are near. a. Figure 3.2.1 illustrates the rivers network features and surrounding built-up area and vacant or available open land for year 2000. Figure 3.2.2 illustrates the overlay of 2012 river network features to find out how rivers has change over time To find out rivers course change and how much available land removed is the main purpose for this research study. Therefore the illustration was put forward only and clearly to highlight and show the river network features and surrounding built-up areas with open land for year 2000 and then overlaying the 2012 river network that was digitized to find out changes of river course and to calculate the available land removed beginning from year 2000 all the way to year 2012. The investigation done to calculate the land area removed by rivers was a location wise investigation.

Figure 3.2.1: River network features and surrounding built-up area with available open land or vacant land for year 2000
3.3. LOCATION WISE INVESTIGATION OF RIVER COURSE CHANGE AND ITS EROSION ACTIVITY

It is rear that the expansion of the city can be towards the northern part, southern, eastern, western or northeast, southeast, north-west and southwest. This is mainly to bring forward development. To expand the city to each Conner, government body has to be aware of these three major river surrounding the city and particularly to each portion or parts of the river(location) where the city is to expand forward or has expanded. With this in mind the study area particularly to those three major rivers, it has been divided into location by location to investigate the rivers course change in that particular location and its impact in reducing the available land. In continuous from above illustration, figure 3.3.1 illustrate the land or boundary area for Lae city and river network features for year 2000 and river network features for year 2012 was overlaid to see changes in rivers and identify the land loss. Figure 3.3.2 illustrates the location wise investigation that was carried out.
Figure 3.3.1: Lae city land or boundary and overlay of rivers

Figure 3.3.2: Location wise investigation
Location wise investigation was purposely done to highlight each part of 3 rivers. This is because city can expand towards any direction. So what sections or parts of rivers from calculation that experiences massive erosion activity can be made known to governing bodies. This is done to what extent or how the city will expand can be utilize or manipulate.

Location wise calculation of impacts towards reduction of available land when the rivers changes their course was done using the ArcGIS software. Proximity analysis and overlay analysis were carried out. The amount of available city’s land removed or eroded by rivers was calculated location by location and tabulated and is shown in table 3.2.1 The calculation was done using ArcGIS software but again confirm with MapInfo Professional software. The total area of each location site was first calculated and then followed by calculation of how much area removed or eroded within that location sites. The greater in hectare the land area removed or eroded, the riskier the location to expand the city forward.

Table 3.3.1: investigation of impacts of Rivers changing course between year 2000 and 2012

<table>
<thead>
<tr>
<th>Rivers</th>
<th>Locations</th>
<th>Total area in ha</th>
<th>Total area in %</th>
<th>area eroded/removed( ha)</th>
<th>area eroded/removed( %)</th>
<th>Left after erosion( ha)</th>
<th>Left after erosion( %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busu River</td>
<td>LC 1</td>
<td>467.83</td>
<td>22.50</td>
<td>9.17</td>
<td>2.93</td>
<td>458.66</td>
<td>25.98</td>
</tr>
<tr>
<td></td>
<td>LC 2</td>
<td>582.03</td>
<td>27.99</td>
<td>56.61</td>
<td>18.06</td>
<td>525.42</td>
<td>29.76</td>
</tr>
<tr>
<td></td>
<td>LC 3</td>
<td>513.57</td>
<td>24.70</td>
<td>74.70</td>
<td>23.83</td>
<td>438.87</td>
<td>24.86</td>
</tr>
<tr>
<td></td>
<td>LC 4</td>
<td>515.64</td>
<td>24.80</td>
<td>173.00</td>
<td>55.19</td>
<td>342.64</td>
<td>19.41</td>
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<tr>
<td></td>
<td>Total</td>
<td>2079.07</td>
<td>100</td>
<td>313.48</td>
<td>100</td>
<td>1765.59</td>
<td>100</td>
</tr>
<tr>
<td>Bumbu River</td>
<td>LC 5</td>
<td>350.14</td>
<td>15.13</td>
<td>8.07</td>
<td>15.32</td>
<td>342.07</td>
<td>15.12</td>
</tr>
<tr>
<td></td>
<td>LC 6</td>
<td>679.65</td>
<td>29.37</td>
<td>16.30</td>
<td>30.95</td>
<td>663.35</td>
<td>29.33</td>
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<tr>
<td></td>
<td>LC 7</td>
<td>630.26</td>
<td>27.23</td>
<td>14.41</td>
<td>27.36</td>
<td>615.85</td>
<td>27.23</td>
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<tr>
<td></td>
<td>LC 8</td>
<td>654.38</td>
<td>28.27</td>
<td>13.89</td>
<td>26.37</td>
<td>640.49</td>
<td>28.32</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2314.43</td>
<td>100</td>
<td>52.67</td>
<td>100</td>
<td>2261.76</td>
<td>100</td>
</tr>
<tr>
<td>Markham River</td>
<td>LC 9</td>
<td>609.06</td>
<td>53.34</td>
<td>196.45</td>
<td>60.75</td>
<td>412.61</td>
<td>50.46</td>
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<tr>
<td></td>
<td>LC 10</td>
<td>532.03</td>
<td>46.62</td>
<td>126.93</td>
<td>39.25</td>
<td>405.10</td>
<td>49.54</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1141.09</td>
<td>100</td>
<td>323.38</td>
<td>100</td>
<td>817.71</td>
<td>100</td>
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<tr>
<td>Overall Total</td>
<td>LC 1-10</td>
<td>5534.59</td>
<td>100</td>
<td>689.53</td>
<td>100</td>
<td>4845.06</td>
<td>100</td>
</tr>
</tbody>
</table>

The estimated total land area used by Lae city/proposed for Lae city development is 10 229 ha

10 229 – 689.53
= 9 539.47 ha

From the table above it can be seen and confirmed that total land occupied by the city or proposed for city development is 10 229 ha. Since location wise investigation was done, the total area of each individual location is 5534.59 ha. Thus the investigation of river course change and how much land area is affected between year 2000 and 2012 and it was seen that total area removed or eroded by river or is occupied by river and its feature was calculated to be 689.53 ha. It was confirmed that between year 2000 and 2012, 689.53 ha of Lae city available land was eroded or removed. Thus up to present (2012) the total land area left is 9539.47 ha. It was estimated that for another 10 years in the future, the river will still continue to going to erode and cut away available land for the city.

Figure 3.2.3 below highlights mainly the amount of city’s land area removed or eroded by each river. It is to give clear understanding on the erosion potential of each river, which river has made greater damage between year 2000 and 2012.
4. CONCLUSION

The study has proved that those three major rivers surrounding Lae City have considerably changed course from year 2000 to year 2012. The effects of rivers changing course was investigated and was found that nearly 700 hectares of Lae city land area was eroded or removed between year 2000 and 2012. The study was carried out with the help of local interview with people leaving nearby rivers and with the data that was acquired. The city is expanding or will be expanding purposely to become a developed city and to achieve vision 2050 [1]. However this study through investigations highlights that the city’s land area will still continue to be cut off or eroded by those three major rivers. Because all rivers has their own geo-morphological process that takes place every time, this is to cut, erode, flooding, etc.. By having in mind that city is surrounded by three major rivers, governing bodies have to take into consideration those geo-morphological processes of rivers and have to do something to protect the land from eroding before they consider development and extension of the city.

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6. REFERENCES


