

Impact of Landuse Changes on Bagmati River

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Abstract: The cities like Kathmandu undergoing rapid urbanization within a period of few decades are exerting tremendous pressure on the limited land, thereby transforming them into impenetrable surfaces. The concealed surfaces not only prohibit the augmentation of the ground water but also sweep the pollutants to the adjacent water resources. In the study area, the present land use typologies ranges from the urban land use, comprising of the built up structures and road networks, to the vigorous waste disposal areas resulting into excessive amount of chemical nutrients reaching the Bagmati area. However, positive development is evident with the emergence of forest area conserved by a local community based organization. Accordingly, the water quality of lower stretch comparatively is in good condition as compared to the upper stretch. The study is aimed at understanding the land development trend along the riverbanks of the Kathmandu valley with their cause-effect relation by considering a specific case in the urban area.

Keywords: Landuse; Water Quality and Quantity; Urban Growth.

1. Introduction

Kathmandu is the largest urban conglomerate in the entire country comprising one third of the national urban population, increasing at the rate of 4% (World Bank, 2013, p. 27). The massive population explosion in the valley in short time supplemented with the absence of efficient land use planning caused the haphazard change of land for urban usage especially along the alignment of the road networks. Prior to 1970, the urban area of Kathmandu was delineated from Bishnumati River and Dhobikhola River in east-west, and Bagmati River and Maharajgunj area in North-south (ICIMOD, MoEST, & UNEP, 2007, p. 46). Evidently, with the introduction of the Ring Road in 1970s, it triggered the urban growth beyond the traditional boundaries and hence in the 2000's era Bagmati River has become the sole boundary between the two districts, Kathmandu and Lalitpur without any river bank.

The Bagmati River suffered the consequences of the land use change in the Kathmandu valley: vanishing aquatic and terrestrial biodiversity, extreme water pollution leading to loss of its socio-cultural values. Apart from this, due to the immense land sealing, it is hard to recharge the ground water resulting into low water table and thus decrease in the water level in the river. Markedly, in case of the rivers of the Kathmandu Valley, the river banks are the easily available space for the settlement of economically deprived communities and more surprisingly, river banks, in the whole stretch within the urban area, are the solid waste disposal sites that are regarded as one of the undesirable activity in the premises of any water body. For the most part, riparian buffer that filters the

excessive nutrients before the runoff reaches the river territory have almost disappeared.

2. Statement of Purpose

2.1. *Research Objectives:*

- To understand the trend of land development in the riparian area.
- To comprehend the impacts of riverbank settlement on Bagmati River
- To brief the existing legal and institutional framework for the protection and maintenance of Bagmati River

3. Research Methodology

3.1. *Research Technique and Strategy*

The research was both the qualitative research and the quantitative research following descriptive case study strategy. The case study was conducted to the answer the questions like 'how' and 'why'. The qualitative research was conducted through the direct observations and the interactive interviews with different stakeholders like the local communities, experts, community based organizations (CBO), legal authorities, I/NGOs, etc. The interviews were unstructured interviews with open ended questions. The questionnaire was rechecked after 5 to 6 interviews. Another research strategy was the correlational research or the survey research which was the quantitative research. The survey was the random stratified survey for the riverbank communities of the Bagmati River. The structured questionnaire survey

was carried on location covering 20% of the riverside communities. The entire questionnaires are broadly categorized into three: Drivers of land use change, Waste generation and management, and their impacts.

3.2. Research method

Table 1: Research Methods

Objective	Methods
To verify the problems and issues of Bagmati river pollution from different literatures	Literature study Site observation Questionnaire with locals
To understand the trend of land development in the riparian area.	Analysis of map of 1978, 1990, 2000, 2012 in GIS Questionnaire with locals
To comprehend the impacts of riverbank settlement on Bagmati River	Site observation Questionnaire with locals and responsible authority
To brief the existing legal and institutional framework for the protection and maintenance of Bagmati River	Study national legislation and policies Questionnaire with responsible authorities

4. Results

4.1. The Case Study Area

The study area is delineated from the Teku to the Chovar section from the edge of the River to the next road. It is located in southern section of the Kathmandu Metropolitan city and the Kirtipur Municipality covering around 1078.85 km² of the river bank area from Kalopul Teku to Chovar. The study area is at 400m and 1000m distance from the historic core of Kathmandu and Kirtipur respectively from the nearest distance.

In terms of land use, the study area comprises of moderate to high density residential and commercial area with 59% and 33% respectively. Specifically, the density varies within the segment: Teku- 262.36 person per hectare, Kuleshor- 371.55 per hectare and Kumari club- 109.54 person per hectare. This data does not represent the density of the informal sector as the settlement has formed a separate block with very high density of nearly 1000 person per hectare.

The Balkhu junction is the one of the major connector between Kathmandu and Lalitpur District, particularly from the date of construction of Ring road in 1970s. The suspension bridge at Chovar dates back to Rana period connecting Chovar to the Sainbu in Lalitpur District. The proximity to the exit point to the Kathmandu valley through road network led to the wholesale market in the area requiring heavy transportation in the recent decades. The Dakshinkali

road that joins Kathmandu to Kirtipur to Chovar is also called Ishwori highway which connects Kathmandu valley Hetauda Municipality. However, due to the road condition, the highway is not usable during rainy season.

4.2. Land Use Analysis of the Study Area

Table 2: Land Use Change (in percent) from 1979 to 2012

(Source: Land use map from Genesis)

	1979-1990	1990-2000	2000-2012
Agricultural	18.06	-1.93	-16.47
Forest	-10.08	0.98	0.33
Institutional	-2.40	1.34	-0.01
Vacant	8.01	-6.53	10.30
Recreational/ Open Space	3.30	-0.03	-0.01
Residential	5.76	11.73	10.91
Transportation	-	0.44	0.47
Water body	-24.79	-6.02	-5.53

From the analysis of land use of different time it was observed that in 1979, the river bank was characterized predominantly by agricultural and forest area by occupying 16% and 21% land respectively. Contrastingly, in the year 2012, residential land increased to 29% reducing the forest by 9%. During the decades of 1990s and 2000s, the riverbanks were extensively used for the agricultural purpose: the land compensated by the shrinkage of the river area itself. However, it plunged by 15% in the 2012. Notably, one of the features of riverbank in recent decade is the absence of the riparian buffer in the urban area. Nevertheless, the downstream section remained relatively unchanged as compared to the upper stretch.

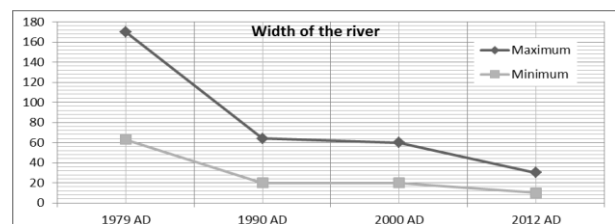


Figure 1: Change in the River Width

The river area declined specifically during the decade of 1980s that slowed but continued in the later decades creating the unclaimed land and easing the riverbank encroachments. At present about 0.14 sq. km. land is occupied illegally in the riverbank of Bagmati River in the study area which is obtained by analysis land use maps. In addition, the land use of river banks is primarily characterized by the dumping sites.

4.2.1. Drivers of Land Use Change

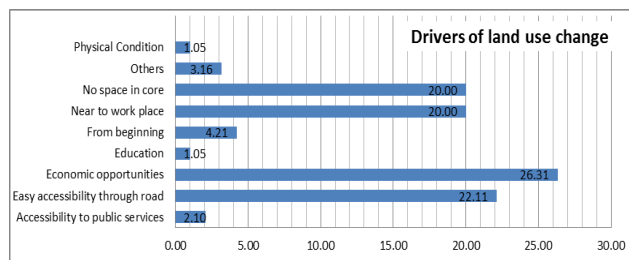


Figure 2 Drivers of Land Use Change

The study revealed that the major reasons for the selection of the area is due to the economic opportunities and easy accessibility through road that covers 26.3% of the sample population. From the survey, in Kuleshor and Kumari club, the easy accessibility through road networks developed urban growth of the area. However in case of Teku, 39% said the reason for settling is due to the economic opportunities and 30% said they had shifted from the core. The numbers were also high for “no space in core” in urban expansion, which tells that this place is also the expansion area of the core. For the most part, the economic opportunity is the major pull factor in all the places.

Being closed to the exit of the valley, Kalanki, and due to the Ring Road, the commercial development that requires heavy transportation like wholesaler for fruit and vegetable market has triggered in this area. According to the vegetable market staff at Balkhu, the reason behind establishing the market in Balku is due to its proximity to the Ring Road, as the heavy vehicles are prohibited to enter the city core during peak hour. Infact these developments has triggered other development in these areas. The area near Kuleshor wholesaler has developed as the godown area with thin residential density in that area. The hospitals and educational institutions have induces more commercial activities like small restaurants, shops in these area.

4.3. Relation of Land use and Water Quality and Quantity

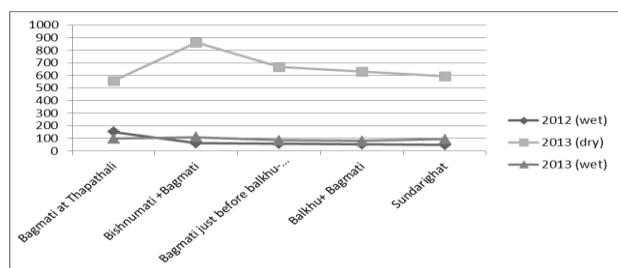


Figure 3 COD content in Bagmati River in two seasons

(Source: HPCIDBC)

The type of land use has direct influence on the quality of water as whatever falls on the catchment area ultimately reaches the river premises. From the above chart, it is evident that the water quality is poor in the study stretch and particularly worst in the dry season: the major factors being the amount of chemical nutrients reaching the river and the water availability in the river.

The analysis of the land use map showed that the open space in the study area is less than 4%, of which the percentage is almost negligible in the upper segment. The available space has also been used for the solid waste disposal. The situation is further worsened as the ground coverage of over 67% of individual plots exceeds 80%. Of the residential land, 74% households have completely sealed open spaces. As a result, there is very low ground water infiltration with high speed urban runoff increasing sediment transport to the river through drains and roads.

As a matter of fact, during the rainy season, 268159.17X1000000 cu. m. rain water collected from 50m distance, which comprises of greater than 80% of total rainfall, carries all the surface material directly to the river causing flooding in the river. On the contrary, in dry season, less than 20% water available cannot neutralize the excess amount of chemicals in the river. Infact, for most of this time, the river remains dry with high COD as shown in above chart. Therefore, the land use has indirect impact on the water quantity and ultimately the water quality of the Bagmati River.

Another important issue is the land being used as the open dumping site. 23% of the respondent admitted that they dispose their household waste in the riverside especially in Kumari club and Teku area. Even though the management of the vegetable and fruit market claims for the responsibility of their waste, the adjacent lands were filled with tons of garbage. Daily about 12 to 13 tons waste is generated by fruit market at Kuleshor. More surprisingly, the Teku river bank was leveled by laying solid waste like the landfill site. Consequently, these are proven by the sudden rise of ammonia from Thapathali to Teku and beyond.

The sewerage connection of the households without treatment in Kumari club, in the same manner, shows the high level of Phosphate in the area. Since the entire sewerage network in the valley ultimately connected to the rivers and with an average of 150 l sewerage per day per household per day, 140000 l of residential sewer reaches the Bagmati River solely from the study area without treatment (includes formal and informal settlement).

Land encroachment is another critical issue which is not limited to the informal settlement but also by the

formal institutions. The change in river area into the vacant land has eased the urban growth in the river banks. This has led to the less area as buffer strip which is vital for maintaining the river quality.



Figure 4 Land Encroachment in various locations

5. Discussions

The study area can be called as the city of 1990s as the urban growth in this area started noticeably from this period. The land conversion has been sequential in the area from river area to agricultural land to built-up area. From 1979 to 1990, the width of the river decreased significantly, which remained either vacant or converted to the agricultural land during 1990 to 2000. The residential development, in general, first took along the side of Balkhu-Kalimati road on the northern stretch and gradually expanding towards the south engulfing the agricultural land. In 2012 the river bank was completely covered to the built structures with the emergence of informal community in the area.

The development of the segment upto Teku was seen during late 70s. Lying close to the historical cores Kathmandu and Kirtipur, it has been the urban expansion area of these centers. The riparian development has been taken on the banks of Bagmati River in the Kulleshor Balkhu area. The other areas in Teku and Chovar have minor changes from 1979 map as compared to the Balkhu area. The land development were seen in Teku in 70s while, in Chovar the development has not been accounted much. In the Chovar area, the development is checked by its physical attributes like geology, gradient and maintenance of forest area by the local community.

The encroachment in the temple land by the guthi members has also been one of the major land issues related to the temples. The lands of Jal vinayak temple complex has been illegally transformed as their individual property. Hence, this has indirectly altered the land function of that locality. The temple area maintained the green belt along the river bank, but with the illegal acquisition of temple land into individual

land, there is the probability of conversion of green areas into more built up structures.

While the road development induced residential and commercial development in the area, these development inturn turned the buffer area into the crude landfill sites for their daily demand waste discard. These land fill sites are seen in all three segments of the study area: at Teku, Kulleshor and Kumari club. The transfer section at the Teku area is the temporary dumping ground of Kathmandu district situated on the bank of Bishnumati River declared by the Government of Nepal. In the absence of landfill sites, the river bank in the Kumari club area has been the dumping ground for the entire Kumari club and partly for Kirtipur municipality and area beyond the study area. The small rivulets, Tekhushi and Silkhusi have literally turned into the sewer system of the local area.

Since the Bagmati River and its tributaries are mostly the rain-fed rivers, the quantity of water in the river solely depends upon the amount of rainfall. Therefore, the rivers are flooded during dry season and almost waterless during the dry season. Earlier land uses characterized by abundant open spaces with water holding capacity, provided the opportunity for the storage of storm water in the form of ground water. Since there is very low storage of ground water, it has declined the gaining characteristics of the Bagmati River leading to the drying up of the river in the dry season. At the same time, the green buffer area that absorbs the excess nutrients from the urban runoff has vanished resulting into direct contact of nutrient rich runoff comprising sediments and wastes from the land surface into the river. These can be seen in as the accumulation of the wastes like plastics, metals and papers during dry season on the river beds.

With the construction of the sewerage network, it will intercept the natural path of the storm water and will be collected with the trunk sewer. Equally important is the fact that there is no separate system of waste water collection system. Consequently, the grey water and storm water that requires less treatment than black water is also sent for the same procedure increasing the cost of the treatment system. All these things considered this will have negative impact on the possibility of recharging the river.

The construction of the riverside road is proposed in every stretch of the Bagmati River after the construction of the retaining wall and the sewerage system. The width of the road is designed 10 m that includes 2m pedestrian was after 20m buffer from the river side. At present there is no river side road in this stretch except for around 900 m road in Balkhu and

600 m Dakshinkali road. However, the river intersects one of the major junctions with heavy traffic flow at the Balkhu Ring road and runoff from this road directly enters the Bagmati River. Accordingly, in absence of the riparian there is high chloride intrusion in the river.

5.1. Analysis of 20 m Setback for Pollution Control

The HPCIDBC has stated that any construction is permitted after the 20m setback from the river boundary and the width of the river should be maintained at 80m. The demarcation of the river width and the river territory is the positive aspect for the prevention of the land encroachment. According to the construction company, at present river training work is carried out with 30 m land setback that include 10m road and 20m green buffer on both side. However, the area demarcation is done on the basis of the flood discharge rather than for extenuating river pollution. For mitigating pollution in the river, the desired width of buffer should be atleast 14m to 100m, for pesticide removal and 5m to 50 m for nitrogen and ammonia removal (Hawes & Smith, 2005, p. 4). Infact, it is required 10 to 30m, especially for the restoration of the aquatic habitat and chloride removal. Therefore, the setback designated by the authority along with the stated river width is not enough for the present context since the river condition is very poor. On average atleast 15m uninterrupted buffer is necessary for low level of pollution.

5.2. Legislation on Land Use and Natural Resources

The legislation for the protection of the natural resource is very limited to the declaration of the river property and punishment related to the pollutant. The legislation and the byelaws for the land development especially for the construction in the riparian have not been formulated. As a result there is massive land coverage by the built structures and open spaces are limited and mostly sealed. In addition, the planned residential area in Balkhu fruit market has ground coverage more than 80% and lacks the area of open space required by planned area. Infact, the existing rules and regulations are even not followed in the study area. For instance, though the large organizations like fruit markets and vegetable markets are dumping solid waste distinctly in the river area, the government is initiating no action against such illegalities. The Vayodha hospital which was established on 2011, has illegally occupied the riverbank of the Bagmati River. Therefore due to the weak implementation of the existing legislation, the activities that are regarded as crime are distinctive.

5.3. Positive development along the study area

Apart from all the negative trend booming in the study area, there are few initiatives that helps in promoting the water quality of the Bagmati River. First is the Jal Vinayak community group that is conserving the forest in the Chovar area and also created the park named Manjushree park in the area. The runoff from the forest possesses basic visual qualities and the chemical nutrients are low in this area. The second is the proposal for the UN park in Teku and plantations in different locations. Private plantation area is seen in staff quarter and a nursery area at Kirtipur. Interestingly, it is observed that the area encroached by the informal settlement comprises of the green area in most of the river edges contrastingly with the area encroached by the formal sector. Third are the waste vendors at Teku. The waste vendors at Teku can have the significant role in the management as the exchange waste all over the city. However, according to them, they do not collect waste from the river banks. Infact, outside rag pickers are not permitted in the transfer station which is located opposite to these vendors.

6. Conclusion

With all these points in consideration, it is thus concluded that the water quality is directly proportional to the land uses. The increased urban land use means the growth in the built up that increases the run-off that carries significant amount of pollutants to the river, and also seal the rechargeable area. In case of the Bagmati River, the land use change is determined by the conversion of the green buffers into the urban land use. Another impact of land use is the encroachment of the river territory by formal and informal communities. This has resulted not only in rise in the run-off but also extensive waste generation ultimately reaching the river premises. Therefore, for the revitalization of the Bagmati River, the traditionally existed green buffers need to be restored with the involvement of the local communities.

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