CHANGE DETECTION OF BUSU RIVER COURSE IN PAPUA NEW GUINEA- IMPACT ON LOCAL SETTLEMENTS USING REMOTE SENSING AND GIS TECHNOLOGY

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Abstract— Water borne accelerated erosion is more significant than any other geomorphologic agents. The present study aims to investigate the amount and nature of shift of the Busu River in Lae City, Morobe province, particularly at temporal interval of 6 years and also to ascertain the possible reasons behind such changes. Such changes of the river course are affecting the livelihood of the local people and also repeatedly damaging and shifting the river banks which lead to destruction of the prevalent land use land cover of the area. People have been forced to migrate permanently due to this hazard. The identification of changes of river course and the kind of impact it has on local settlers happen to be the main objective of this research project. Constructive suggestions for control the bank erosion and resultant shifting of Busu River have been given. An attempt has been made here, to use GIS and RS techniques for change detection of river courses using past and present geographical data sources of river courses 6 years interval data have been used to identify changes in river stream and the impact on local settlers around Busu River.

Index Terms— Busu, Channel shifting, GIS, Remote Sensing, Riverbank erosion

1 INTRODUCTION

Lae, being the largest industrial urban town in Papua New Guinea has vast manufacturing, and diverse range of industries including private and public business firms, institutions and dotted with settlements in every nook and corner of the city. Currently the city is expanding, posing strain on the available land. That is industries and business firms are increasing along with settlements and institutions. However the city is located within three major rivers and these are Markahm River, Bumbu River and Busu River and the concern here is; the capriciously turning path, thereby decreasing the land availability of the city and forcing settlers to relocate or migrate away.

Floodplains are formed by a complex interaction of fluvial processes. Their character and evolution depends upon stream power, sediment behavior, and channel features [1]. Floodplains have been extensively used for human activities like agriculture, settlement, and industry for millennia, and are vulnerable to morphologic changes to adjacent channels. Study of floodplain formation, stability, and the frequency of flooding is of utmost importance in the river sciences [2]. Changes in river courses and channel morphology alter the characteristics of floodplains, and may abandon floodplains as terraces. These changes often occur at a spatial scale that is ideal for study by remote sensing methods. Floodplain changes may be slow and progressive or rapid in the sense of geologic time, and may occur naturally or in response to human activities.

Remote sensing technologies are increasingly being used to analyze fluvial landforms and processes [3]. Information on river morphology and changes over time is commonly needed for water resources planning and river management [4]. This information can be studied using recent and historical remotely sensed data [5]. 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

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important role in generating information about river systems and their temporal changes through time.

River is one of the natural features that can cause mass damage to the surrounding environment, both manmade and natural. 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. Keeping this in mind, a change detection study was proposed to be carried out at Busu River and its surrounding environment using time series remote sensing data. The study area is located in Lae city around -06°39',147°34' and it is in the Ahi LLG.

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 find out the impact the River has caused, or is causing or will be manifesting to the surrounding environment. 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, settlers from relocating or migrating. The study is of paramount importance because the River is within the boundary of the city.

1.1 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 changing and bank erosion at the study area. The spatial analysis on the river course change and its impact on the local settlements would provide invaluable information and increase the understanding of how to carry out risk management.

GIS and remote Sensing application can help in understanding how fast or slow is the river bank is eroding. It provides answer as to why and how changes of channel occur and what preventive measure or method can be put forward to assist the local settlements with their assets including infrastructure and also to minimise the loss of land.

1.2 OBJECTIVES:

1. To identify the changes of river course over the time.
2. To identify risk zone of two bank sides.
3. To identify impact of channel shifting as well as bank erosion on local settlers

1.3 STUDY AREA

The study area that was selected to carry out the research was Busu River and its surroundings. It is located in Lae city around 06o39'S,147o34'E and has the height above mean sea level of 8m. It is Papua New Guinea fast flowing river [6]. The topography of the study area is the river itself with its geomorphologic features including urban and built up area and agricultural areas. Thus the landscape of the study area is both flat and hilly. Towards river the flat landscape changes to steep slope about 90o.The length of the study area is approximately 6-7km and its width is approximately 2-3km. The soil type of the study area is mainly sandy loam.

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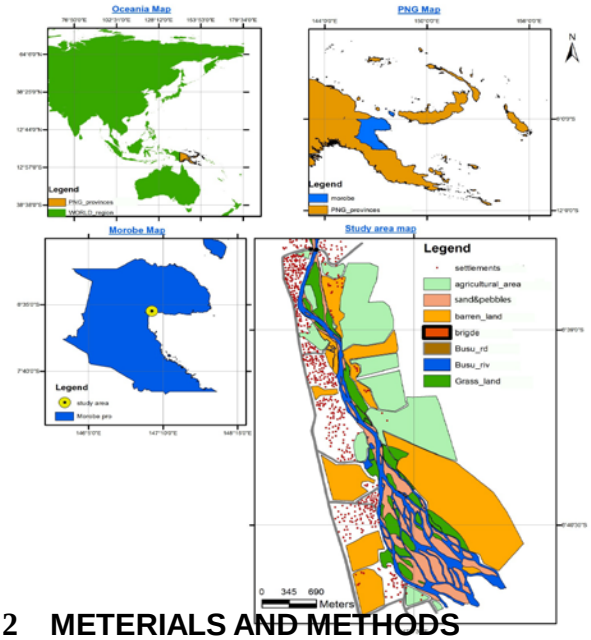
Figure 1.3.1: Study area/location map



2 METERIALS AND METHODS

In order to do change detection study of a particular area, several remote sensing images of the same area captured at different years are 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 othorphoto, 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 Busu River and the surroundings that is for year 2000. The other data used was high resolution Quick bird satellite image at 3.9 meter spatial resolution of Lae city captured in 2006. Thus from there the study area (Busu River and Surroundings was cropped. Again every individual feature of the study area was digitized to extract vector layer. The last and foremost data used for the study area was LIDAR image (othophoto) of Lae city captured in 2012 at 20 cm spatial resolution. Again the study area was cropped and each and every individual feathers of the study area was digitized to extract vector layers. The three types of data collected for different years (2000, 2006, 2012) that is 6 years intervals. The data collected was rectified and the study area was cropped using ERDAS Imagine 8.5 and was geo-referenced to WGS84 with projection system UTM zone 55 southern hemispheres. That is once different temporal maps are overlaid, the differences can be found out.

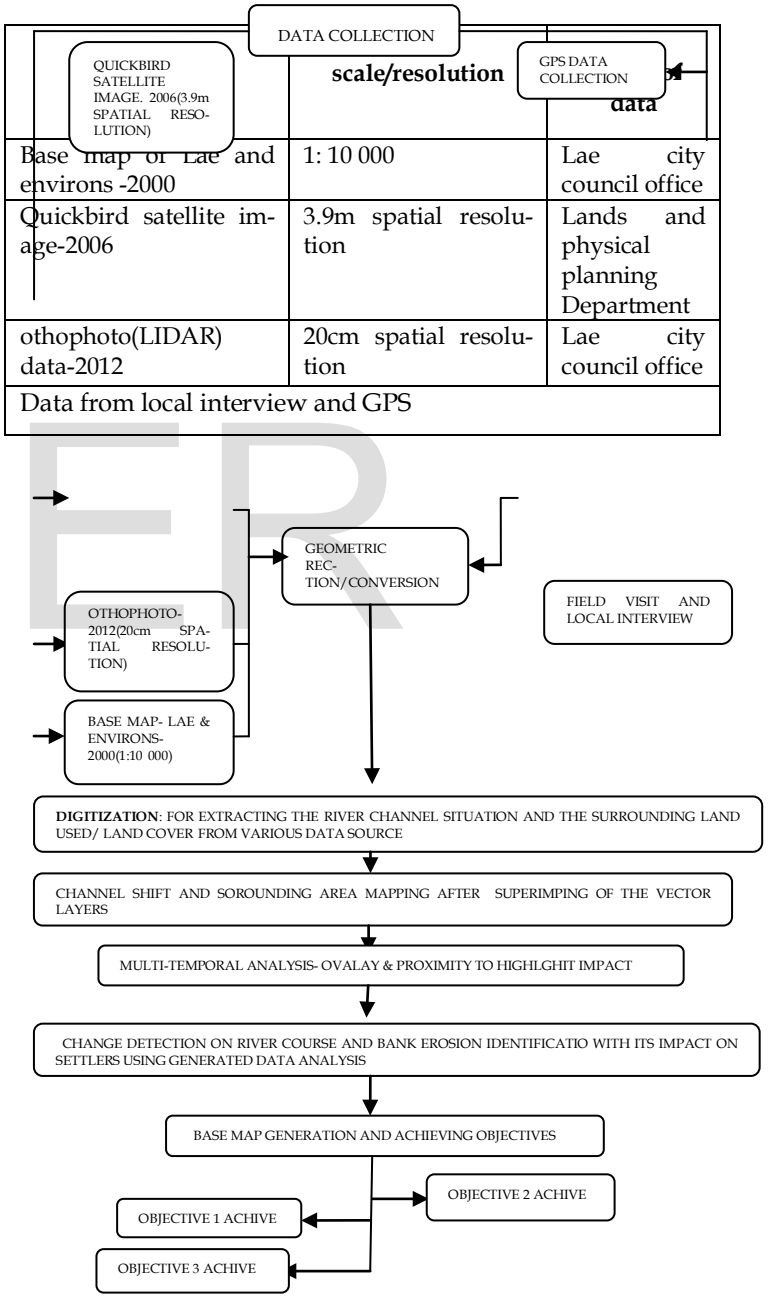
The digitization procedure was carried out using MapInfo Professionals 10.1 software. After extraction of the vector layer done using MapInfo software, individual vector file in tab format was converted to shape file which is readable by ArcGIS 10. Thus ArcGIS 10 was used to perform overlaying analysis and proximity analysis of river changing its course and its societal impact. ArcGIS 10 was used for generating current landscape/terrain view in 3D form and slope of study area. This is clearly to highlight past activity of Busu River that has changed the landscape of study area and what is left behind after those past activity.

As was discussed above, the river geometrical information and its surrounding extracted throughout digitization procedure on one another for change detection and bank erosion mapping. Changes of channel are mapped and the bank erosion analysed which is useful for various fluvial geomorphologic planning sector and societal impact assessment. The following data and methodology were adapted.

DATA USED

Base map of Lae and environs -2000	1: 10 000	Lae city council office
Quickbird satellite image-2006	3.9m spatial resolution	Lands and physical planning Department
othophoto(LIDAR) data-2012	20cm spatial resolution	Lae city council office
Data from local interview and GPS		

METHODOLOGY

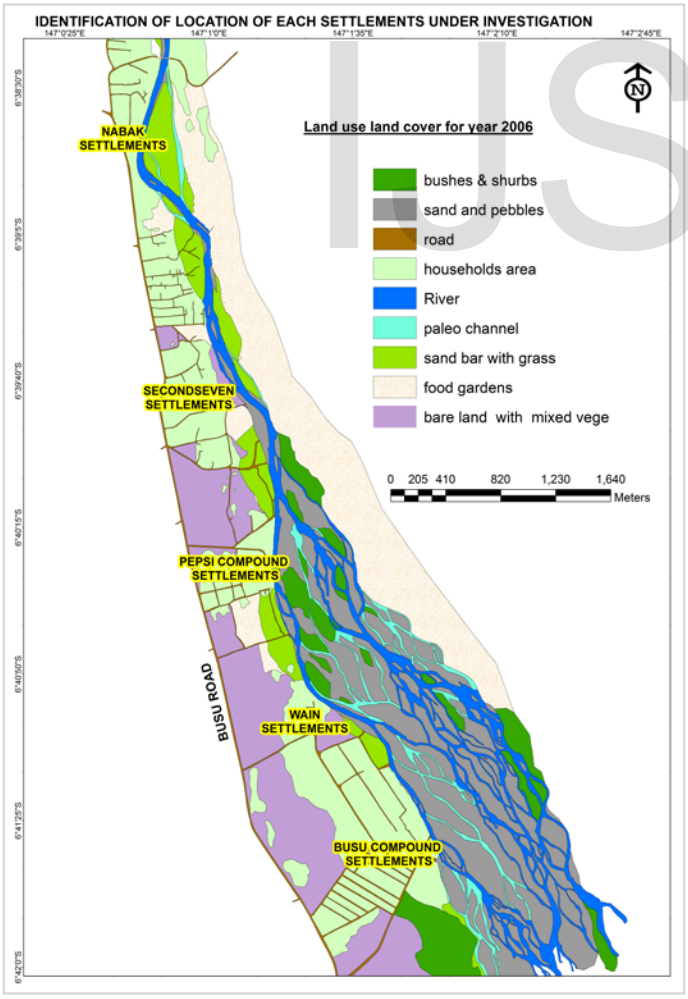


3 . RESULTS AND DISCUSSION

The study has been carried out with the help of remote sensing data and ArcGIS 10 software and MapInfo Professionals. All this data were individually processed and analyzed in a GIS environment. After overlapping those shape files, the changes of river course and its societal impact was identified and analyzed. The study area was divided into 3 sections namely, Nabak settlement, secondseven_Pepsi compound settlement, and wain_Busu compound settlements. Three settlements were individually investigated and assessed for the Busu River course change impacts. The identification of location of each settlement under investigation towards impact from change course of Busu River is diagrammatically shown in figure 3.1 below.

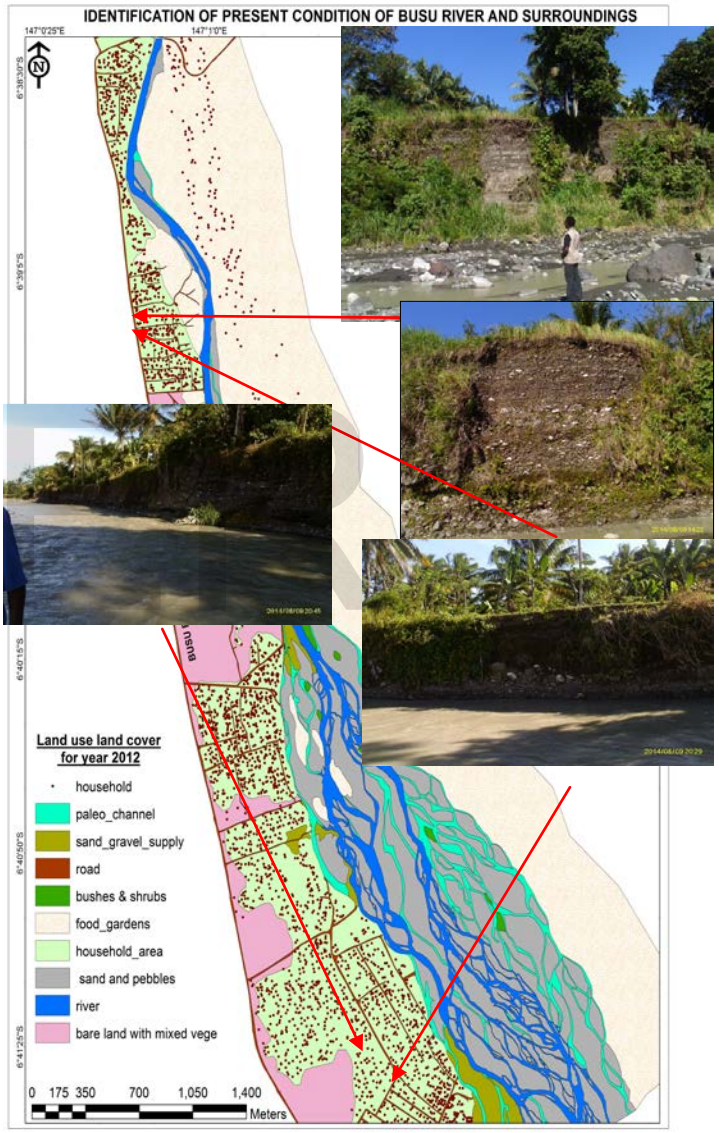
3.1 Present Impact of River Course change

Due to fast flowing river, huge deposition, bank erosion and



along with human activities near the river has lead to river course change that invariably impact/affect the communities near the river. It was found out through interview and investigation during field trip that Busu River was continuously eroding the banks, that result in evacuation of the settlers and reducing of the land availability. During the field trip, few photographs were taken for the present condition of the Busu River. That is, the result of past activity of Busu River.

Figure: 3.2 present impact of Busu river course change



3.2 Settlement wise investigation of impact of Busu River course change through change detection study.

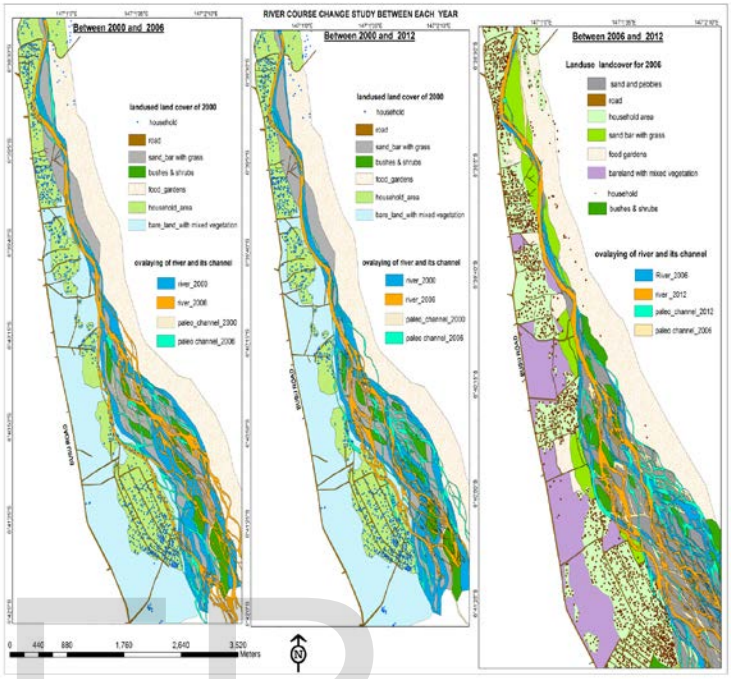
The figures above illustrate the results of past activity of Busu River. To find out what impact actually has been caused or is

causing by Busu River towards surrounding community and their assets, a change detection study was carried out. Change detection analysis encompasses a broad range of methods used to identify, describe and quantify differences between images of the same scene at different times or under different conditions. Change detection menu allows measuring changes between a pair of images that represent initial stage and final stage. For this research study, two remote sensing images and one base map produced from othophoto were used, they are of six(6) years interval, that is 2000 to 2006 and 2006 to 2012 which were used to do analysis and find out the river course change and its impact towards settlements.

Each individual river features layer was overlaid to find out the possible cause of impact towards settlers. As the river changed its course, what land use land cover type got destroyed or how much of the total area was eroded between 2000 and 2006, 2000 and 2012 and 2006 and 2012 were estimated. This was the type or method of year wise change analysis that was carried out. Study area was separated into three sections to do each settlements wise analysis. There is about 5 settlements area, however depending on the extent of each settlement; it was again grouped into three sections. The analysis was done also with the help of investigation, field trip and interview.

The first and foremost things that were done is identification of the land use land cover pattern of each settlement within each year interval. Once the river features network layers was overlaid on to each other for each year interval, the river pattern and its course changes were found out with the land use / land cover that was or are affected . Upon that, further settlement wise investigation of impact was carried out. This is by discovering the number of household removed within each year, identification and calculations of area of each individual land use land cover type that was eroded or removed, identifying and calculation of total area of land use land cover before overlaying of river network. Figure 3.3 highlights the master map or overall maps of every land use land cover and the river flowing pattern of year interval of 6 starting from 2000 up to 2012.

Figure 3.3: overall layout of river features and land used land cover for river course change study.



In Figure 3.3 the first illustration/map shows the land use land cover for the year 2000 and hence 2006 river feature was overlaid to investigate the river course change and its effect on land use land cover for year 2000 and this was noted as river course change study between 2000 and 2006.

In Figure 3.3 the second illustration/map shows the land use land cover for the year 2000 and hence 2012 river feature was overlaid to investigate the river course change and its effect on land use land cover for year 2000 and this was noted as river course change study between 2000 and 2012.

In Figure 3.3 the third illustration/map shows the land use land cover for the year 2006 and hence 2012 river feature was overlaid to investigate the river course change and its effect on land use land cover for year 2006 and this was noted as river course change study between 2006 and 2012.

Followed by this, each settlement wise investigation was carried out to clearly, closely and specifically identify and show the impact of river course change. Each individual settlements

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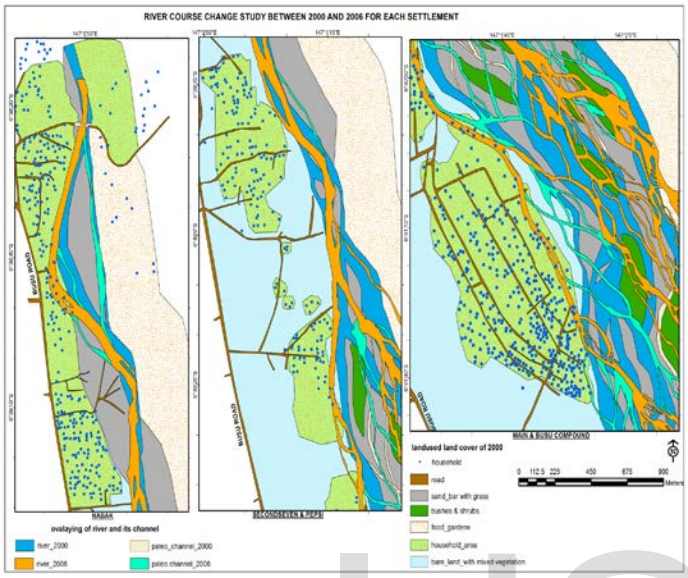
were investigated to find out impact of Busu river course change between 2000 and 2006, 2000 and 2012 and finally between 2006 and 2012.

Figure 3.4: settlement wise investigation of Busu river course change and its impact between 2000 and 2006.

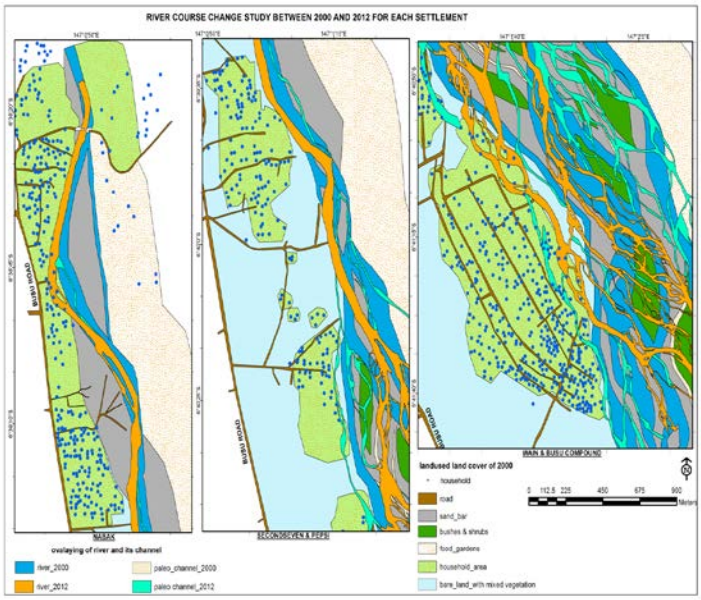


In Figure 3.4 the first illustration/map shows the Nabak settlements area for the year 2000 and its land use land cover and hence 2006 river feature was overlaid to investigate the river course change and its effect on land use land cover. This is a river course change study between 2000 and 2006 for the Nabak settlement and surroundings.

In Figure 3.4 the second illustration/map shows the Secondseven and Pepsi compound settlements for the year 2000 and its land use land cover and hence 2006 river feature was overlaid to investigate the river course change and its effect on land use land cover. This is a river course change study between 2000 and 2006 for the Secondseven and Pepsi settlement and surroundings.

In Figure 3.4 the third illustration/map shows the Wain and Busu compound settlements for the year 2000 and its land use land cover and hence 2006 river feature was overlaid to investigate the river course change and its effect on land use land cover. This is a river course change study between 2000 and 2006 for the Wain and Busu settlement and surroundings.

Figure 3.5: settlement wise investigation of Busu river course change and its impact between 2000 and 2012.



In Figure 3.4 the first illustration/map shows the Nabak settlements area for the year 2000 and its land use land cover and hence 2012 river feature was overlaid to investigate the river course change and its effect on land use land cover. This is a river course change study between 2000 and 2012 for the Nabak settlement and surroundings.

In Figure 3.5 the second illustration/map shows the Secondseven and Pepsi compound settlements for the year 2000 and its land use land cover and hence 2012 river feature was overlaid to investigate the river course change and its effect on land use land cover. This is a river course change study between 2000 and 2012 for the Secondseven and Pepsi settlement and surroundings.

In Figure 3.5 the third illustration/map shows the Wain and Busu compound settlements for the year 2000 and its land use land cover and hence 2012 river feature was overlaid to investigate the river course change and its effect on land used land cover. This is a river course change study between 2000 and 2012 for the Wain and Busu settlement and surroundings.

Figure 3.6: settlement wise investigation of Busu river course change and its impact between 2006 and 2012.

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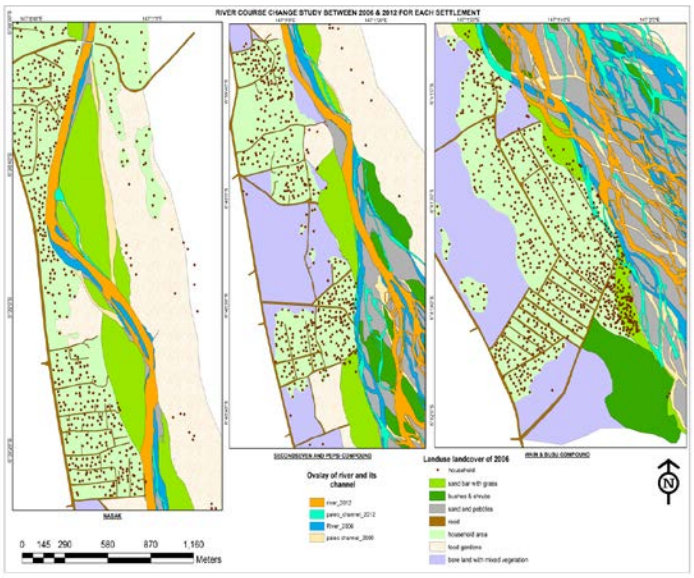


In Figure 3.6 the first illustration/map shows the Nabak settlements area for the year 2006 and its land use land cover and hence 2012 river feature was overlaid to investigate the river course change and its effect on land used land cover. This is a river course change study between 2006 and 2012 for the Nabak settlement and surroundings.

In Figure 3.6 the second illustration/map shows the Secondseven and Pepsi compound settlements for the year 2006 and its land use land cover and hence 2012 river feature was overlaid to investigate the river course change and its effect on land use land cover. This is a river course change study between 2006 and 2012 for the Secondseven and Pepsi settlement and surroundings.

In Figure 3.6 the third illustration/map shows the Wain and Busu compound settlements for the year 2006 and its land use land cover and hence 2012 river feature was overlaid to investigate the river course change and its effect on land use land cover. This is a river course change study between 2006 and 2012 for the Wain and Busu settlement and surroundings.

It can be seen clearly from above figures what features river has removed when changing its course. This was highlighted when river feature layer was overlaid to each other within year interval of six (6). That is once the 2006 river layer overlaid on top of river layer of 2000, there's a change that was found out from maps that was produced, so that means, once the river changes its course, it has removed or eroded the river bank and the different kinds and types of land use land cover that was in the vicinity. After change investigation between 2000 and 2012 for each settlement wise, the same process was carried out for change investigation between 2000 and 2012 followed by 2006 and 2012.

The results of river course change and its impact are all shown in table 3.1.

Settlements	Land used /land cover	2000 (hector)	Area in %	2006 (hector)	Area in %	2012 (hector)	Area in %	Difference (%) 2000 & 2006	Difference (%) 2000 & 2012	Difference (%) 2006 & 2012
Nabak	Household area	71.70	42.48	68.55	42.87	68.77	41.97	-3.31	-2.93	0.22
	Sand bar with grass	25.63	15.19	20.85	13.04	25.38	15.49	-4.78	-0.25	4.53
	Food gardens	65.20	38.63	65.00	40.65	65.00	39.67	-0.20	-0.20	0
	Bare land with mixed vegetation	6.24	3.70	5.51	3.45	4.72	2.88	-0.73	-1.52	-0.79
	Total	168.77	100	159.91	100	163.87	100	-9.02	-4.9	3.96
	No of house	263		249		253		14	10	4
Second seven & Pepsi settlements	Household area	46.46	25.63	45.05	27.45	54.00	31.21	-1.41	7.54	8.95
	Bare land with mixed vegetation	57	31.44	52.65	32.08	52.48	30.33	-4.35	-4.54	-0.17
	Sand bar with grass	12.63	6.97	10.35	6.31	10.89	6.29	-2.28	-1.74	0.54
	Food gardens	65.21	35.97	56.09	34.17	55.65	32.16	-9.12	-9.56	-0.44
	Total	181.3	100	164.14	100	173.02	100	17.16	-8.30	8.88
	No of house	178		175		175		3	3	0
Wain and Busu compound	Household area	99.91	48.55	84.90	36.92	82.58	33.53	15.01	-17.33	-2.32
	Bare land with mixed vegetation	105.89	51.45	75.80	32.96	90.35	36.69	30.09	-15.54	14.55
	Sand bar with grass		0	0	0	0	0	0	0	0
	Food gardens	94.41	45.87	69.25	30.12	73.35	29.78	25.16	-20.86	4.1
	Total	205.8	100	229.95	100	246.28	100	79.26	53.73	16.33
	No of house	420		369		364		51	56	5
Total area affected & under investigation	Household Area	218.07		198.5		205.35		19.57	12.72	6.85
	Bare land with mixed vegetation	169.13		133.96		147.55		35.17	21.58	13.59
	Food gardens	224.82		190.34		194		34.82	30.82	3.66
	Sand bar with grass	38.26		31.2		36.27		7.06	2.14	5.07
	Total	650.28		554		583.17		96.62	57.26	29.17
	No of house	861		793		792		68	69	9

Table 3.1: Area under different Land used/land cover categories during 2000-2012 affected by Busu River.

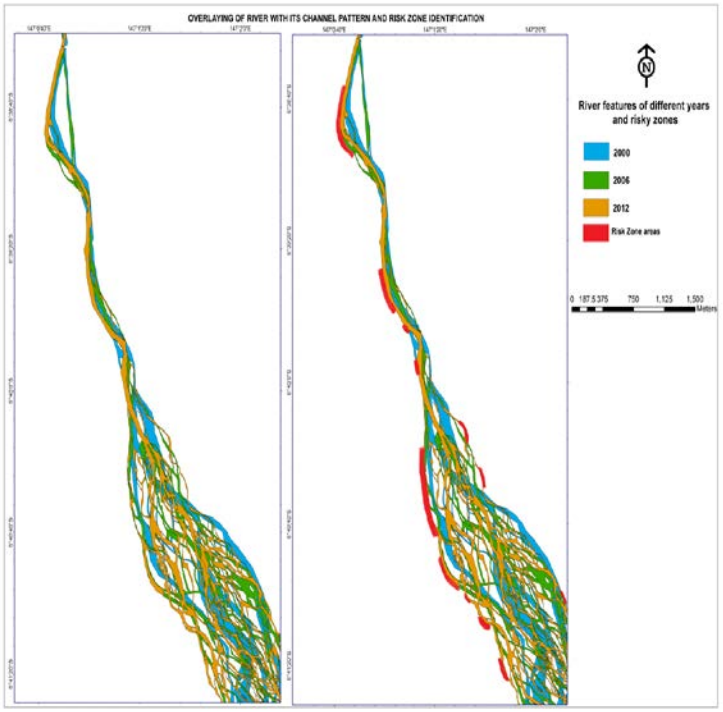
The table clearly highlight the results of settlements wise investigation of Busu river course change between year 2000-2012.It was found out from the above table that flowing pat-

tern and course change of Busu river which were illustrated on the maps above shows that the river has changed course much to the destruction of the surroundings settlers with their assets.

The type of land use land cover that was destroyed or removed when the river changes its course, are all measured and written in hectare except for each household, it was measured base counts. That is how many household been removed or washed away between 2000 & 2006, 2000 & 2012 and finnaly between 2006 & 2012. Same procedure was also applied to other land used land cover.

3.3 Nature of River Course and its risky zone area (high erosion activity)

During the overlay of vector layer, it was shown that the Busu river changes course every time. Which has much impact to the settlers living around the River; this is because the river is a fast flowing river and erodes the banks at high rate and also deposits at high rate. Huge deposition increases the sand bars which can be a cause of river changing its course. The river channel pattern is meandering pattern at the top and in the low lying area, the river pattern is braided. Thus at the meandering area, the river is not spread out it flows at only one direction at high speed that cuts and erodes the bank at a brisk rate. However at braided pattern area, the river spreads out in all directions and moves which leads to huge deposition and increasing of sand bars. It lowers the water holding capacity and once the flood occurs it can't hold much so the river can create a new channel by eroding the banks. Figure below shows the meandering and braided pattern including the overlay of 2000 and 2012 river netwok features in order to identify river pattern of Busu River and its Risk zone area over the time (high bank erosion):



3.4 Impact of river course change and bank erosion

Channel shifting or river course change is the main reason behind down cutting or erosion of banks. Once down cutting or erosion of banks due to river course change occurs each and every land use land cover surrounding the river is affected. Human being and River's relationship has great historical prospective, many a human civilization was developed on the bank of rivers. Thus, the human interaction with river system is indispensable. Some of the momentous impact that was found out during the study was:

(1) River bank erosion creates difficulties for the inhabitants as well as the native.

(2) Degradation of fertile soil which has higher capacity of productivity and efficiency.

(3) Water level goes down due to deepening of bed.

(4) Unuseful sand growing (deposition) in opposite direction of erosion.

(5) Change in river morphology and geometry.

(6) Some settlements shifted due to higher bank cutting.

(7) Impact upon human life as well as its various activities.

(8) Meandering of River due to changing the stream flow and geometry of river.

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(9) Changing physical characteristic of river and surrounded environment.

4. Conclusion

From the study fallowing conclusions can be made:

This study shows that Busu River shifted in The both banks i.e. right and left bank during the period of 2000 to 2012. However it was found out that major impact of Busu river course change happened to be at the Left side. It was found out that Busu River is both meandering and braided pattern in the study area. High flow velocity and flowing pattern is the main causes of bank erosion and river course shifting. Changing river morphology and human activities have also contributed to higher river bank erosion and its societal impact. Local people have faced severe problem from bank erosion as they have lost residential and farm land, loss of agricultural productivity and other valiable properties.

River course change and bank erosion has provided great negative impact on people's livelihood along the river, loss of properties, income, increased sediment in water which affects water consumption and river water quality.

The northern part of Nabak settlement and middle part of Secondseven and pepsi settlement of the Busu river course have not seen much change (2000 to 2012), because this area covered by hard rock. The greatest river course change and its impact is observed in Nabak, Wain and Busu Compound settlements that is on left bank of the river.

5. Mitigation Measure/Recommendation

From the results and discussion, the study has proven that the changing pattern or course of Busu river change has caused much destruction to its associated land use / land cover. It was also found out that the land availability is decreasing and many household have been removed from 2000 to 2012.

Thus there must be some mitigation measures are to be put forward to reduce the impact of Busu river course change. To prevent future damages we can prepare the embankment, revetment, the wire creating spur. Thus it will be a useful measure to reduce the flow velocity and also protect the bank erosion and down cutting. Scientific River training management, awareness generations in local people to save the food gardens or agricultural area near the river bank is required as well as to reduce the tendency of deforestation, agricultural practices in river bed etc. Some of the Engineering Solutions can also be implemented for problems reductions which are explained here. Bank revetment and or construction of embankment are considered to be the best available engineering response to the serious river course change and bank erosion occurring along the Busu River. The wall construction will also useful where the high curvature and sensitive spot is.

6. References

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