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Monitoring and Modelling Socio Economic Impact of Landuse/Cover and Pollution along Yamuna River, Delhi

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ABSTRACT

The water quality of Yamuna at the point of its entry into Delhi fits to water quality standards in terms of Dissolved Oxygen (DO) and Bio-chemical Oxygen Demand (BOD). The BOD level in the Yamuna River has been in the range of 12 to 51 mg/l. The range of Chemical Oxygen Demand in Delhi varied from 50-155 mg/l. However, during its exit, the water quality becomes unfit for any purpose. This Research paper analyses the present status of the river Yamuna. Despite ongoing research efforts on land-cover and land-use patterns, there remains a need for development of basic land-cover datasets providing quantitative, spatial land cover information. With the rapidly growing population in Delhi, pollution levels are at an all-time high and continue to become increasingly dangerous to city residents. Delhi is subject to pollution in all forms and has been categorized among the top ten most polluted cities in the world. The pollution of the river Yamuna has a variety of impacts on Delhi's environment. This paper analyzes the land use/cover (LULC) of the past, present and futuristic modeling along river Yamuna and evaluated Land Use/Land Cover Change (LULCC) on the basis of socio-economic parameters.

Key words: Monitoring, Modelling, Biochemical Oxygen Demand, Chemical Oxygen Demand, Dissolved Oxygen, Yamuna, Pollution, Land Use and Land Cover

INTRODUCTION

A study of urban land use is quite important for an understanding of human ecology. The factors contributed to the land structuring, help to understand land use pattern of the present scenario and also future urban development. Planners of the future need to understand the paradoxes of land use pattern and make an effort to remove further misuse of land, thus enabling mankind to preserve the environment for future generation. Land is a combination of geology, topography, hydrology, soils, and communities of plants and organism that are interacting under the deep influence of climate and human activities. The land use and land cover can be classified into Urban or built-up area, rural land, forest land, water bodies and barren land. These categories can be sub classified into further subdivisions. Change in land use is a very complex and time taking process. There is complex and dynamic land-use land-cover change at various scales from local to global. Therefore,

it provides vista for research at various levels due to the dynamism and continuing nature of the LULCC problems. Yamuna is the major tributary of River Ganga which caters to diverse needs of the people. It provides irrigation facilities, water supply for domestic use, large amount water for industrial purpose etc. Yamuna River in Delhi and its surroundings is facing serious problem of pollution. Delhi alone contributes about 80 per cent pollution in Yamuna River which means it is the most polluted river after River Ganga in India. There is huge expenditure on Yamuna action plan to restore water quality in the river but government efforts have totally failed. It is also the major source of drinking water in the city which is contaminated in the form of heavy metals, biological oxygen demand and dissolved oxygen etc. which ultimately affects human as well as animal life.

Pollution levels are very high and this trend is very dangerous for city inhabitants because population is increasing at an alarming pace in the city. Delhi city is facing pollution problem at several levels viz air, water and land. Water quality is very bad in the whole stretch of river in Delhi from Wazirabad to Okhla. The water of river is so poisonous that it is called green soup because of its colour between Delhi and Agra. Water pollution is also very dangerous for wildlife and aquatic life surrounding Yamuna River in Delhi. Sal and Chir forests are decaying because of contamination as well as scarcity of water. If water pollution and contamination will continue in the same rate, fauna and flora will be on the verge of extinction.

River Yamuna has great religious, social and economic importance for the large section of the society. The total length of River Yamuna from its origin in Himalayas of Uttaranchal to its confluence in the River Ganga at Sangam in Allahabad district of Uttar Pradesh is about 1376 kms. The river enters Delhi at Palla village near Wazirabad and leaves Delhi at Okhla barrage. River Yamuna passes through one of the fertile tracts of the country, which is called the granary of the north India. This shows the economic significance of the river. At Wazirabad Barrage River is tapped for water supply for drinking purpose to urban agglomeration of Delhi. During summers water supply in the river is insufficient which can't even fulfil the demand of the city though River is perennial in nature. At the Wazirabad water treatment plant untreated waste water is treated which is supplied by major drains from Delhi. The National Capital Territory of Delhi is situated between 28º12'17" N -28º53'00" N latitude and 76º50'24"E - 77º20'37 E longitude. The City is a part of great North Indian plain of India which has average height of about 200 m above the mean sea level. The stretch of River Yamuna in Delhi is about 22 kms. Delhi is a mega city and its population is increasing at an alarming rate to cater the needs of many people. The demand of water supply in Delhi is not fulfilled by Yamuna alone subsequently it is now made by Ganga River through extended pipelines. Delhi is the administrative, economic and social centre of the whole country (Figure 1).

Figure 1. Map of the Study Area

The study is being conducted with the objective of assessing and analyzing land use/cover (LULC) of the past, present and futuristic modeling along river Yamuna, evaluating Land use/cover Change (LULCC) on the basis of socio-economic parameters quantifying and analyzing the impact of LULCC on the basis of land, water and air along the river and establishing Sustainable Socio-Economic Framework (SSEF) for better LULC practices in accord with Delhi Vision 2021.

RESEARCH METHODOLOGY

The research methodology adopted includes identification of critical steps in the understanding of the problem, analysis and interpretation of data and other aspects of team work. Purposive stratified random sampling techniques have been used for conducting survey. Parameters used for LULCC analysis include: agricultural/cultivable/commercial land transformation. Parameters used for Socio-Economic impact analysis include: livelihood security and risks. Parameters used for water and air quality analysis include: Temperature, NO_x, SO_2, CO_2, RSPM, SPM, soil and water PH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chloride content.. Parameters used for Sustainable Socio-Economic Framework (SSEF) analysis includes: on the basis of Delhi Master Plan vision 2021 analysing assets like: forest, cultivable land, air and water together with infrastructural assets.

LAND USE CHANGE DETECTION

The methodology of the study includes many steps to achieve its various objectives. The first objective has been achieved by going through various literatures available and factors affecting past, present and future scenarios identified and analyzed. For second and third objective, the factors affecting the socio-economic transformation, land, air and water quality of the study area has been identified and accordingly different layers has been produced and prepared for this analysis where the forecasting is done on Matlab programming. After completing the analysis to show the maps cartographically correct, various cartographic techniques in ERDAS 9.1, ArcGIS 10 and ArcView 3.2a is used. Various figures, charts and diagrams have been prepared to represent data in lucid way. The Land Use Land Cover data collection, classification and analysis have been done for over a decade (2001-2012) on the basis of LISS III, Landsat TM/ETM, STRM-DEM, SOI toposheet, from various government agencies and organizations. The physical data have been collected from organizations like: Survey of India Publications, Topographical Map 1:50,000, National Remote Sensing Agency (NRSA), Hyderabad, Central Pollution Control Board (CPCB), New Delhi and socio-economic data from Census of India Population Totals for Delhi, 1991 and 2001; District Statistical Handbooks etc. Remote Sensing data and techniques and geographic information systems (GIS) provided efficient methods for analysis of land use issues and tools for land use planning and modelling.

Land Use Land Cover (LULC) maps of 2001 and 2011 were compared. The LULC of the study area had changed dramatically. Therefore, the data interpretation and data analysis is based on the comparison of LULC for different periods during 10 year period. In the first part population census v/s built-up area were analysed. Furthermore, sprawling nature of built-up area and loss of forest and agricultural land is also noticed (Fig. 2 and 3).

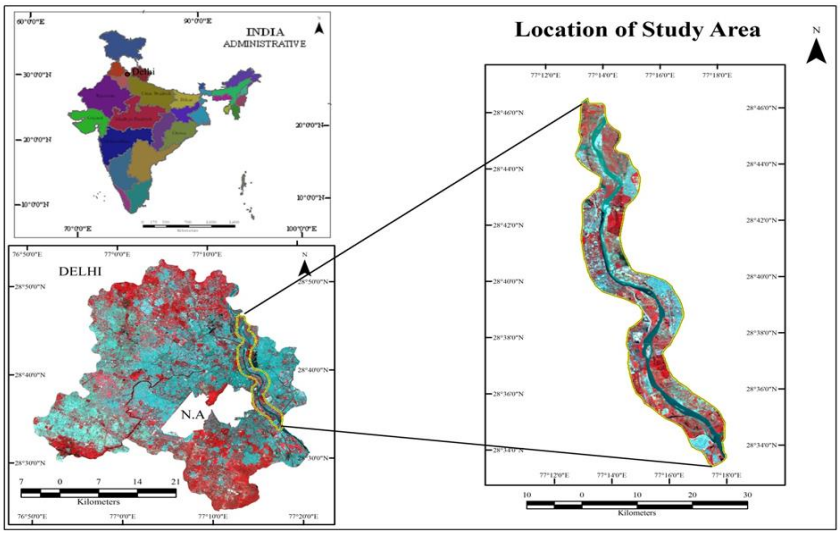

Figure 2. Location of the Study Area

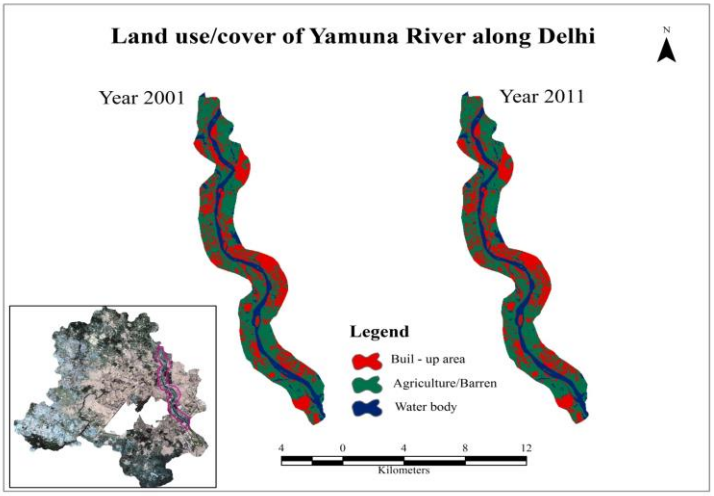

Figure 3. Land Use/Cover Change in Yamuna River

SOURCES OF POLLUTION

The major sources of water pollution in the city are domestic, industrial and solid waste. The domestic source is the major source of water pollution in the city which contributes about 80 per cent of the total water pollution. The domestic pollution is mainly contributed by sewerage produced by urban agglomerations. There are many unauthorized colonies in Delhi which are responsible for large amount of sewage waste which is generated. Nearly 40 per cent population of Delhi resides in slums which are not accessible to basic amenities. Inorganic and organic source are the prime component of pollution in the river. There is no proper collection, transportation and disposal of solid waste generated from these colonies and it is dumped directly or indirectly in to river through tributaries and various drains.

The second important source of water pollution is industries which can be categorized in to large and medium scale. These include thermal power plants, oil refineries, textiles, food processing

items, paper, sugar and leather industries etc. Many of these industries are discharging their effluents without treatment into the river. In order to comply with the environment legislations, it is mandatory for these industries to treat the effluent to maintain prescribed standards before discharging effluent into the Yamuna River.

Yamuna's stretch in Delhi is about only 2 per cent but it is responsible for about 80 per cent of pollution. Delhi discharges about 3,684 MLD (million litres per day) of sewage through its 18 drains into the Yamuna. Delhi Jal Board mentioned that the river remained a sewage canal due to the 143 unauthorised colonies, 1080 slums and villages that present a problem in collection of sewage water that flows into the Yamuna untreated (CPCB). The dumping of animal and human bodies is also noticed in the river which makes water more polluted and unfit for drinking purpose and it increases the risk of pathogenic contamination besides other negative impact for human beings.

STATUS OF WATER QUALITY

The BOD level in the Yamuna River at its origin near Palla village is generally between 1-3 mg/l with annual average not more than 4 mg/l. This is because there is pouring of sewerage and waste water in the river at the entry level and after is fresh which is useful for drinking purpose. There is tremendous increase in the BOD level when biggest drain of Delhi, Najafgarh drain joins the Yamuna River. This drain contributes nearly 70 per cent pollution in the river. At the Nizamuddin Bridge BOD level in the River increased 6 to 50 mg/l, which show that it is contributed by Delhi alone? BOD concentration was low at some places; it may be due to heavy rainfall in the catchment area of the River. In the Delhi catchment of the River, water quality is worse at Okhla Barrage. In terms of pollution, Delhi contributes highest amount into the river followed by Agra, Mathura, Panipat, Sonipat, Baghpat and Etawah.

The amount of dissolved Oxygen (DO) in the Yamuna River is very high between Wazirabad and Okhla barrage. It also depends on period of photosynthesis and its utilization by fauna and flora and microorganisms etc. In the aquatic ecosystems, the dissolved oxygen occurs maximum in the afternoon and very less during night when sunlight is minimum. This variation may be due to variation in sampling size and time. Conductivity was at all places and maximum in the entire river stretch during dry season and again it declined at the time of heavy rainfall. On an average conductivity was below 300 micrograms /cm upto the Hathnikund barrage and increased to the level of 500 micrograms/cm up to Palla. Between Wazirabad and Okhla the average conductivity was in the range of about 600 to 1000 micrograms/cm and maximum conductivity was recorded at Okhla. Maximum conductivity was recorded at Agra, where it ranged from 450 to 2300 micrograms/cm. This shows water quality is deteriorating rapidly from Palla village to Okhla Barrage in the stretch of Yamuna River in Delhi.

Yamuna is a perennial river but drainage basin and discharge in Yamuna River varies significantly during monsoon and non-monsoon season because of the availability of rainfall. This seasonal variation indicates that dissolved oxygen level is always below the prescribed limit in both the seasons. The biological oxygen demand in Palla is above the prescribed standards both in non-monsoon and monsoon periods. From Hathnikund to Nizamuddin Bridge there is slight increase in pH values. In many of the places ammonia and nitrogen were reduced during monsoon period. The maximum BOD level was observed at Nizamuddin Bridge. The minimum values of ammonia were observed at Hathnikund Barriage and highest near Nizamuddin.

At few locations DO was high even after high BOD concentration, this may be due to persistence of both eutrophic and septic conditions. The COD (SD ranged from 3.15 to 33.25), BOD (SD ranged from 0.00 to 10.57), Ammonia (SD ranged from 0.32 to 10.19) and TKN (SD varies from 0.79 to 11.06) having low standard deviation at those places which were relatively clean and high at those locations reflecting significant impact of pollution discharges. The standard deviations for DO ranged from 1.0 to 4.2. Higher standard deviation values of conductivity (ranged from 47 to 533). The contribution of these parameters in the Yamuna stretch varied significantly with the, space and weather conditions mainly characterized by rainfall.

The data for each monitoring location was categorized into two on the basis of percentile viz 90 percentile and 10 percentile. The 90 per cent values for pH were from 7.74 to 8.96 whereas, 10 per cent values were from 6.70 to 7.52. For COD and BOD, 90 per cent was in the range of 6 to 107 mg/l and 1 to 34 mg/l. Maximum value of 90 percentile for both COD and BOD was observed at Nizamuddin downstream. The value of 10 percentile for these two parameters varied for 1 to 29 mg/l and 1 to 7 mg/l respectively. In terms of ammonia and TKN, 90 percentile values varied from 0.80 to 27.26 mg/l and 2.01 to 34.68 mg/l. 10 percentile of ammonia and TKN data was in the range of BDL (below detection limit) to 3.82 and 0.16 to 7.06 mg/l. At Nizamuddin Bridge and Agra Canal 90 per cent data were not conforming tothe standard in terms of DO and at three locations, 10 per cent data reflecting nil. Further, at another three locations 10 per cent data did not meet the prescribed limit. For conductivity the 90 and 10 per cent values in the entire river stretch were below 154 to 1846 μmhos/cm and 45 –omrr4ato 506 μmhos/cm (CPCB, 2006).

POLLUTION AND HEALTH

Water borne diseases in Delhi are increasing because of contamination and unsafe drinking water in the river. People are suffering from many communicable diseases because of deteriorating water quality and unhygienic condition. Underground water in Delhi and surrounding areas is also polluted because polluted water on the surface percolates down into the ground and it is also evidenced by polluted water supplied by hand pumps.

Major contaminants of water are heavy metal, insecticides, pesticides, various chemicals, fertilizers and micro particles etc. and all these are very dangerous for human health. The best example of water borne disease in Delhi can be mentioned in Delhi in the year 1055, when many people suffered from hepatitis E virus, infected about 3000 people. Poor water quality is mainly responsible for water borne diseases such as cholera in Delhi. According to the statistics provided by Municipal Corporation of Delhi nearly 15 per cent water of Delhi is not suitable for drinking purpose. Almost whole Delhi is facing the problem of water contamination but the areas surrounding River Yamuna are more infected. Civil Lines, Karol Bagh, central parts and many colonies in south Delhi are facing this problem severely. In southern part of Delhi, contamination is highest with more than 50 per cent of the samples found to be polluted.

Nearly 50 per cent of the respondents in Delhi reported that occurrence of waterborne diseases had increased over the last few years. There are many drains in the city which contributes water pollution in River Yamuna and among these Nazafgarh drain is the largest one and which is responsible for nearly 70 per cent of sewerage alone.

RESULT AND DISCUSSION

The study of people's perception gives an idea about societal behaviors with the explanation of the real world. It is the process by which an individual or a community gains knowledge of the world by receiving stimuli from the environment through his senses and creates an image of that environment. Individuals and groups related to their environment through their perception and accordingly take decisions within the framework of his perceived set of elements. The usual image that he/she creates is filtered down based on his/her reasoning and past experiences. Geographers have shown more concern with the spatial pattern of behaviour rather than the behavioural process (Davis, 1972). Spatial behaviour is understood to be a product of personal views, experiences and preferences.

The persons have been interviewed according to a well-structured questionnaire which has included the personal characteristics of the respondents, their concern for types of land uses like residential, industrial and commercial, their knowledge about industrial development and types of industries and pollution from industries. For understanding the water quality people have been interviewed about the sources of water pollution, their perception about the problems and diseases caused due to deteriorating water quality, risk assessment, health hazards, impact of land use change on human society, role of government, effectiveness of the recent water pollution control measures and suggested penalties against the polluters, along with various prospects in the field of water pollution control.

This study is essentially based on primary data. People have been questioned on the basis of well-structured questionnaire regarding various socio-economic conditions of study area. People were questioned in three sample villages Chilla, Patparganj and Wazirabad. From each village 50 respondents were selected therefore 150 respondents were selected in total. Stratified random sampling was considered most suitable for conducting primary survey. Nearly 33 per cent respondents replied that forest area has been converted into build up area and 35 per cent respondents indicated that agriculture land is converted into build up area. 10 per cent people answered that forest land is converted into barren and waste land. Around 7 per cent respondents said that agriculture land is transformed into barren land. Nearly 15 per cent respondents replied that agricultural and forest land is converted into water logged. People were also interviewed regarding shifting agricultural seasons and pattern. Their views are very interesting. Nearly 55 per cent respondents perceived that there is wide transformation in the agricultural pattern. It indicates very high awareness of people about shift in agricultural pattern.

People were questioned regarding floods. More than 50 per cent respondents asserted that risk factor due to floods are very high. It shows that flood is a major problem in Yamuna River in Delhi. Many acres of agricultural land are destroyed every year in this region. Two-thirds of people replied that there is very low livelihood security due to floods in this region. Agriculture is very unstable and in subsistence in nature in this region of Yamuna river. There is a great transformation in land use/cover in this region which has resulted in many types of social problems like unemployment and criminal activities are also on rise. The quality of water of Yamuna River is worse in the Delhi segment. In this segment nearly 80 per cent pollution is alone contributed by Delhi. The amount of Biological Oxygen Demand and Dissolved Oxygen is very high in Delhi segment of river Yamuna. About 70 per cent respondents replied that quality of river water is unfit for utilization. Major sources of pollution are discharge of sewerage waste through drains, industries and agro waste etc. People replied that role of government in cleaning river is negligible. At the same time community participation is also lacking to tackle the problem. Yamuna Action Plan I and II have totally failed to clean the river.

MEASURES TO CONTROL POLLUTION

Yamuna Action plan was implemented with the financial assistance from Japan international Agency in first phase since 1993. Yamuna Action Plan Phase I was started in 1993 at the cost of 682 crore Rs. to clean the River. Yamuna Action Plan II was commenced in 2003 with an estimated cost of Rs. 624 crores. Many measures were taken under these plans to clean and make the River environment friendly. Many water treatment plants were constructed on the bank of the river for the treatment of sewerage. Because of the failure of earlier plans, Yamuna Action Plan III was launched with a total cost of 1656 crores Rs. in 2011.

River has been converted into drain due to excessive industrialization and urbanization and increasing construction activities. Cleaning of River Yamuna is must because it is life supporting system for Delhi and other cities in the country. For the effective implementation of government policies, mass level awareness and education is must, then only the water quality in the river may improve. Some of the important steps which can improve water quality in the river are following.

- Utilization of waste water through innovative technologies and it can be used for other purposes.
- There is need for the improvement in the sewage system, which can prevent waste water going directly in to the river.
- Bio-fertilizers should be promoted by farmers instead of the current usage of chemical fertilizers.
- Large scale plantation is required in river bed to prevent soil erosion.
- Effective implementation to control pollution through strict government policies and legislations.
- There is need of proper treatment and management of Waste water near the river.
- Utilization of water resources wisely and effectively.
- Proper channelization of Drainage system and water management.
- Adequate financial support for implementation of various programmes.
- Large scale improvement in needed in the sewage system.
- Capacity enhancement and up gradation of sewage treatment plants.
- Proper disposal and management of sewage treatment plants.
- Disposal of sewage at designated sites.
- Construction of public toilets in slum areas.
- Construction of electric crematorium and awareness to use them.
- Construction of holy bathing ponds to save river.

CONCLUSIONS

At the end it can be concluded that people's participation is necessary for preventing river Yamuna from pollution. There is need of creating awareness among the people regarding the pollution and its consequences in Yamuna River in Delhi. People should be trained to adopt new technologies

and strategies to reduce the levels of pollution in the River. River bed development can be proved to be the best solution to this problem. Government has formed 10 feet high wire barricades along Yamuna Bridge to prevent people tossing various things in to the River. Role of various Non-Governmental Organizations is very significant in creating awareness among the masses. Awareness can also be created among the people with the help of electronic and print media to save the river.

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