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Landscape Transformation in Turag River Basin between 1980 and 2010

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Abstract
Landscape transformation process for the study area has been analyzed for three decades. The change of each class has been studied and attempt has been made to find out the reasons of changing pattern. The change dynamics were not same all over the study area, so for detail analysis the whole basin has been classified into three different zones (High, Medium and Low land) on the basis of elevation as adopted by Soil Resources and Development Institute (SRDI) of Bangladesh. "Human settlement" has been changed more actively in "High land (Zone 1)", on the other hand "Small area built-up" has been changed more actively in "Medium land (Zone 2)". These two classes have been changed positively. "Forest" has been changed negatively in "High land (Zone 1)" compared to other two zones (Medium land and Low land). "Urban" area has been changed to "Medium land (Zone 2) as it is very near to Dhaka city. Another significant positive change has been found in "Brick field" area in low land (Zone 3) along the main stream of Turag river, and the reason for this is the easy transportation of bricks to Dhaka city and around by river transportation.

Key words: Landsat TM, Landscape transformation, River basin

Introduction

Zhang, et al., 1990 emphasized that river basin plays an important role in geomorphic andhydrologic research and addressing the quantitative measurement of river basin perimeters which leads to a wide variety of applications within the context of spatial databases. It is reported that landuse land cover change analysis is an important tool to assess global change at various spatial-temporal scales. It also reflects the dimension of human activities on a given environment (Lopez *et al.*, 2001). Remotely sensed data may be particularly useful in developing countries where recent and reliable spatial information is lacking (Dong *et al.*, 1997). Studies demonstrated that the transformation of land use/cover either by human activity or natural origin can profoundly impact the hydrological cycle by accelerating volume and rate of surface runoff (Weng, 2001; Shi *et al.*, 2007), mounting flood risk (Nirupama and Simnovic, 2007), degradation of water quality, and causing erosion (Weng, 2001). Transformation of landuse classes within a particular area may be varied from other area, even in a particular area transformation may be varied from one section to other sections. The transformation may be taken place between two landuse classes or more. Considering these facts, the present study has been taken to investigate the landscape transformation in Turag river basin between 1980 to 2010.

Materials and Methods

Study area

The present study has been undertaken to focus the entire Turag river basin as a study area which may also termed as 'basin approach'. The reason behind this approach was to know the complete picture of the study area in an integrated way. Various components for hydro-geological studies of an area like total rainfall, water flow measurement, ground water recharge and fluctuation and as well as the evapo-transpiration can be closely and continuously measured and monitored if that area is a 'river basin'.

The study area is situated within 23° 46' 57.30" and 24° 25' 32.05" N latitude and 90° 08' 56.54" and 90° 26' 15.51" E longitude and generally located at central area of Bangladesh (Figure 1). The study area covers the Savar, Tejgaon, Kaliakoir, Gazipur Sadar, Sripur, Mirzapur, Shakhipur, and Bhaluka Upazilas partially or fully under Dhaka, Gazipur, Tangail and Mymensingh Zilas of Bangladesh. Geographical orientation of the study area in terms of other nearest rivers is as below: Old Brahmaputra River is in the north-east side, Meghna River is in the south-east side, Buriganga River is in the south and Dhaleswari River is in the west.

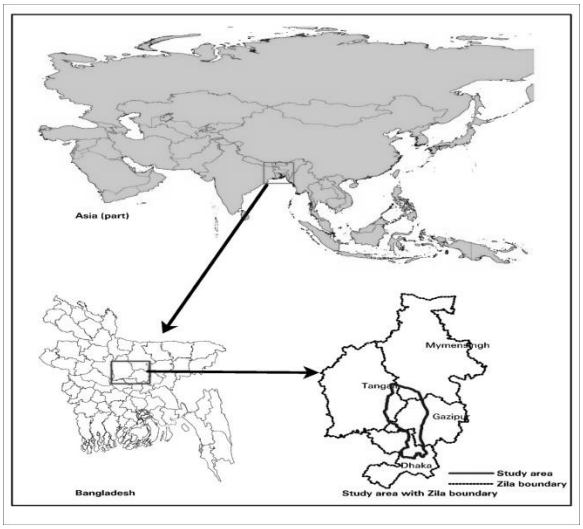

Fig. 1. The study area- Turag river basin.

Data and software used

Black and white aerial photographs of landuse maps of 2000 has been used under supervision from competent authority within SPARRSO laboratory. Landsat TM, Landsat MSS images for the year 1980, 1990 and 2010 respectively have also been used for the study. "Soil and land type map" of Soil Resources and Development Institute (SRDI) of Bangladesh has been used for this study. Digital image processing (DIP) was carried out in ERDAS IMAGINE software. Vector layers have been prepared in Arc/Info software.

The following methodology has been adapted for the present study. The flow chart of the methodology for the present work has been shown in figure 2.

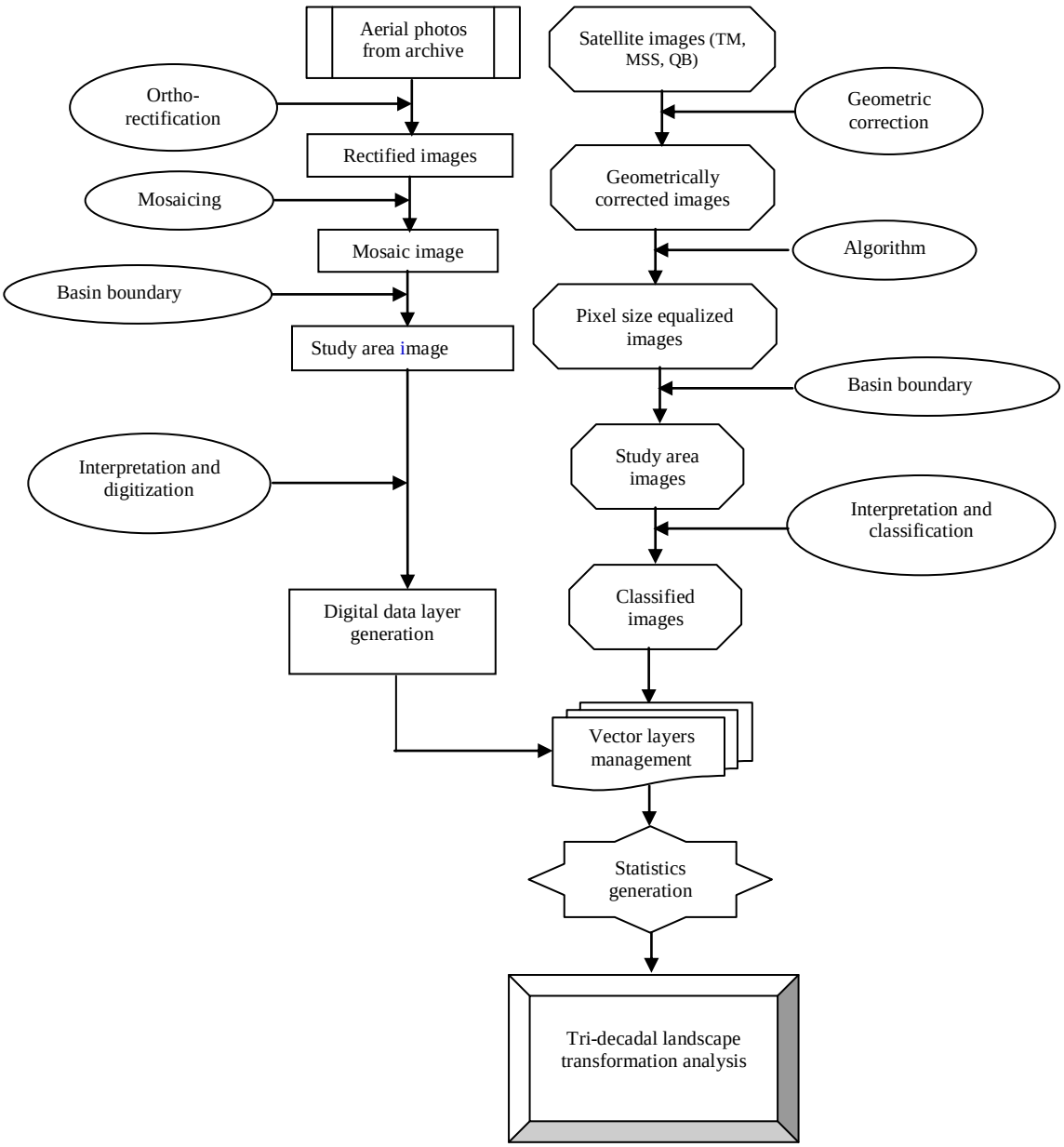

Fig. 2. The flow chart of the methodology of this study

Results and Discussion

Analyzing the landscape transformation in entire Turag river basin

The land use statistics of Turag river basin (TRB) and landuse map has been shown in table 1 and figure 3, respectively below. Then the trend analysis has been done for each landuse and analyzed findings have been recorded in the following sub sections.

Table 1. Aerial extent of landuse and land cover changes in TRB between 1980 and 2010.

Sl. No.	Landuse class name	1980 (area in 'ha' and %)	1990 (area in 'ha')	2000 (area in 'ha')	2010 (area in 'ha' and %)
1	Human settlement	20814.31 (17.94)	26575.97	28981.28	32915.54 (28.36)
2	Small area built-up	605.27 (0.52)	867.67	1297.91	2015.39 (1.74)
3	Urban area	2000.99 (1.72)	2734.00	3189.23	3998.15 (3.45)
4	Forest	16111.3 (13.88)	14492.29	13222.03	9632.22 (8.30)
5	Brick field	78.61 (0.07)	152.06	441.15	484.96 (0.42)
6	Pond	625.8 (0.54)	806.86	1170.61	1247.73 (1.08)
7	Ditch	6389.36 (5.51)	5233.17	3752.88	2121.34 (1.83)
8	Khal/canal	455.27 (0.39)	434.56	419.15	336.2 (0.29)
9	River	1697.29 (1.46)	1422.69	1144.32	730.13 (0.63)
10	Agriculture and others	67269.4 (57.97)	63328.31	62429.02	62565.94 (53.91)
Total		116047.58 (100)	116047.58	116047.58	116047.58 (100)

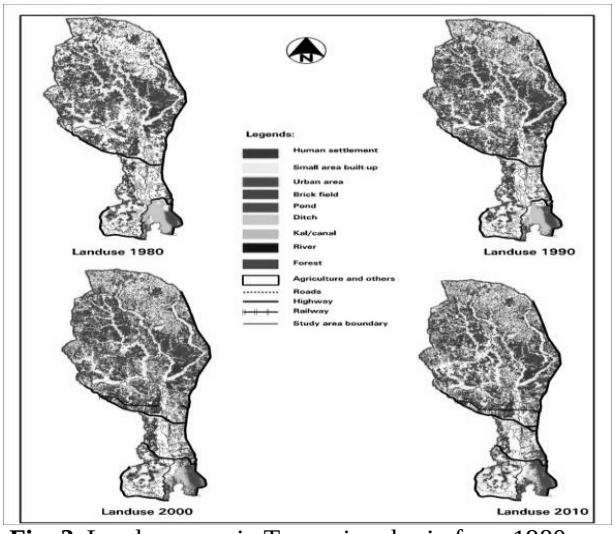

Fig. 3. Landuse map in Turag river basin from 1980 to 2010

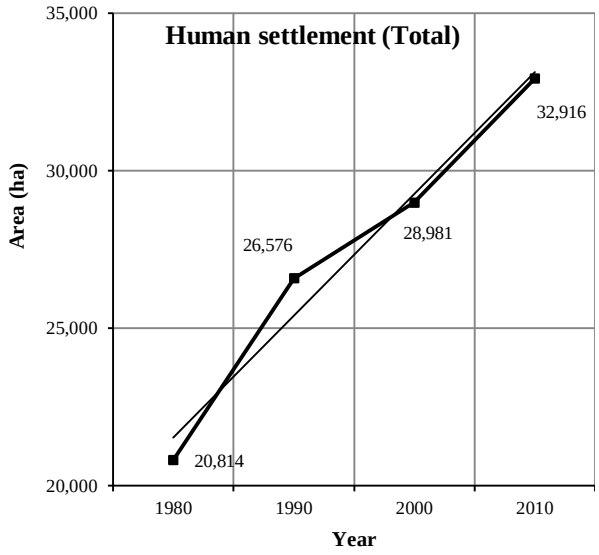

Fig. 4. Change of 'human settlement' area

'Human settlement' area comparison in entire Turag river basin

In Bangladesh, the population is increasing with a significant growth rate since past decades. For maintaining the demand of shelters the more lands are required for human settlement and similar trend has been found in Turag river basin. In the present study it has been found that 'human settlement' area has been increased sharply from 20814.31 ha to 32915.54 ha during 1980 to 2010 (Figure 4). Increasing demand of shelter is another cause for landscape transformation that has been found in the study area. Joint family has been segregated into different families and as a result they need more land for making their new house. In this case mainly agricultural land, some fallow land, and deforested land has been used for building new houses.

'Small area built-up' area comparison in entire Turag river basin

The similar trend has been found for 'small area built-up' also. The area under this landuse has been increased from 605.27 ha to 2015.39 ha during 1980 to 2010 (Figure 5). Several growth centres has been built in the study area and centered on this small market, shops, hat-bazar has been developed. Along with the rapid growth of population the new infrastructure has been developed for various demands and needs. Growth centre, markets, hat-bazar, educational institutions, health service institutions, industries, roads, highways, water protection dam has been constructed in the study area. Along with this a significant growth has also been taken place for urbanization. As a result a great landscape transformation has been taken place among variouslanduses in the study area.

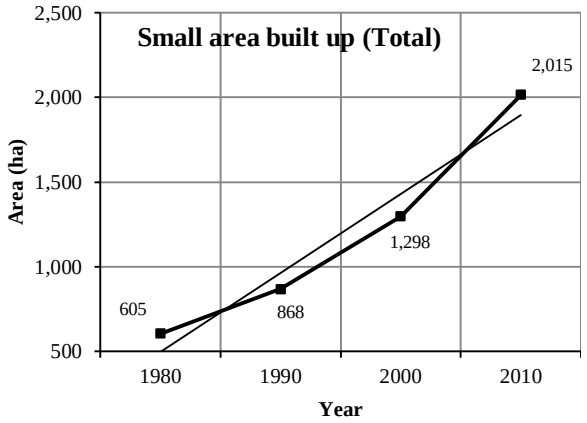

Fig. 5. Change of 'small area built-up'

'Urban area' comparison in entire Turag river basin

Urbanization is another landuse in the study area which has been found as one of the most dynamic pattern. The area under urbanization has been increased from 2000.99 ha 3998.15 ha (Figure 6) during 1980 to 2010 both as planned and unplanned as well.

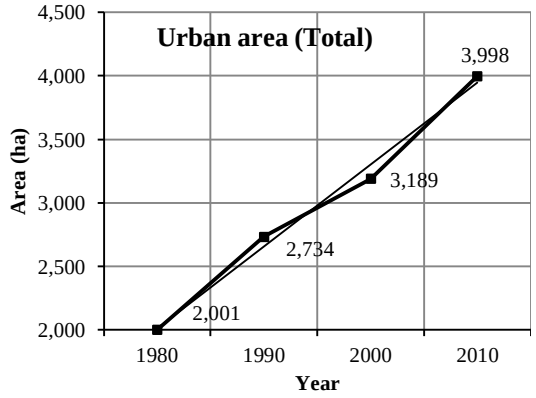

Fig.6. Change of 'urban area'

'Forest area' comparison in entire Turag river basin

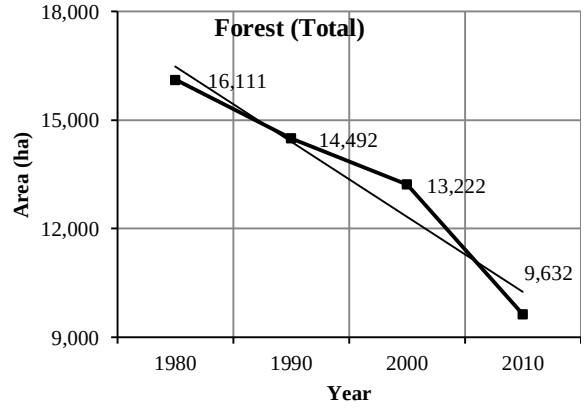

Fig. 7. Change of 'forest area'

Forest area has been decreased in the study area from 16111.3 ha (13.88% of total landuse of 1980 shown in table 1) to 9632.22 ha (8.30 % of total landuse of 2010 shown in above table1 between 1980 and 2010, and this area has been converted to mainly for human settlement and other infrastructure construction and some parts are also being used for agriculture (Figure 7). The decrease of the forest area is an alarm for environmental degradation in the study area. Deforestation is one of the landscape transformation processes that occurred in the study area. As the population is growing up, therefore, land clearing has been occurred initially for agricultural cultivation, human settlement development, and so on.

'Brick field'area comparison in entire Turag river basin

The area under brick field has also been increased from 78.61 ha to 484.96 ha during 1980 to 2010 and as a reason it has been found that a rapid urbanization has been taken place during this period (Figure 8). A large number of brick filed has been constructed in the study area and it is mainly along the bank of Turag River and also parallel with the highway of Gabtoli Bazar to Nabinagar area of Savar upazila. Similar situation has also been noticed along with Tongi-Bypass highway. The main cause for construction of these large numbers of brickfield is to meet the demand of brick that required for building the houses, roads and other infrastructures as a result of rapid urbanization in and around Dhaka city. In this case semi-low land, low land and some agricultural land has also been transformed for the construction of brick fields in the study area.

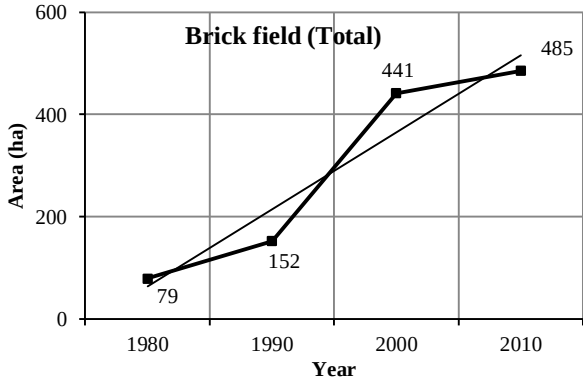

Fig.8. Change of 'brick field area'

'Pond area' comparison in entire Turag river basin

The area under brick field has been increased from 625.8 ha to 1247.73 ha (Figure 9) during 1980 to 2010. Initially it has been surprised to see the increasing of this (pond) landuse but through field investigation it has been found that this is due to the rapid development of aquaculture/fisheries development in the mid and upper parts of the study area. It has also been noticed that a number of land filling has been done on some ponds in urban area but as a whole the pond area has been increased in the study.

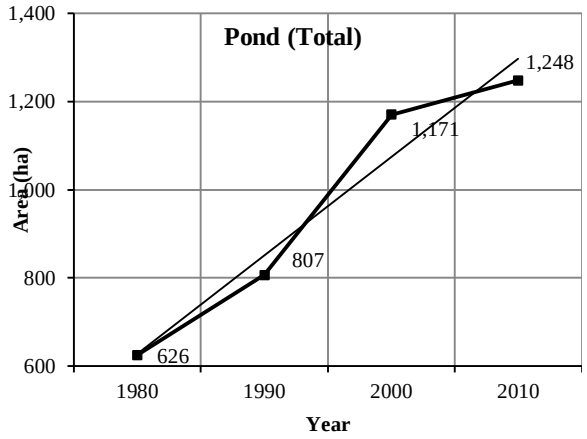

Fig. 9. Change of 'pond area

'Ditch area' comparison in entire Turag river basin

Ditch area has been decreased in the study area from 6389.36 ha to 2121.34 ha (Figure 10) during 1980 to 2010 and this area has been converted to high or medium land urbanization and other infrastructures construction.

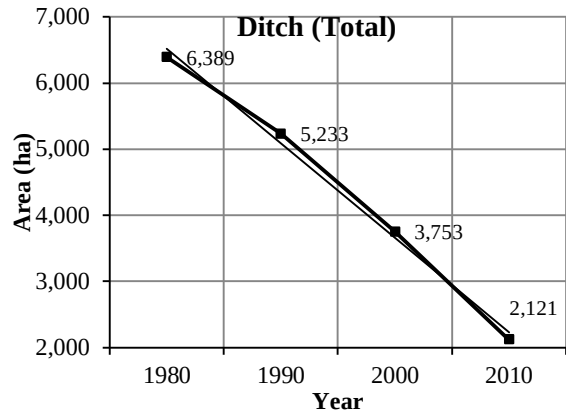

Fig. 10. Change of 'ditch area'

'Khal/Canal area' comparison in entire Turag river basin

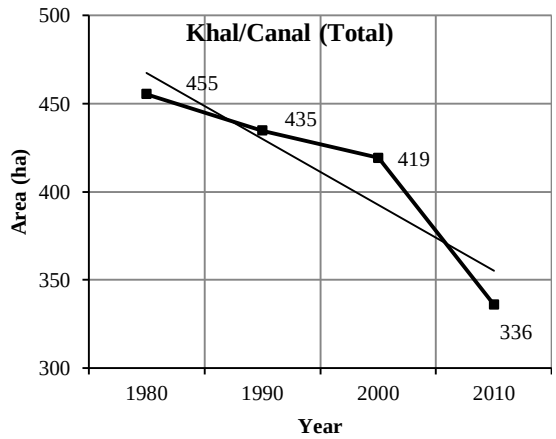

Fig.11. Change of 'Khal/Canal

Khal/Canal area has been decreased in the study area from 455.27 ha to 336.2 ha (Figure 11) during 1980 to 2010 and this area has been converted to high or medium land urbanization and other infrastructures construction.

'River area' comparison in entire Turag river basin

River area has been decreased in the study area from 1697.29 ha to 730.13 ha (Figure 12) during 1980 to 2010 and in some parts the river area has been occupied by the people for their own interest and building construction. As a result, the normal flow of the river has been interrupted and the water navigation from Ashulia landing station towards down to Gabtoli Amin Bazar has been hampered during the dry seasons of the year.

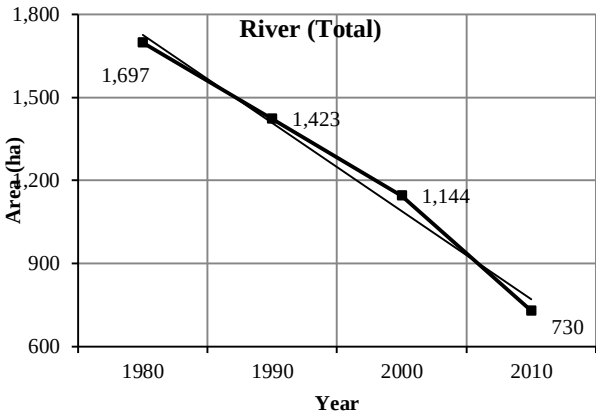

Fig. 12. Change of 'river'

'Agriculture and others' comparison in entire Turag river basin

Agriculture and others (here 'others' mean fallow /barren land) has been decreased in the study area from 67269.4 ha to 62565.94 ha (Figure 13) during 1980 to 2010, as a result per head agricultural land has been decreased in the study area. Excessive and unplanned uses of pesticides, fertilizers are being practiced, and as a consequence, men animals are being affected by 'residual effects' of chemical through food chain. The forest land, fallow land and some extent the 'baid', river bed, small khal/canal bed has been transformed for agricultural cultivation.

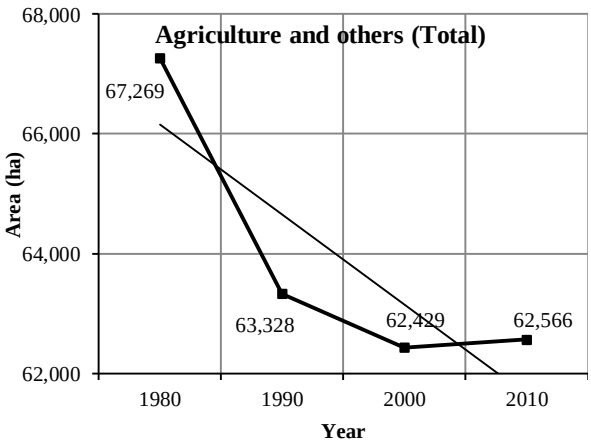

Fig.13. Change of 'agriculture and others'

Analyzing the landscape transformation in different zones (High land-Zone 1, Medium land-zone 2, and Low land-zone 3) of TRB

Detail transformation of different landuse in the Turag river basin has been analyzed from the year 1980 to 2010 not only for TRB but also in different zones i.e High land (Zone-1), Medium land (Zone-2), and Low land (Zone-3). The extent and magnitude of landuse changes have not been occurred in the same way across the entire TRB. So the detail analysis has been done separately in all three zones of TRB. The whole Turag river basin has been classified into High (Zone 1), Medium (Zone 2) and Low (Zone 3) land on the basis of elevation as adopted by SRDI of Bangladesh. The classification of Turag river basin as High (Zone 1), Medium (Zone 2) and Low (Zone 3) land has been shown in figure 14 and the statistics in table 2.

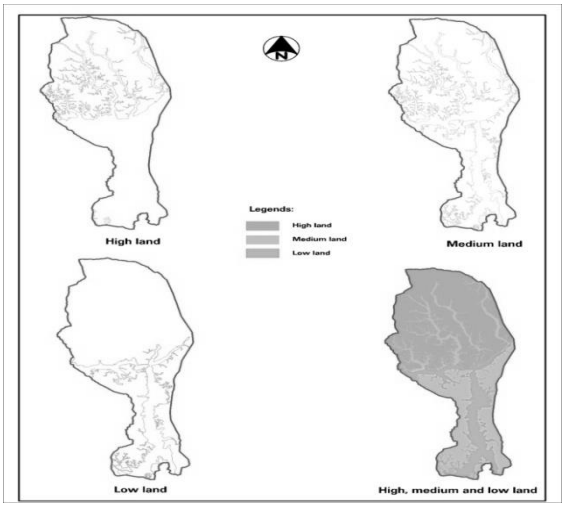

Fig. 14. Landscape map of Turag river basin

Table 2. Extent of the types of the landscape in Turag river basin

Sl. No.	Landscape organization	Area in (ha)	Area in (%)
1	High land (Zone 1)	60447.14	52.09
2	Medium land (Zone 2)	37805.92	32.58
3	Low land (Zone 3)	17794.52	15.33
Total		116047.58	100

The distribution of different landuse classes has been analyzed Zone 1, Zone 2 and Zone 3 for different years and landuse statistics comparison between the year 1980 and 2010 in above three zones has been shown in table 3.

Table 3. Comparison of the extent of landuse in TRB between 1980 and 2010

Sl. No.	Landuse classes	Zone 1(ha)		Zone 2 (ha)		Zone 3 (ha)	
		1980	2010	1980	2010	1980	2010
1	Human settlement	13526.55	21955.58(+)	6759.57	9733.85(+)	528.19	1226.12(+)
2	Small area built-up	114.52	397.31(+)	428.57	1430.47(+)	62.18	187.61(+)
3	Urban area	0.00	0.00	1987.12	3470.74(+)	13.87	527.41(+)
4	Forest	13145.25	7762.97(-)	2947.84	1855.13(-)	18.21	14.12(-)
5	Brick field	1.14	9.67(+)	21.87	120.14(+)	55.60	355.15(+)
6	Pond	221.76	372.95(+)	354.72	623.77(+)	49.32	251.01(+)
7	Ditch	177.15	86.21(-)	1863.11	525.60(-)	4349.10	1509.54(-)
8	Khal/canal	3.63	4.84(+)	368.17	260.06(-)	83.47	71.29(-)
9	River	20.79	0.00(-)	122.22	12.78(-)	1554.27	717.34(-)
10	Agriculture and others	33408.45	30157.88(-)	22919.84	19646.44(-)	10941.11	12761.59(+)
Total		60619.24	21955.58	37773.03	9733.85	17655.33	1226.12

(+), (-) sign indicate the increasing and decreasing of area respectively.

Then the comparison of trend analysis in different zones has been done for each landuse and analyzed results have been shown in following sub-sections.

'Human settlement' area

Area was increasing from the year 1980 to 2010 and for this landuse it has been found that Zone 1 is more active than Zone 2 and Zone 3 (Figure 15).

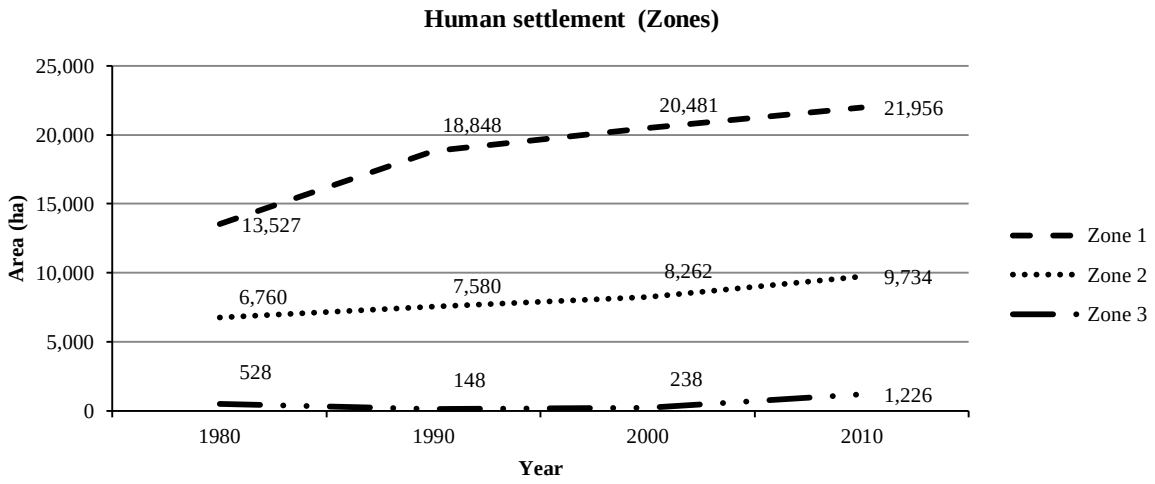

Fig. 15. Change of 'human settlement' area in different zones.

'Small area built-up' area

Area was increasing from the year 1980 to 2010 and for this landuse it has been found that Zone 1 is more active than Zone 2 and Zone 3 (Figure 16).

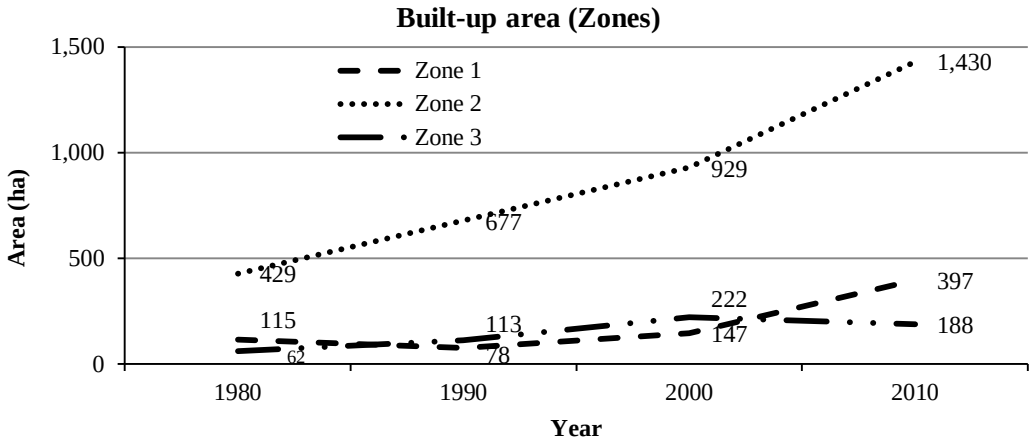

Fig. 16: Change of 'small area built-up' area in different zones

'Urban area'

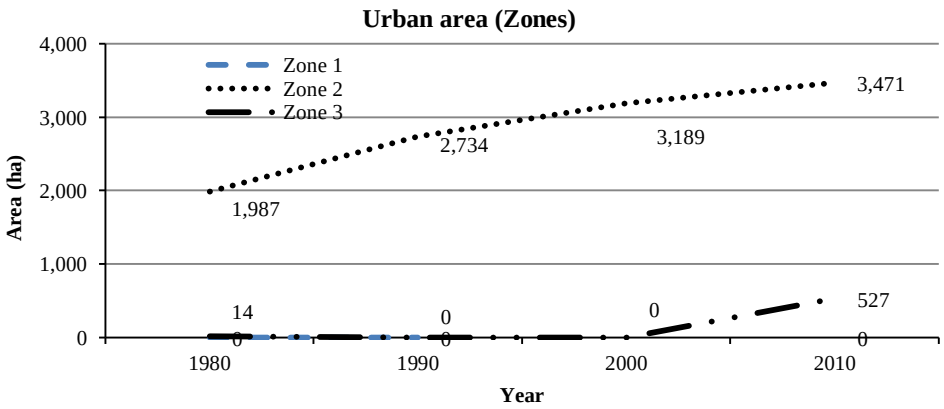

Fig. 17: Change of 'urban area' in different zones

Area was increasing from the year 1980 to 2010 and for this landuse in Zone 2. There was no urban area in Zone 1 and in Zone 3 a very little urban area has been found and those are basically unplanned urbanization in low land (Figure 17).

'Forest area'

Area was decreasing from the year 1980 to 2010 and for this landuse in zones 1, 2 and 3. Most of the forest area has been found in Zone 1 and very less in Zone 3. As the settlement area has been increased in Zone 1 and almost in a same way the forest area was decreasing in Zone 1. It indicates that the forest land has been clearing out for human settlement and for building up the other infrastructures (Figure 18).

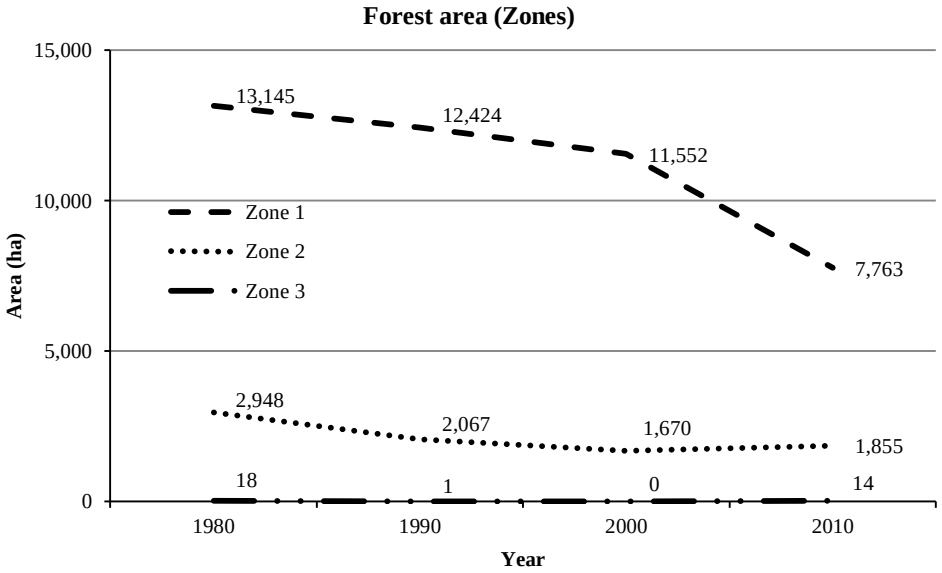

Fig.18. Change of 'forest area' in different zones

'Brick field' area

Area was increasing from the year 1980 to 2010 and for this landuse in. The increasing rate was very high in Zone 3 compare to Zone 2 and Zone 1 (Figure 19). As a reason for highest area of brick field in is found that the brick transportation facilities are easy through waterways in Turag river. Secondly, the reason for second highest area of brick fields in Zone 2 may be the higher demand of brick for urbanization in Dhaka city and around. Thirdly, the lowest area in Zone 1 is may be due to some embargo from environment for not to construct brick fields near to forest areas (mainly reserve forest), basically which is mostly located in Zone 1 of Turag river basin.

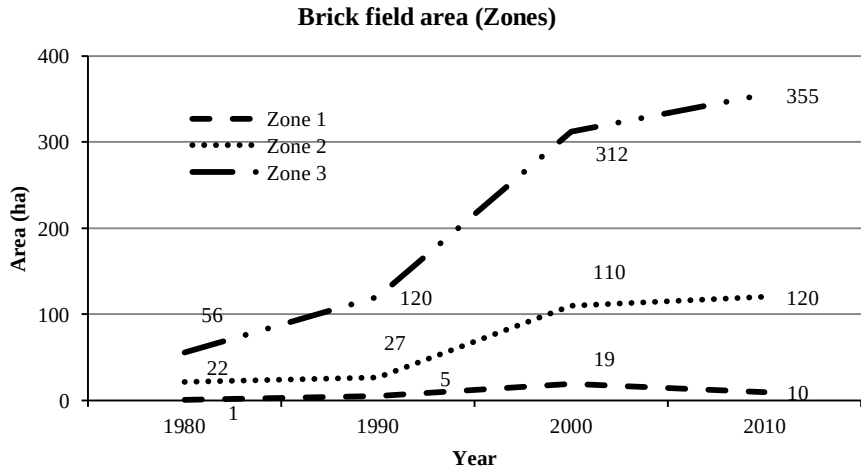

Fig.19. Change of 'brick field' area in different zones

'Pond area'

Area was increasing from the year 1980 to 2010 and for this landuse in zones 1, 2 and 3. The increasing rate and the area were high in Zone 2 compare to Zone 1 and Zone 2 (Figure 20). It has been found that as a popularity of aquaculture/fisheries many fish farms have been established in the area especially in Zone 2. Secondly, the pond area was more in Zone 2 compare to Zone 1 which may be due to low elevation, as a result, water can retain longer time compare to high elevation land.

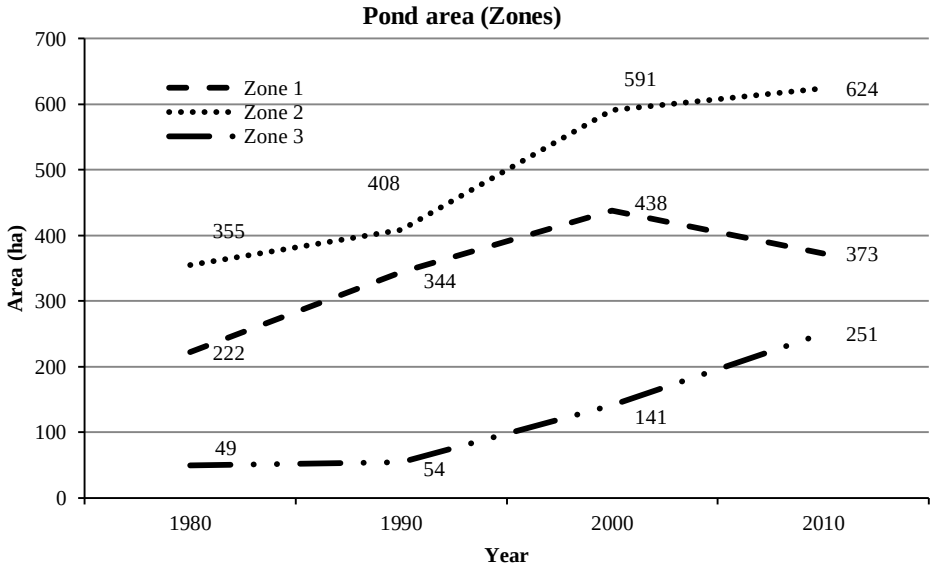

Fig. 20. Change of 'pond area' in different zones

'Ditch area'

Area was decreasing from the year 1980 to 2010 and for this landuse in zones 1, 2 and 3. Highest areas in Zone 2 compare to Zone 3 and Zone1 (Figure 21). Decreasing rate was highest in Zone 2 compare to Zone 3, whereas the lowest rate in Zone 1. It has been found that a lot of ditch are has been filled in through land filling for urbanization and other housing purposes.

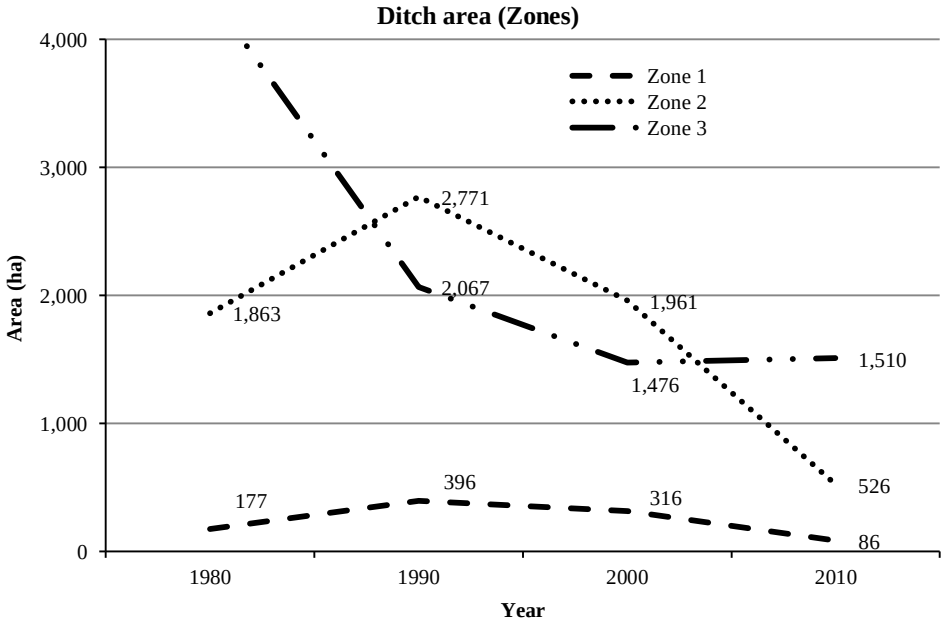

Fig. 21. Change of 'ditch area' in different zones

'Khal/Canal area'

Area was decreasing from the year 1980 to 2010 and for this landuse in zones 1, 2 and 3. Highest area in Zone 1 compare to Zone 3 and Zone 2. Decreasingrate was highest in Zone 1 compare to Zone 3, whereas the lowest rate in Zone 2 (Figure 22).

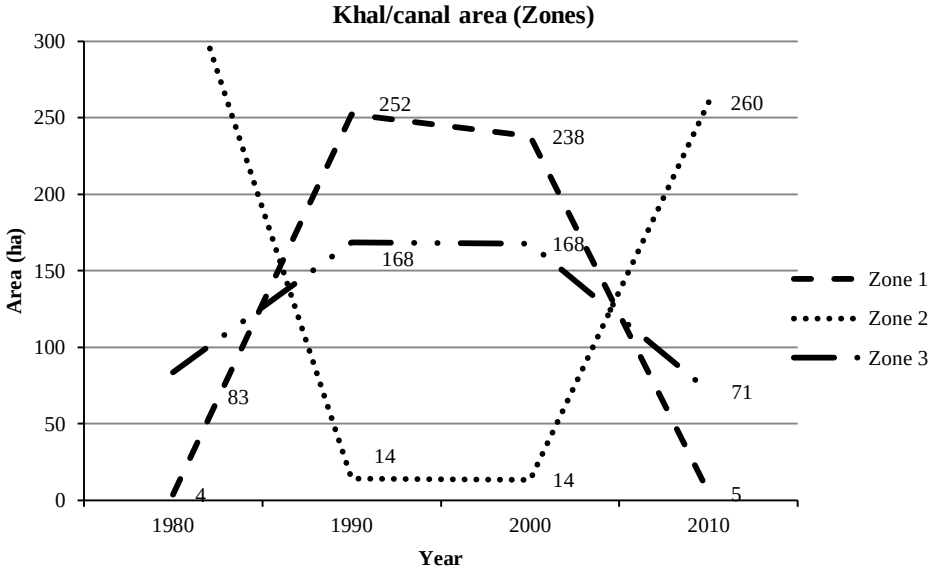

Fig. 22. Change of 'khal/canal area' in different zones

'River area'

Area was decreasing from the year 1980 to 2010 and for this landuse in zones 1, 2 and 3. Highest area of river located in Zone 3 and small areas are located in Zone 1 and Zone 2 (Figure 23). Decreasing rate was highest in Zone 3 compare to Zone 2, whereas the lowest rate in Zone 1. The main areas of Turag and 'Karanati' rivers are located in Zone 3**.**

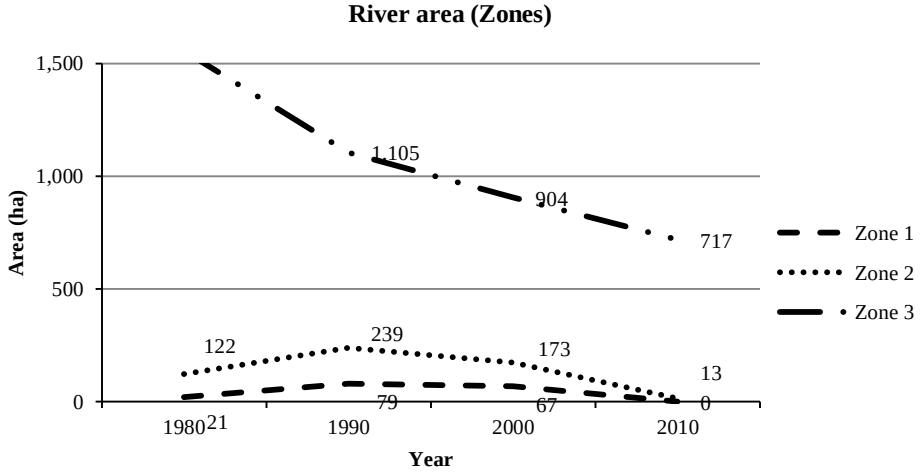

Fig. 23. Change of 'river area' in different zones

'Agriculture and others'

Area was decreasing from the year 1980 to 2010 and for this landuse in zones 1 and 2 (Figure 24). In Zone 3 areahas increased a little, and basically it is the increasing of low land which is being made ready for urbanization. Generally the area of 'agriculture and others'landuse was decreasing in the Turag river basin from 1980 to 2010.

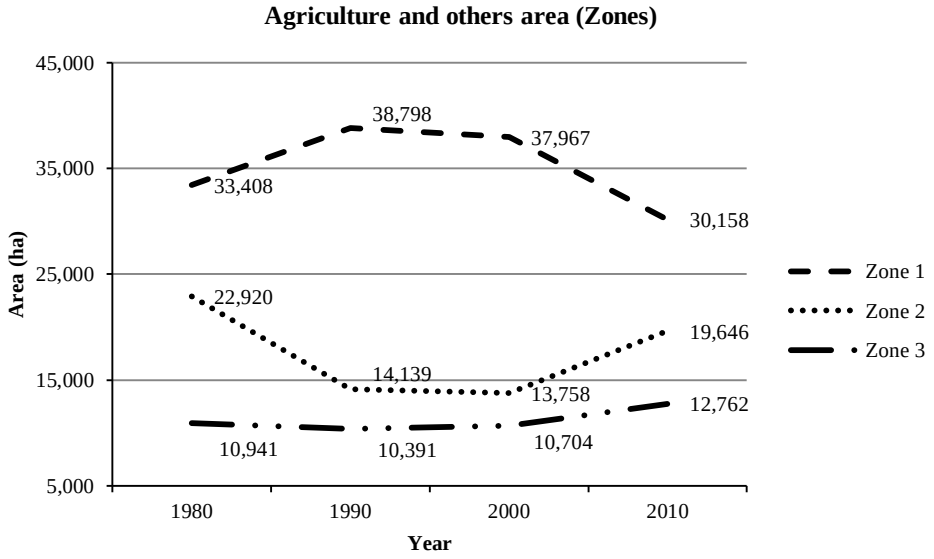

Fig. 24. Change of 'agriculture and others area' in different zones

Conclusions

Both direction and magnitude of landscape changes of TRB were found and documented in this research. The changes in forest area to built-up and agriculture area and losses of wet land through converting the drainage and ditch to other types of landuseare phenomenal.The studyperformed quantitative analysis on the magnitudeand patterns of landscape changes for the last three decades in Turag river basin and thus the findings are valuable resources for planners and decision makers to devise sustainable landuseand environmental planning.

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