Industrial Waste and Urban Bio-diversity in Developing country: Mapping Aquatic Biodiversity in Nepal

Bista, Raghu

5 November 2019

Industrial Waste and Urban Bio-diversity in Developing country: Mapping Aquatic Biodiversity in Nepal

Raghu Bir Bista[1], PhD
Associate Professor, Department of Economics, Patan Multiple Campus[2]
Tribhuvan University[3], Nepal, bistanepal@gmail.com

Abstract:

This study investigates empirically the relationship between industrial waste and urban biodiversity in Nepal by using mapping method based on secondary data sources. In addition, it estimates social cost of urban biodiversity loss. Its result is positive correlation between industrial waste and urban biodiversity loss. Its social cost is interestingly significant.

Key words: Industrial Waste, Urban Biodiversity, Aquatic Biodiversity, Nepal etc.

1. Introduction

Industrial waste is widely accepted as major driver of the contaminated water pollution having hazardous nature and characters in river and wetlands. Industrial Waste is by product of industrial activity such as factory, mill and mines (http://www.safewater.org/) and (www.legislation.sa.gov.au). The industrial waste includes metallic, chemical, wood, dirt, gravels etc. The waste can be divided into hazardous and non hazardous waste.

[1] Raghu Bir Bista is a Senior Lecturer of Economics Department appointed by Tribhuvan University in 2002. He joined as research associate working in contract in 1999. He teaches policy economics, public economics and macroeconomics. He did Masters of Philosophy(MPhil) in Economics from Jadavpur University, India in 2010 and his research title was *Global Role of Nepalese Forest: A case of Reduction Emission from Deforestation and Degradation(REDD)* published by Lambert publication in Germany in 2011. He was a SANDEE fellow at that time. He did PhD in 2017 on *Economics of Climate Change Vulnerability and Household Adapatation in Sotkhola Water Basin in Surkhet, Nepal*. He was University Grant Commission Fellow. (see his webpage: www.linkedin.com/dr-raghu-bir-bista ; www.researchgate.net/Raghu Bir Bista; ; www.facebook.com/raghu.b.bista

[2] Patan Multiple Campus is one of constituent campus of Tribhuvan University established in 1954 AD. It offers 15 courses including Master and Bachelor programs. It locates in the heart of Lalitpur, Kathmandu Nepal spreading 27,296 square m. area.(see its details in websites: https://edusanjal.com/college/patan-multiple-campus/)

[3] Tribhuvan University is a public university established by the Government of Nepal in 1959 A.D with an objective of higher education promotion and production of highly qualified human resources. The university is the oldest university in Nepal and the tenth largest in the world in terms of enrollment. Till 2018, it has 60 constituent campuses and 1084 affiliated colleges across the country (see its details in websites: tribhuvan-university.edu.np).

Hazardous waste may be by product of manufacturing industries. They are fluids, paints, pesticides, chemicals, metallic materials etc. Nonhazardous waste may be non-chemical and nontoxic but not like as organic waste produced by households and municipalities (http://www.safewater.org).

Industrial waste in urban areas has been a big problem for a long time. In Nepal, this problem has come out in the post liberalism and industrialization policy 1990. Liberalism policy has opened up the growth of industrial number, location and density. Approximately 10000 Industrial units in Kathmandu Valley were established in the post 1990. Out of total industrial units, there was 70 percent polluting industrial units including dairy, carpet, vegetable oil, textile, sugar, leather, beer etc (Devkota and Neupane, 1994). The industrial waste is inorganic, toxic and chemical nature having high load of oxygen demanding wastes, diseases causing agents, synthetic organic compounds, plant nutrients, inorganic chemical and minerals and sediments (Bista, 2006, MOPE, 1998 and Devkota and Neupane, 1994). The study of Devkota and Neupane (1994) estimated industrial waste with 0.764 million tons of Total Suspended Particles (TSP), 8.557 million cubic meter of waste water, 0.057 million tons of Biological Oxygen Demand(BOD), 0.096 millions of Total Suspended Solid (TSS) and 0.220 million tons of solid waste. In general, total industrial waste is estimated to be 22000 tons. In industrial population, there are most waste generating industries such as leather, canning, sugar, carpet and distillery (NECG, 1991).

It is said that almost all industrial firms in Nepal are free rider to common water resource, called Bagmati River by discharging freely, directly and illegally the without treated waste (inorganic, toxic and chemical ingredients) having the higher amount of BOD. This industrial waste having non rival and nonexclusive is nothing except negative externality to agricultural producers, water users and asset owners in the periphery of the river. In the absence of property right, regulatory and market mechanism, the industrial firms have been enjoying producer's excessive surplus without internalization of the negative externality as the higher marginal cost of farmers, water users and asset owners with additional aversion cost and transaction cost. Thus, like as monopolist firm,

the free riding of all firms to discharge their waste has been a major driver behind water pollution of Bagmati River.

Industrial waste is major source of the amount of Biological Oxygen Demand (BOD) in River. The study of UNEP (1992) found higher amount of the Biological Oxygen Demand (BOD) and lower amount of Dissolved Oxygen (DO) in Bagmati River. The evidence indicated the higher concentration of industrial waste leading lower quality of water and the flow of water in the river. In another words, industrial waste may be negative to habitats and food chain not only for aquatic biodiversity and also for terrestrial biodiversity.

The positive correlation between industrial waste and urban biodiversity loss (aquatic and terrestrial biodiversity) has made curiosity whether aquatic biodiversity loss of Bagmati River is larger, whether there is physical change of river and biodiversity loss and whether there is relevancy with urban life. In order to explore above these curiosities, this paper has a broad objective to map aquatic biodiversity loss of urban areas in Nepal. Specific objectives are as follows: to assess level, type and nature of water quality and pollution level of river, to find out biodiversity losses and physical change, to examine its relevancy to urban life and development and to find out alternative solution.

This paper is organized into sections. Section 1 introduces the concept of industrial waste in Nepal. Similarly, section 2 explains method of this study containing GIS data and Image analysis method and source of data. Section 3 presents results of the case of aquatic biodiversity in Nepal. Firstly, this paper describes nature, characteristics and size of physical change of Bagmati River. Secondly, it presents water quality and pollution level. Thirdly, it explains river biodiversity loss and then fourthly it deals the relevancy of aquatic biodiversity to urban life and development and finally, it provides alternative solution.

2. Methods and Materials

This study is case study method based on explorative and descriptive research design to map aquatic biodiversity in Nepal by studying case of Bagmati River. Its data sets of this case study used primary and secondary. In case of Primary Data of Individual's perspective and responses, the interview method and observation method were applied in the selected Bagmati River Sites. The Bagmati River was divided into four sites including in Nepali namely Balkumari Ringroad, Sankhamul, and Thapathali. These sites were observed two weeks for understanding the dynamics of Bagmati River and for taking images like as the old images for comparative understanding. Simultaneously, the visitors to Bagmati River who were 100 sizes were interviewed as sample size.

The secondary data was collected from GIS map (from 1970's to 2000's) and Images of different time period (from 1920's to 2012) for comparative understanding and analysis. The GIS land set map was collected from US land set web sites. Reliability and validity of secondary data sets may be high because these data sets are generated and produced by NASA (US). As supplementary, the different scientific journals data and information such as ICIMOD publication, UNEP, Ministry of Environment, Central Bureau of Statistics, NASA etc. were used.

There were used materials as sources of secondary data.

- Land set data of Kathmandu Valley and Bagmati River 1964, 2001 and 2007
- Land Set data of Kathmandu Valley 1967, 1978, 1991 and 2000
- Images of Bagmati Rivers collected from Old Nepal
- Recent Images of Bagmati River from the Field Study 2012

3. Study Area

Nepal is the second richest country of water resources. There are considered the scattered 6000 river and rivulets as major source of water resources (DHM, 1998, MOPF, 1998, Bista, 2008, Bista, 2011 and Bista, 2016). Bagmati River is one of these sources flowing from top hill region to Indian low land in which it originates Bagdwar from the southern slope of Shivapurilekh, north of Kathmandu basin at an altitude of about 2650m and flows straight to south-west cutting Mahabharata range (Sharma,

Image No-1: Bagmati River in Kathmandu

Source: US Land set Images, 1964, 2001 and 2007

1977). The journey of Bagmati River continues in the south and merges into the Gangas in India.

In Kathmandu Valley, the Bagmati River's physical course seems to be zigzag (see its details in Image-1). First it runs southward and then changes courses to westwards bordering Kathmandu and Lalitpur Districts. It again changes course towards south when it reaches Balkhu and Dallu areas. Its total length is about 196 km in Nepal and the catchments area of the river is 3610sq. km which is 2.25% of total area of Nepal (Shanker & Kiran, 1976).

Hydrological studies (Tuladhar, 1979 and Pradhan, 1998) explain it run off river having 24 main tributaries originating from Mahabharat and Siwalik lekh which fed the river Bagmati. Out of 24 tributaries, it receives water from only 5 main tributaries namely as Bhisnumati, Monohara khola, Balkhu khola, Nakkhu khola and Tukucha Khola in Kathmandu Valley.

Traditionally, the river is used for irrigation and clean drinking water in the periphery of the river. At present, households of Kathmandu valley uses daily 82 percent ground water discharged by Bagmati River in accordance with Kathmandu Metropolitan City. Hydrological studies indicate its potentiality in Hydropower. All these practices and potentialities are being critical because of dumping sites for solid wastes, outlets for domestic sewerage and industrial and agricultural effluents. In addition, Slum dwellers illegally encroaches the river banks of Bagmati River. Furthermore, the illegal sand extraction disturbs natural structure and mechanism of the river.

4. Results of Survey and GIS images

4.1. Physical Change

Image No-2: Physical Change

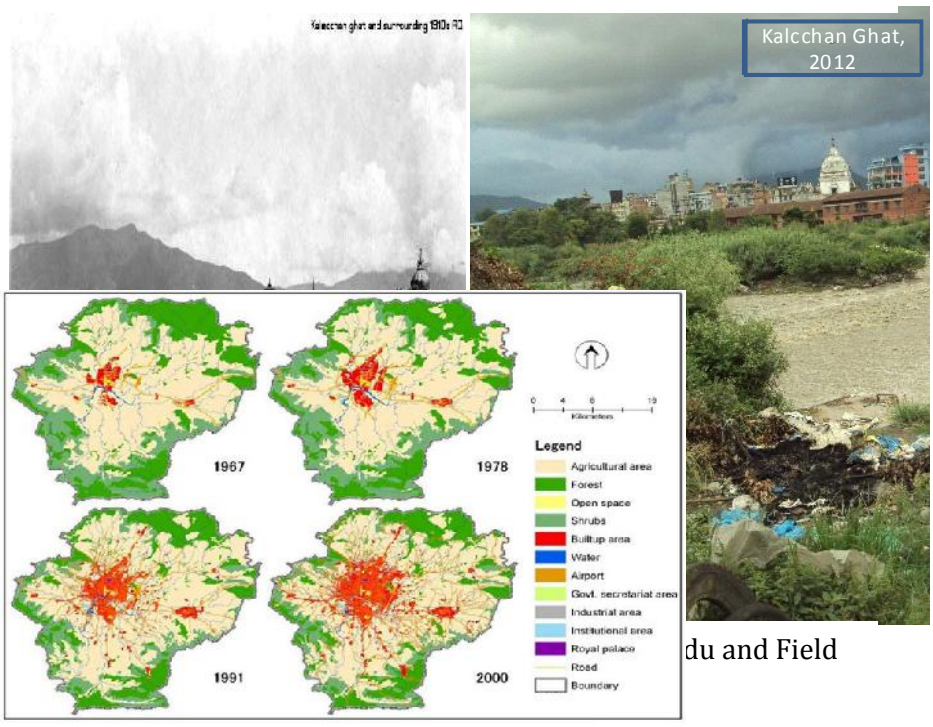
GIS images and Traditional Images of Bagmati R sites of the study sites visualize three periodic physical set up of

1910, 1970 and 2012. These images provide greater width of Bagmati River than its depth till 1970. Its physical set up was sand made. The flow of water was quiet nice and beautiful. The water was fresh having natural biodiversity and human uses.

The physical set up of Bagmati River has started to be changed since 1990, when the large number of industrial firms in Kathmandu Valley became free rider as polluter of industrial waste in the river and the illegal sand extraction was uncontrolled. The river has lost natural beauty and physical characters one hand and another hand water quality and biodiversity. The course of river has narrowed down at central area by leaving land in the river banks. It looks like ugly with bad odors. Depth of the river is approximately 6 ft below with 12 ft width. The flow of water is speedy and dangerous in summer and is bored in winter. The water is having bad smells and black colors. Illegal encroachment of slum and development encroachment of the government can be found as major driver of bad shaping of Bagmati. Thus, Bagmati has unnatural huge physical change in size, width and flow of water because of human activity. Thus, the change is to be natural threat to biodiversity and urban life.

4.2. Water Quality and Pollution Level

Image No-3: Water Quality and Pollution of Bagmati River



du and Field

In Environmental science, the amount of dissolved oxygen (DO) and Biological Oxygen Demand (BOD) are considered major indicators and measures of

water health. These indicators are applied by UNEP (2001), CEMAT (2001) and ICIMOD (2005) in the study of Bagmati River. The amount of "DO" indicate status of oxygen in river meanwhile "BOD" measures demand of oxygen.

GIS images and Traditional Images of Bagmati River in 1920, 1970 and 1980 visualized the fresh water with high amount of DO and low amount of BOD. In the GIS images and Images of 1990 and 2000 and the different studies, Bagmati River has the high value of BOD and low value of DO as a result of a result of the high concentration of domestic and industrial effluent. Some 21,000 kg of domestic sewage is discharged daily into the Bagmati River from Kathmandu valleys, cities- 42% of the total BOD load produced. The total industrial BOD load discharged directly into the river is 3,151 kg per day (CEMAT, 2001). The carpet industries alone consume about 6.1 million liters of water per day and generate 5.5 million liters of waste water daily (MoPE, 2001). It has been estimated that total industrial waste water volume in the Kathmandu valley is approximately 2.1 million cubic meters. To which, nearly 76 present is contributed by carpet factories (1.6 ısand m3, finishing textile 66700 m3, leather and leather product 62700 m3, soft drinks and carbonated water 52000 m3, beer manufacturing 51000 m3 and distillery, rectifying and blending spirit 50000 m3(Devkota and Neupane, 1994).

NASA

Source: Land set data of 1967, 1978, 1991 and 2000

Pollution level in Bagmati River has been intolerable issue. The studies such as IUCN (1991), Teubtt(1992), Devkota and Neupane(1994), NWSC(1999) and CEMAT(2000) provide sufficient evidence to explain extremely critical pollution. In 2012, the survey has found its higher extremity. In the source analysis, there are categorically three sources behind such pollution. They are namely household waste, industrial waste and city sewerage and drain.

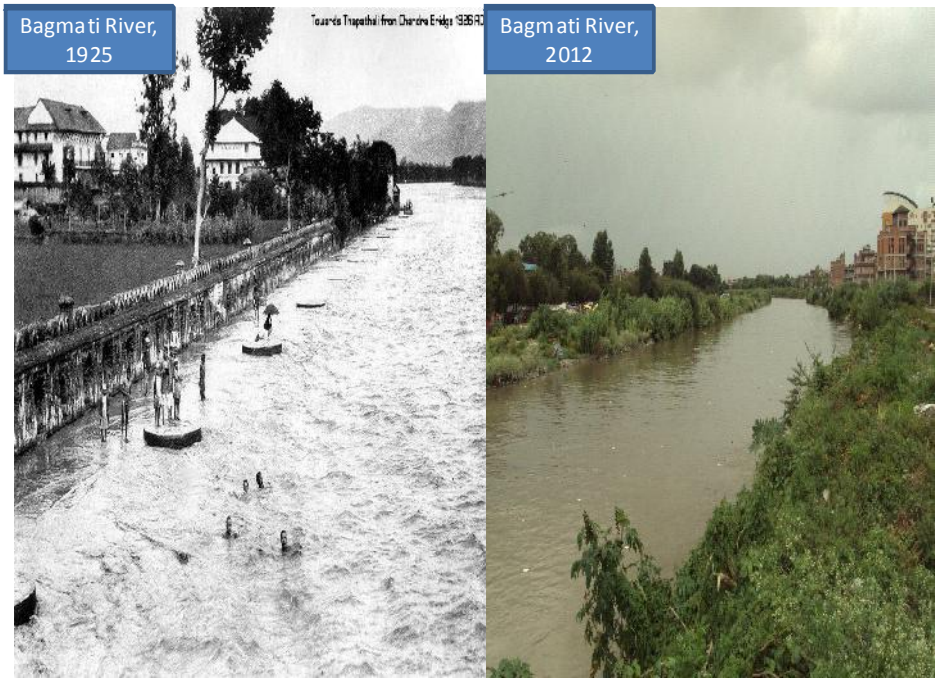
So far concerning household waste, the inhabitant of Kathmandu Valley which was small and well managed from the period of ancient and medieval to the 1980s has become a large i.e. approximately 0.5 million population. It is supplemented by the GIS map. GIS map shows how fast population and settlement was increasing. Naturally, such growth

of population increases household waste generation having organic characteristics. In the past years, agriculture helped to manage these wastes. At present, such process has been damaged. However, there is not proper system developed as alternative solution. Subsequently, there is found direct discharge of household waste without treatment. Tebbutt(1992) estimated average of 50g biological oxygen demand (BOD)/person/day and 50,000 kg BOD/day/ total inhabitants. CEMAT (2000) further studied on it and found the discharge of 20,846 kg BOD/day.

4.3. River Biodiversity Loss

The biodiversity of Bagmati River is comprised with two categorical bio diversities: terrestrial and aquatic. In terrestrial biodiversity, there are found vegetation and birds. Vegetation is an important attributes of river biodiversity. In river, the vegetation not only contributes greenery in the corridor but also provides nutrition to aquatic species and birds and water purification system. In the study site, there is not fresh water and natural vegetation. In natural vegetation, there are scattered small bushes and small patches of forest vegetation in the corridor. There are available two

Image No-5: Bagmati River's Water level, Thapathali



Source: Old Image 1925 of Bagmati River in Kathmandu and Field Image 2012

groups of vegetation such as trees and bushes. In tree, there are found two species such as Painyu (prunus ceracoides), Lapsi (choerospondias axillaries), meanwhile in bushes, there are Bains (Salix species), Gulmohar(delonix regia) and lahare pipal (populas deltoids). In addition, the Bagmati River itself is the main habitat for birds. Beside this, muddy area of river bank, patches of grass and shrubs, cultivated land near-by and some patches of forest with pine and uttis are the main habitat types found in the study site.
These two images visualize that Bagmati River in 1925 had vegetation only in the bank of the river. However, the image in 2012 has shown vegetation not only in the river bank but also the corridor of the river because of the changing course of the river.

In terrestrial ecosystem of Bagmati River, birds are major species. In different survey, there are identified a total of 100 bird species. The increasing greenery is providing a good habitat and food chain in Bagmati River but water and aquatic food chain are found toxic and hazardous to their survival. Therefore, their frequency are recorded declining and there are extinctions of species. It is a big loss for river biodiversity and then urban biodiversity.

Similarly, Bagmati River from the period of 1920's to 1980's had its physical set up like as the image of 1925. The amount of Dissolved Oxygen (DO) was higher but the amount of Biological Oxygen Demand (BOD) was lower. In another words, water quality which was fresh and free from pollution was a healthy habitat to aquatic life and ecosystems. There was found species of aquatic life: fish (3), frog (2), Coleoptera, (2); Chironomidae (2); Baetidae (2); Physidae (2); Oligochaeta (3)(Pradhan, 2005). In addition, there were valuable ecosystems within the river. However, the physical set up and water quality of Bagmati River has been drastically changing since the 1990's liberal economic policy. The flow of river is not favorable to aquatic life and ecosystems because of its high speed. Simultaneously, the degrading water quality cannot provide secure habitat and food chains to aquatic and terrestrial species and ecosystems because the amount of BOD is higher and the amount of BD is lower. In simple, freshwater scarcity, flow of water and hazardous food chain are negatively correlated with aquatic and terrestrial biodiversity. If there are found any such biodiversity, there may be extremely

vulnerable. This has huge economic and socio-cultural value in urban life and urban development.

4.4. Relevancy of River Biodiversity Loss to Urban life

Holy Books, *Bedd*, *Mahabharat* and *Ramayana* mentioned Bagmati River as a holy river to Hindu and Buddhist. Its water is explained not only as water but as sin purifier and holy water for death ceremony. Since the ancient period, the water of the river has been important for Hindu rituals and functions. Therefore, it is Holy River having socio cultural and religious value in Kathmandu Valley where Lord God Pausupati Nath Temple and more than 100 Hindu temples are located.

Bista (2011) and Anderson(1983) explained the first civilization established in Kathmandu Valley as the catchment areas of Bagmati River by Gopalaya mentioned in Gopal Bansawali. The civilization is so called Bagmati Civilization. There may be different arguments out of which some section of historical economist argues socio economic point of view in which there was a logic: the water of Bagmati River could give survival of human life, economic activities (agricultural and livestock farming) and socio-cultural functions. Basic idea was that no water meant no life, no activity and no development. Socio economically, the river was a major surface water supplier all over the valley for irrigation and recharging ponds, wells and public taps. In GIS map, population and households of Kathmandu Valley were very scattered, lower density and smaller than the present population. There were sufficient agricultural lands having fertile soil and irrigation. The river was the lifeline of civilization and economic activity of the people. Finally, the river was rich biodiversity with fresh water and species. Therefore, Bagmati Civilization was socio economically relevant.

In recent years, Bagmati River has been losing river biodiversity, water quality and physical set up after increasing free riding of industries and sand extractors, although industrial development is relevant to GDP growth and employment generation. This is called public bad of industrial development. In another words, it is called market, policy and institutional failures to enforce the polluting industries for internalization of negative externality. Almost all industries have excessive producer's surplus. However, Economic cost of industrial waste as negative externality to agro producers, water users and corridor households is being a part and parcel of production and consumption. Therefore, its negative impact can be found in urban life and economic activities.

This negative externality of polluting industries can be found as water pollution and its bad odors. Its economic cost to Hindus is quite high because they have to drop their traditional and religious habit and behavior based on the water of Bagmati River. For socio and religious rituals, Hindus are exploring alternative water for purification and death ceremony for averting health hazardous and bad odors. Thus, its cultural and religious utility is declining.

In addition, Bagmati River has lost its natural physical set up and biodiversity as negative externality of polluting industries. As huge economic cost, farmers are not able to use water for irrigation objectives in agricultural land as obvious practices of ancient and medieval society. Agricultural activity of farmers in the various places of Kathmandu Valley has been declining. Similarly, biodiversity loss has economic cost to urban life and households.

5. Discussion and Conclusion

Above four results of the study of GIS data and map and the comparative study of images provide sufficient evidence of dying Bagmati River having loss in physical set up, water quality and biodiversity because of the free riding of Industrial firms in common property resources, Bagmati River and of sand extractors. Its negative externalities to households are bad odors, contaminated water, loss of beauty, aquatic life and

biodiversity, damages in agricultural activities, livestock farming and fish farming, skin diseases etc. These negative externalities have cost to households such as economic cost, social cost and environmental cost.

Economically, the dependent households including farmers, fisherman and livestock farmers living in the corridors of Bagmati River that is approximately small sized population have economic cost of such negative externality because they can not use the contaminated water for irrigation, fish farming and livestock farming. In urban areas, such activities are found unnaturally closed down. In case of farming, the water is used but its negative implication is found in consumption. Similarly, Bagmati River Corridor is generally used by the large units of population and households of Kathmandu, Patan and Bhakatpur for bathing and recreational activities in Kathmandu Valley. The river has recreational value but such negative externality has damaged such value. Its economic cost is also additional to households. Similarly, household uses ground water which is discharged by Bagmati River is also contaminated. Almost households use the water after purification. Thus, the household has economic cost of purification and alternative sources. In total, economic cost of water pollution may be huge in Kathmandu Valley.

Bad odor and toxic chemical substances as negative externality of the polluting industries are considered a health hazardous to corridor households and general visitors. These are higher possibility of skin diseases, respiratory problem, eye allergy, cancer etc having huge social cost.

Finally, the loss of aquatic biodiversity due to the contaminated water pollution and free riding of sand extractor has damaged significantly on food chain system, aquatic life, plants and water regeneration system. The rehabilitation and conservation cost of biodiversity loss in Bagmati River may be huge. Thus, in total cost of negative externality in Bagmati River to urban life will be huge, along with emotional and religious attachment value.

In future, the total cost of negative externality of Bagmati River to urban life and the society in Nepal will be huge, when the fresh water demand growth will be higher because of the population growth, climate change and urbanization process. Therefore, the failure of policy, market and institution could be addressed for internalizing cost of negative externality of the polluting industries by tax or subsidy instruments and standardization and treatment provision of industrial waste and strict regulatory mechanism.

6. Reference

Anderson, J.G (1983*). Insight Guide*. (Ed) Hong Kong: Apa Production

Bista, R.B. (2006). Urban Development in Nepal. In K.R. Gupta & P. Maiti(Eds.), *Urban Development Debates in the New Millennium.* New Delhi (India): Atlantic publishers and distributors.

Bista, R.B. (2008). *Economics of Nepal*. Kathmandu: Prativa

Bista, R.B.(2011). *Economics of Nepal*. Kathmandu: Hira Books

Bista, R.B.(2016). *Economics of Nepal*. Kathmandu: Hira Books

CEMAT (2000) "Report on surface water quality monitoring works of Kathmandu valley". Urban water supply reforms in the Kathmandu valley project.

DHM, (1998). Hydrological Record of Nepal; A stream flow summary in Nepal. Kathmandu: Department of Hydrology and Meteorology.

Devkota, S.R.; Neupane, C.P. (1994) *Industrial Pollution Inventory of the Kathmandu Valley and Nepal*. Kathmandu: Industrial Pollution Control Management Project, HMG/MOI/UNIDO/91029

ICIMOD/UNEP/MoEST (2007) Kathmandu Valley Environmental Outlook. Kathmandu

MoPE (2001), *Status of the Environment Nepal*. Kathmandu: MoPE

-------- (1998), *Status of the Environment Nepal*. Kathmandu: MoPE

Pradhanga T.M (1988): Water quality of the Bagmati river in the Pashupati area, Pub. by RONAST.

Pradhan, B (1998) Water Quality Assessment of the Bagmati River and its Tributaries, Kathmandu Valley, Nepal. Ph.D. Dissertation, Department of Hydrobiology, Institute of Water Provision, Water Ecology and Waste Management, BOKU University, Vienna, Austria.

Shankar and Kiran (1976): Paper on water hydrology in Nepal, Symposium on water and energy recourses under the joint sponsorship of NWREC, CEDA and UNDP Ktm.

Sharma, S (1988), Studies on the effect of some physico-chemical parameters on the distribution and abundance of Zoobenthose in the river Bagmati, Kathmandu, M.Sc. thesis, T.U, Kathmandu

Tebbutt, T.H.Y. (1992) *Principles of Water Quality Control*. Oxford: Pergamon Press

Tuladhar, D.R (1979): The rainfall runoff characteristics of Bagmati river, *J .Nat. Hist. Mus., T.U. Inst. Of Sci. and Tech.(1-4)*

United Nations Environment Programme, (UNEP) (2001) Nepal: state of Environment 2001.Bangkok: United Nations Environment Programme, Regional resource Centre for Asia Pacific.

viewed on the Internet at: www.legislation.sa.gov.au

http://www.safewater.org/PDFS/knowthefacts/IndustrialWaste.pdf