Open access e-Journal
Earth Science India, eISSN: 0974 – 8350
Vol. 4(III), July, 2011, pp. 80-104
http://www.earthscienceindia.info/

Restoration Plan of Gomti River with Designated Best Use Classification of Surface Water Quality based on River Expedition, Monitoring and Quality Assessment

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Abstract

In this paper, an attempt has been made to reclassify the designated best use of water quality based upon river expedition carried out from March 27 to April 2011 in the entire stretch of Gomti river at 30 different segments. Based on the observation of the river expedition, a restoration plan is also prepared. Older satellite images (LANDSAT 1978, LISS III 2008) were consulted to prepare land use maps in the Gomti basin and compare them with the recent satellite maps (2011). There has been severe reduction in forest cover and wetlands in the entire Gomti basin due to rapid land use change and increasing demand of pristine land from urbanization. This has affected flow of water in Gomti river adversely as most of the tributaries originate from water bodies or forests and reduction in their density has caused reduction in water availability in the river. Except Pilibhit and Kheri, all the districts falling under the basin are deficient in forest cover. Secondly, the result of sampling indicates that the quality of the water has deteriorated due to discharge of untreated wastewater from about 50 major drains in its entire course of 960 kms. The stretch between downstream of Lucknow to upstream of Barabanki, and between downstream of Sultanpur and Jauanpur is most polluted with designated class as E. The water quality between downstream of Jaunpur till confluence in Ganga at Kaithi, Ghazipur has been put in class D. Water quality of Gomti which deteriorates due to mixing of untreated sewage and industrial effluent up to Lucknow improves as a result of self purification process between Pipraghat to upstream of confluence of river Reth and Loni. The water quality at Lucknow and Jaunpur has been found quite unsafe. Due to self purification process between downstream Sultanpur to upstream Jaunpur city, DO levels improve.

Key- words: river restoration, floodplain, Gomti Basin, water quality

Introduction

The Gomti, an alluvial river of the Ganga Plain and one of the important tributaries of the Ganga, is considered to originate near Mainkot, from a lake– '*Fulhar Jheel'* in Madhotanda about 30 km east of the Pilibhit town in Uttar Pradesh, at an elevation of 185 m (about 55 km south of the Himalayas foothills). The river flows through an incised valley before meeting the Ganga river in Kaithi, Ghazipur bordering Varanasi (at an elevation of 61 m) after traversing 960 km in south south-east direction. Majority of the surface area of the Gomti Basin is generally flat sloping towards S and SE with altitude varying from 200 m to 62 m amsl. After flowing southwards through the districts of Sitapur, Lucknow, Barabanki, Sultanpur, and Jaunpur, it confluences with River Ganga in Kaithi, Ghazipur bordering Varanasi. For about 450 km from the origin, the difference in the elevation is about 100 m amsl. For the remaining stretch of 500 km, there is an elevation difference of 25 m.

The characteristic of the river is perennial and effluent. The river is characterized by sluggish flow throughout the year, except during the monsoon season, when heavy rainfall causes a manifold increase in the runoff. 75% dependable flow in September has been recorded as 450 cumec at Maighat (after Sai-Gomti confluence) and 125 cumec at Hanuman Setu, Lucknow. The average lean flow recorded for the month of April, has been 25 cumec and 15 cumec for these locations respectively.

The river flows in the great alluvial plain, which is of Pleistocene-Holocene origin, and redistributes the weathered sediments of the Gangetic alluvial plain derived from Himalaya (Kumar and Singh, 1978). Most of the sediments are transported during high river discharge, in monsoon period. This area is part of the Indo-Gangetic plain and its formation consists mainly of sand, silt, clay and occasional kankar bands. These materials are found intermixed and beds are variable both in lateral extent and thickness. At places an admixture of these formations is also found. The structure and thickness of sand beds are such that these form very potential aquifers.

The total drainage area of the river is 30,437 sq. km. Sai river is its major tributaory having drainage area of 12,900 sq. km, approximately 43% of the total catchment area of Gomti basin.

The Gomti-Kalyani doab is a fertile area, irrigated by canals, tube wells and open wells. This doab lies in the Barabanki district of U.P. and is bounded by Kalyani river on the North and the Gomti river and its tributary on the South covering an area of about 146,526 ha. On the west, the area extends up to the Sarda Sahayak feeder channel and on the east up to the confluence of the Gomti and Kalyani rivers.

While the amount of forest cover in UP is 9.01% of the total geographical area, the total forest cover in the Gomti Basin is just 4.10%. This indicates that the basin is deficient in total green cover. Ideally, the green cover in the basin can be increased to 12%, but this will require three times increase in the existing green cover. This calls for a massive plantation drive in the basin. There are ample lands available by the side of the river which can be utilized for forestation.

On the banks of the river, Sitapur, Lucknow, Sultanpur, and Jaunpur, are the four major urban settlements. The river, subsequently, receives the untreated wastewater and effluents from these locations in its course through more than 45 major drains. Throughout its stretch, there are a many tributaries such as- Kathina, Bhainsi, Sarayan, Gon, Reth, Sai, Pili and Kalyani, originating within short distances and carrying the wastewater and industrial effluents from different towns and industrial units in the basin. Besides Lucknow, it supplies drinking water to other towns located on its banks. These include Lakhimpur Kheri, Sultanpur and Jaunpur. While each of these towns pollutes the river, the condition is the worst in Lucknow where most of the stretches of the river look like a drain.

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Review of Literature

According to study carried out by several researchers on Gomti river, it has been observed that, the water quality has degraded rapidly in recent years with wide encroachment of flood plains (Arora *et al*., 1973; Bhaskaran *et al.,* 1963; Bhargawa and Ram Tirath, 1982; Kuwar and Kant, 1987; Pathak, 1991; Bhatt and Pathak, 1992; Mishra, *et al*., 1994; Singh *et al.,* 2003; Mishra and Mishra, 2008).

Bhaskaran *et al.* (1965 in Trivedi, 2001) carried out physico-chemical studies on the river Gomti at Lucknow and concluded that the river water was significantly polluted showing lower value of DO at many places. Arora *et al.,* (1973 in Trivedi, 2001) observed that the river Gomti at Lucknow was severely polluted. Bhargawa and Ram Tirath (1982) studied water quality of river Gomti at Lucknow and concluded that water quality at upstream of Gaughat was good for almost all beneficial uses, and water quality downstream of Lucknow was heavily polluted and it was not suitable for bathing, drinking without treatment, fishing, recreation etc. Kuwar and Kant (1987) analyzed the water of river Gomti at Lucknow at several place for few heavy metals and observed that it was polluted with copper (Cu), zinc (Zn), and chromium (Cr). Pathak (1991) analysed the physico-chemical parameters and heavy metal contents of river Gomti from Gaughat to Malhar. The authors observed increased DO during winter season with its drastic depletion during the summer months at all station, except at Gaughat. The author also concludes that the cadmium (Cd) and nickel (Ni) in Gomti river was little on the higher side respectively during monsoon and winter.

Bhatt and Pathak (1992) concluded that river got highly polluted downstream of Lucknow due to human interference and input of municipal and industrial wastewater. Mishra, *et al.* (1994 in Trivedi, 2001) concluded that the river Gomti was highly polluted at Sahjahanpur, Kheri and Lucknow having high value of BOD and COD during summer seasons. Gaur *et al.* (2005) studied the impacts of domestic/industrial waste on the water and sediment chemistry of river Gomti with special references to heavy metals in different seasons (summer, winter and rainy). High concentration of all the six heavy metals namely Cd, Cr, Cu, Ni, Pb and Zn were noticed in water and sediments in rainy season compared to summer and water.

Gupta and Subramanian (1994 & 1998) analyzed water and sediment samples collected from the Gomti river during the post-monsoon season. The results indicated almost monotonous spatial distribution of various chemical species, especially because of uniform presence of alluvium Dun gravels throughout the basin. The river annually transports 0.34×10^6 tonnes of total suspended material (TSM) and 3.0×10^6 tonnes of total dissolved solids (TDS), 69 percent of which is accounted for by bicarbonate ions only. Samples collected downstream of the city of Lucknow showed the influence of anthropogenic loadings for a considerable distance in the river water. Na^+, Cl^-, and SO_4^{2-} concentrations build up downstream. The bed sediment chemistry is dominated by Si (36 percent), reflecting a high percentage of detrital quartz, which makes up about 74 percent of the mineralogy of the bed sediments in the River Gomti. The average Kjeldahl nitrogen concentration (234 μg/g) indicated indirectly the amount of organic matter in the sediments. The Hg concentration in sediments has been found to be higher (average 904 ppb) than the background value. The

suspended sediments are well sorted, very finely skewed, and extremely leptokurtic, indicating a low energy condition of flow in the Gomti river. The influence of chemical loads in the Gomti has been found to be small or nonexistent on the Ganges river, perhaps because the water discharge of the Gomti (1.57 percent) to the Ganges is quite low.

Mishra and Mishra (2008) carried out physico-chemical studies on the river Gomti and observed that the high concentration of all metals like Cr, Cu, Ni, Pb and Zn were noticed in water and concentration of these metals increased from 2006 to 2008, while Cd was found below the detectable limit. COD and TDS value were also observed to increase day by day due to increase in quantity of industrial effluents and sewage being discharged in the river, the level of DO also falling rapidly due to increase in BOD and COD.

The concentrations of cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc in water and bed sediments of river Gomti have been studied in a fairly long stretch of 500 km from Neemsar to Jaunpur by Singh *et al.* (2005*a*). Based on the geoaccumulation indices, the Gomti river sediments from Neemsar to Jaunpur are considered to be unpolluted with respect to Cr, Cu, Fe, Mn, and Zn. It is unpolluted to moderately polluted with Pb. In case of Cd it varies from moderately polluted to highly polluted. As far as Ni is concerned the sediment is very highly polluted at Barabanki and Jaunpur downstream. No correlation was found between enrichment factor and geoaccumulation index. Grab samples of water (October 2002–March 2003) and bed sediments (December' 2002 and March' 2003) were collected from 10 different locations following the standard methods. Profiles of the heavy metals across the Lucknow urban stretch showed a progressive downstream increase due to additions from 4 major drainage networks discharging the urban effluents into the river. The study revealed that the urbanization process is associated with higher concentrations of heavy metals such as Cd, Cu, Cr, Pb, and Zn in the Gomti river sediments. To keep the river clean for the future, it is strongly recommended that urban effluents should not be overlooked before their discharge into the river.

Assessment of water quality of river Suheli and Gomti is carried out by Singh and Tandon (2010) in May and august in 2007 and in January 2008. In the month of January the sites of Suheli river and Basantpur village showed the values for conductivity whereas the site of Gomti river from Gaughat to Pipraghat Showed increasing trend in turbidity. In the month of January, May and August the site of Suheli river and road bridge showed maximum dissolved oxygen and the Basantpur region showed the lowest dissolved oxygen value in the year 2007 but in the year 2008 the Kaima region showed the highest dissolved oxygen and the tiger haven showed the lowest dissolved oxygen value whereas the site of Gomti river showed the significantly decrease in the dissolved oxygen in Gaughat to Pipraghat in both of the years. In the month of January, May and August the site of Suheli river and Basantpur village showed the maximum B.O.D. value and the Kaima region showed the minimum B.O.D value whereas the sites of Gomti river showed the increasing trend of B.O.D from Gaughat to Pipraghat.

A combined study of Gomti river and Varuna river is done by Srivastava, *et al.* (2010) on water characteristics and Algal biodiversity in river Varuna and Gomti. The studies have been carried out in relation to diversity and pollution. The members of Bacillariophyceae were most dominant and Cyanophyceae dominated in winter months. Euglenophyceae

members were poorly represented but members of Chlorophyceae were not much significant. Desmids also occurred in fairly good numbers. The comparative study of physico-chemical factors indicate that river Varuna is more polluted in comparison to river Gomti, as Varuna is although facing anthropogenic activities along river course in Varanasi. The algal population was also higher in the river Varuna as compared to river Gomti.

Singh *et al.* (2005*b*) carried out a study on a 630 km stretch of river Gomti, to study the distribution of heavy metals in sediments and the partitioning of their chemical species between five geochemical phases (exchangeable fraction, carbonate fraction, Fe/Mn oxide fraction, and organic fraction) using Tessier's analytical sequential extraction technique. Most fractions in the sediments associated with the carbonate and the exchangeable fractions were between 11 and 30% except in a few cases where it was more than 50%. According to the Risk Assessment Code (RAC), the sediments having 11–30% carbonate and exchangeable fractions are at medium risk. The concentrations of cadmium and lead at mid Lucknow, Pipraghat, Sultanpur U/S and Sulthanpur D/S are between 31 and 50%. They thus pose a high risk to the environment. Since the concentrations of cadmium and lead at Neemsar (Cd 56.79%; Pb 51%) are higher than 50%, the RAC as very high. In most cases, the average metal concentrations were lower than the standard shale values.

Extensive surveys were conducted to explore the diversity of fishes, distribution patterns, abundance, threat, and habitat status in the upper, middle, and lower stretch of river by Sarkar *et al.* (2010). Altogether 56 fish species belonging to 20 families and 42 genera were collected from various sampling sites. Of the 56 species, five belonged to the 'endangered' (EN) category and 11 belonged to the vulnerable (VU) category. Six major categories of habitat were identified and pattern of fish assemblage and dominant genera in each habitat studied. Considerable differences were observed in the fish species richness and relative abundance (RA) of the species in the different sampling sites of river Gomti. Indiscriminate catch, poisoning, using of fine mesh sized nets, dumping of sewage, siltation, water abstraction, changing land use pattern, decreased water discharge, and exotic species threaten the fish diversity.

Geological and Geomorphological set up of the Gomti Basin

In the Indian sub-continent, the Indo-Gangetic Plain is one of the largest fluvial sedimentary basins of the world. It is located between the world's most tectonically active regions, the Himalaya in the north and stable Indian Craton in the south. The entire Gomti basin is underlain by thick alluvial sediments of the Quaternary age. The alluvial sediments consist of boulders, pebbles, gravels, sand, silt, clay and *kankars*. The unconsolidated unit may be further subdivided into younger alluvium. The younger alluvium occupies the present day flood plains while the older group occupies elevated portions mainly the *doab* portions. The older alluvium is characterized by *kankar* nodules at depth otherwise it is similar to the younger alluvium.

Incision of the Gomti river and its valley has been studied using characteristics of longitudinal profile, escarpment heights, valley morphology and channel sediment characteristics by Thakur *et al.* (2009). The tectonic-driven incision is younger and superimposed over the base level-linked incision. The role of climate-derived factors in fluvial incision is secondary and not easy to evaluate.

The valley margins of Gomti river show prominent bluff or escarpment and are sometimes referred to as banks. Escarpment height is basically height of the vertical cliff along the margin of the river channel and river valley. The downstream increasing trend of escarpment heights of the both river margins is primarily related to incision of the river and controlled by the lowering of base level of the Ganga river. Longitudinal profile of the Gomti river runs from 185 to 60 m above mean sea level and shows three prominent breaks in slope. The conspicuous convexity in the profile is located above the sub-surface Faizabad Ridge and may be related to the movement along this ridge.

Downstream wave-like variation in average escarpment height reveals undulating topography with prominent upwarps and downwarps attributed to the compressional tectonics of the Ganga Plain. The Gomti river provides the expression of base level linked (2 to 10 m deep) fluvial incision associated with the Ganga river, and tectonically-driven (6 to 15 m deep) incision is connected with intra-basinal tectonics of the Ganga Plain Foreland Basin.

Valley morphological feature of the Gomti river shows highly sinuous active channel near Gularia in the upper segment, river valley margins with discontinuous and dissected high escarpment in the middle segment and the lower segment shows sinuous river valley showing 10 to 12 m deep incision on the Ganga Plain near Chandwak before merging with Ganga at Kaithi (Thakur *et al.,* 2009). The impact of tectonics and climate change is noteworthy and effective, which may lead to incision of river channel and rejuvenation of entire drainage network in the past.

Fluvial incision is the most distinctive geomorphic characteristics shown by all active rivers of the Ganga Plain. Monsoon-controlled climate of the Ganga Plain controls rainfall received by the Gomti river Basin and discharge of the Gomati river. The discharge of the Gomati river increases downstream due to contributions from surface runoff and groundwater. In the upper segment of the Gomti river, incision is low, although rainfall is high; on the contrary in the middle and lower segments, incision is high, while rainfall is low. In the middle segment, water discharge is less than in the lower segment, but it shows maximum incision. Further, there is wave-like pattern of incision. Indicating that rainfall alone can not explain the incision pattern of the Gomti river.

Extensive aquifers occur in the quaternary alluvium formations at various depths. The phreatic aquifers are unconfined in nature and main source of water from drinking purposes. These are classified as follows:

a). Phreatic aquifers up to depth of 50 m below the ground level
b). shallow aquifers between 50 m to 150 m below the ground level
c). medium depth aquifers between 150 m to 300 m below the ground level
d). deep aquifers between 300 to 500 m below the ground level
The river is divided into three segments:

(i) The upper segment of the river till u/s of Sitapur
(ii) The middle segment of the river – from d/s of Sitapur to u/s of Sultanpur
(iii) The lower segment of the river – from d/s of Sultanpur to the confluence with the Ganga

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Upper segment of the river

When it originates from a lake called Fulhar *Jheel* near Madho Tanda east of Pilibhit, the Gomti doesn't look like a river or not even a stream. There are isolated patches of lakes with very little water. In one of the lakes which is actually referred to as, 'Fulhar *Jheel'*, remains filled with water round the year, though even its water goes down during the summer. The river doesn't originate from Gomat *Taal* or Fulhar *Jheel* as it is commonly believed, but from upstream of Pilibhit between Khatima and Tatarganj-Bahmanpur forests (Fig. 1). There are paleo-channels and smaller streams coming from Himalayan foothills at the Indo-Nepal border on the western side of the Sharda river which is known as Kali in Nepal (Fig. 2). Groundwater-fed alluvial rivers are common features of the Ganga Plain. These rivers originate in the interfluve regions of the major Himalayan rivers such as the Yamuna, the Ganga, the Ghaghara, the Gandak, the Kosi rivers etc, and are entrenched into the Ganga Plain. Fluvial incision or the vertical down cutting of river channel of Gomti into alluvium must have been controlled by the sediment/discharge ratio brought by the run-off from the Himalayas. However, external factors such as tectonic, climate and base level changes also contributed to the incision of the river. Due to massive run-off from the Himalayas in the foothills, water used to gush through once heavily forested area which used to extend till Puranpur. The heavy discharge in the river must have silted heavily downstream resulting into low channel capacity through thousands of years of time span (Fig. 3). This also facilitated change of river course and development of huge aquifers. The local farmers and villagers have also started growing crops in the depressed land which otherwise seems to be connected with the lake. According to the local people, this area gets flooded during the monsoon. To ensure that adequate water was available in the lake during the summer, the Irrigation Department had connected the lake with the main branch of Sharda canal, though a minor canal. The plan was to release water in the main branch to maintain water table of the lake. Later the irrigation department stopped releasing water from the Sharda canal into the minor canal. Slowly, the local farmers encroached on the canal and started cultivation. When the pilgrims and local people raised the demand for release of water into the lake, the district administration connected a drain that passes through the Madho Tanda town within the lake. Now sewer water flows directly into one of the adjoining lakes of Fulhar *Jheel*. Earlier fresh water was released into the lake through the canal, but the drain was bringing dirty water released from the houses and small industrial units.

For first 60 kilometers, the river is intermittent of its course, becoming perennial only after Ekkotarnath and after meeting with Jhukna river. There is no flow in initial reach of Gomti in about 60 km length during non monsoon months. Gradually, the stream which is even dry at many places, starts growing feebly. At several places, the river is non-existent and farmers have encroached upon the riverbed (Fig. 5). At Dhimapur Bridge (Triveni Baba Ashram) and all along Puranpur-Khuthar road, the river is almost filled with silt and local farmers do cropping for 7 months when there is no water (Fig. 6). Two small streams, between Puranpur and Ghungchiyee, join Gomti and make a 'triveni'. There is a forest patch afterwards at Gularia. At this place, the small stream forms a big lake surrounded by forests which extends downstream for few kilometers into a marshy land area (Fig. 4). There is also a very old Shiva temple called *Ekkotarnath Mahadev*. The river looks like a marshy river at this place with beautiful treeline along the riverside. There are good number of fishes and turtles in the lake. Some local people have also spotted crocodiles in this lake.

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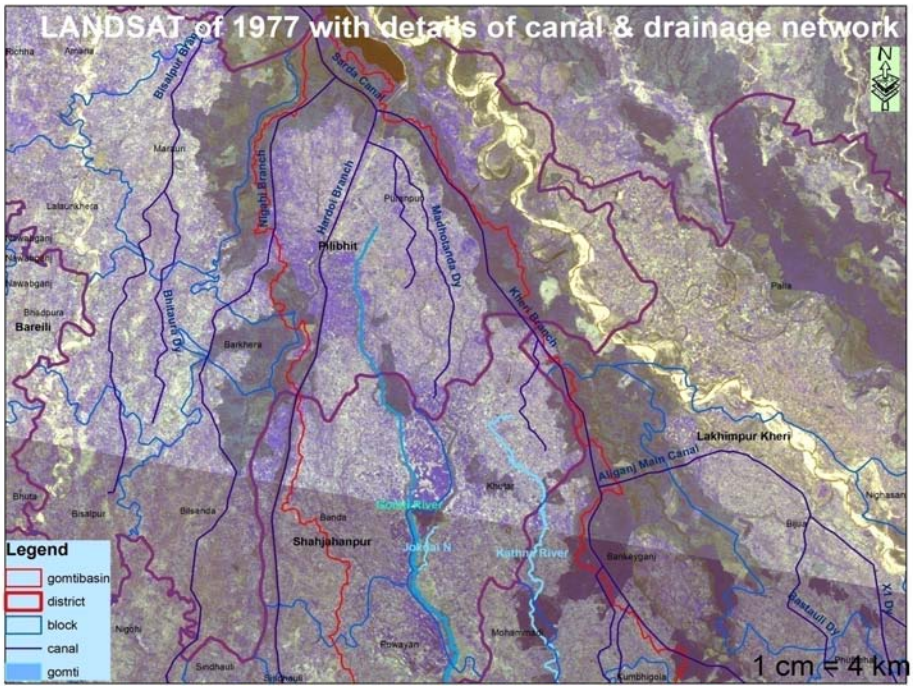

Fig. 1: LANDSAT image (1977) of the upper segment showing the drainage of the Gomti river.

Fig. 2: Origin of the river showing Himalayan foothills and the Sharda river based on Satellite picture (Google 2011).

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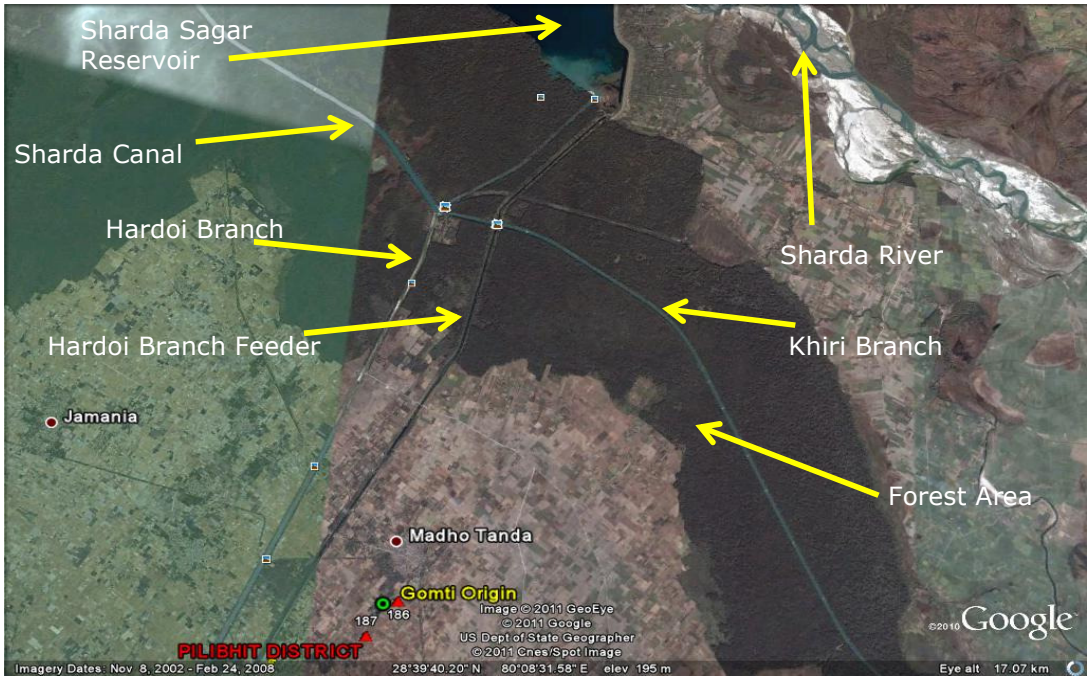

Fig. 3: A closer look of a section of the upper catchment showing the origin of the river near Himalayan foothills and the Sharda river based on Satellite picture (Google, 2011).

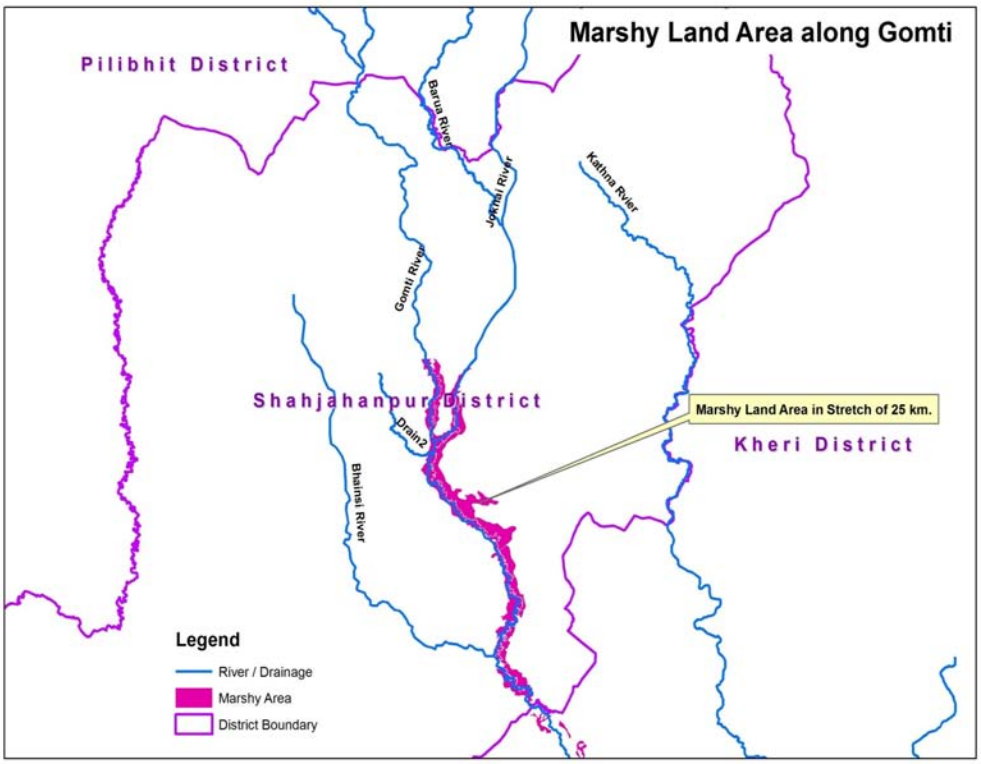

Fig. 4: Marshy land area along the Gomti river in its upper segment.

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After leaving Ekkotarnath in Pilibhit, Gomti enters Banda in Shahjahanpur. At this place, there is an old Shiva temple called 'Sunasirnath Mahadev' which is situated just along the riverside. There are many *Shivalingams* and one of them is almost 7 to 8 feet down in a *kund* which is filled with water. The water is normally withdrawn during *Shivratri puja* with the help of pumping sets. The water keeps coming naturally to this *kund* as it is surrounded by river. During monsoons this temple is inundated with water completely. After leaving Banda, a tributary called 'Jhukna *Nadi*' meets near Khuthar. The river gets fair amount of water from this tributary.

Around 75 km away from this point of its origin, this stream is joined by tributaries like Sukheta, Choha and Andhra Choha near Mohammadi Kheri, a tehsil of Lakhimpur Kheri. Choha and Andhra Choha were found to be completely dry. At one or two places, small ponds were visible with very little water. The stream now turns into a river. Sukheta is a perennial stream that originates near village Kiratpur in Sindholi Block of Shahjahanpur district and drains into the Sai river near Lonar in Hardoi district. En route, it flows through large parts of the cane command areas of Loni and Hariyawan units. Although reduced to a rivulet for most of the year, it swells during monsoons and inundates vast stretches of land on either side of its bank. The name of the stream literally means – 'one that gives prosperity'. True to its name, it has brought prosperity to the farmer. It has provided water for irrigation and carried away the runoff from his fields during rains. The sugarcane crop that feeds these units is irrigated, in no small measure; by water drawn from this stream. Unfortunately, human activities are damaging this stream beyond its capacity to regenerate itself. Deforestation along the banks is leading to runoff depositing silt in the stream bed. This leads to flooding during monsoons. Unrestricted use of pesticides in fields is strangling aquatic life. Untreated sewage from human habitation is finding its way into the stream polluting it and making it unfit for consumption by humans, wildlife or cattle.

The middle segment of the river – from d/s of Sitapur to u/s of Sultanpur

The river is under 'assault' at various points of its journey d/s of Sitapur as it meanders through the industrial belt of sugar processing, paper and plywood industries. From industrial effluents to domestic discharge, the river becomes more of a flowing dumping yard for the 15 smaller and bigger towns, Lucknow, Sultanpur and Jaunpur, in its catchment area. The river is still somewhat clean- or it cleanses itself through a natural oxidation process- when it approaches Balaganj in Lucknow. Balaganj is around 350 km away from Fulhaar *Jheel.*

It is here in Balaganj that the British had set up a raw water pumping station– the Gaughat pumping station. The river meanders for another 12 km through the middle of the state capital and then shrinks. The surging 25 big nullahs fill the river with domestic discharge. And thus at Gomti barrage, the river is reduced to a mere 'dead' water body. The flow almost stops and the dissolved oxygen diminishes. On 31st March 2011, DO content at the barrage was found to be 1.4 mg/l. Aquatic life is severely affected because of this. Fish die and whatever planktons (water plants) are left in the river are destroyed. According to water pollution norms, dissolved oxygen levels should be in the range of at least 3 to 4 mg/l for any aquatic life to survive.

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Fig. 5: Intensive agriculture in the upper catchment of the Gomti river near Puranpur. (Google Image, 2011).

Fig. 6: Intensive agriculture in the upper catchment of the Gomti river near near Gopalpur, upstream of Shajahanpur (Google Image, 2011).

At Gomti barrage, the dissolved oxygen is often below 2 mg/l which results in heavy aquatic mortality. Recently, Uttar Pradesh *Machuhara Sangh* had put forth its demand for immediate redressal of the problem, however, fish mortality is quite a routine problem, often linked with discharge of effluents from sugar factories upstream. The Gomti leaves the barrage and drags further downstream with low dissolved oxygen – trying to purifying itself through the natural oxidation process. It is hoped that the newly constructed Sewage Treatment Plant (STP) at Bharwara village near Gomti Nagar would make things better. But according to a recent BBC report, the situation in the DO content of the river has not at all improved after the STP began operational – a number of drains have still not been connected with the STP.

The Kadhu *Nadi*, one among the larger tributaries of Gomti, enters from district Raebareli, and after a course of about 37 km discharges itself into the Gomti (Fig. 7). It is a combination of two streams. Between Jagdishpur and Gaura Jamo runs a large drainage channel known as the *Naiya*, a term applied to any rain stream. It is almost dry in summer, but gets huge surge in the rains. At Tanda in Jagdishpur, it is reinforced by another large water course which rises in Parwezpur to the north and thenceforward the combined stream is known as the *Kandu* or *Kadhu*. In the Southeast of the Jagdishpur, it is joined by another drainage channel serving the villages round into the north. In the extreme northeast of the Gaura Jamon a third deep drainage channel, which runs irregularly from near Jamo and carries off the surplus from that village and the neighbourhood, joins the mainstream. The banks are broken by ravines, and here and there are some small tract of jungle. The Kadhu *Nadi* then continues eastward through *pargana* Musafirkhana, and joins the Gomti at Chandipur. Although it assumes considerable proportion after heavy rain, it is a shallow stream at other times, and there is never any danger of flooding along its course.

Around 150 km downstream, it reaches Jagdishpur where once again ‘purified’ raw water is tapped and pumped into the town for drinking purpose. The river passes through Sultanpur and eventually meets the Ganga near Saidpur, Kaithi in Ghazipur. According to a report of the Centre for Science and Environment, the riverine biota being affected by pollution is an indicator of an impending ecological disaster.

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This river is the chief drainage line of the many districts it passes through and is in fact the only stream of any importance. In *pargana* Jagdishpur it winds along the whole of the northern boundary, separating this district from Barabanki and Faizabad, and receiving all the drainage of the northern portion of the *pargana* by various natural water resources.

Along the upper reaches down to Sathin the banks are high and sometimes precipitous, and the bed is well marked. South of Sathin the river opens out, the high banks recede, and from Mau Atwara onwards the low lands are subject to damage from flooding.

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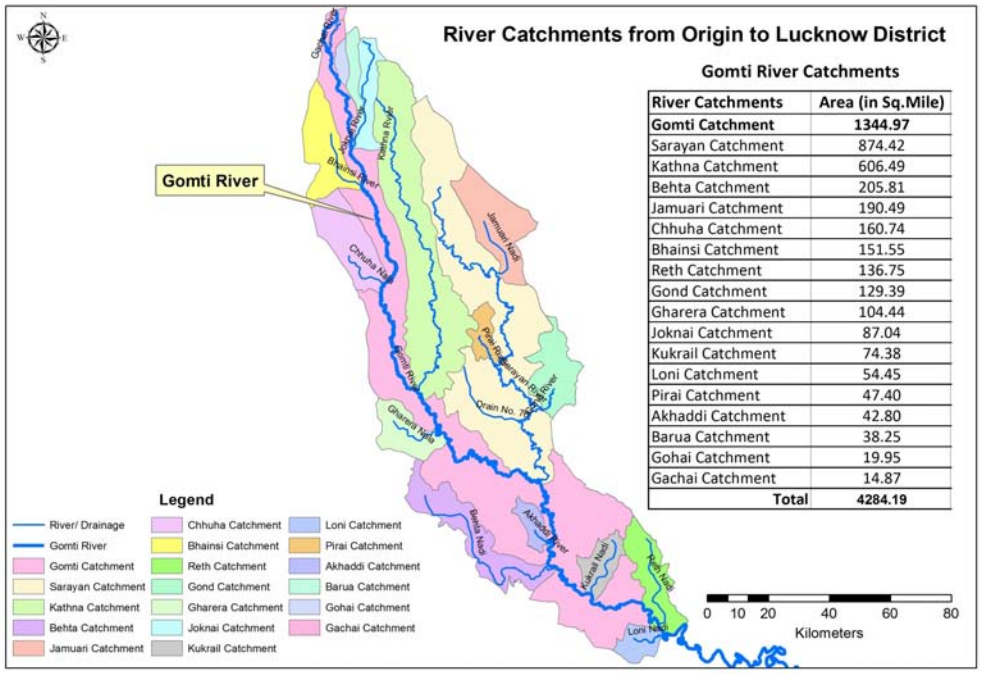

Fig. 7: The upper and middle segment showing major tributaries from origin to Lucknow district.

South-eastwards from Jagdishpur the river separates the two parganas of Isauli on the north and and Musafirkhana on the south. Here, again, the there is fair extent of lowland, and the river seems to have altered its course in the past, and looks as if it once ran in a fairly direct line from Fatehpur. At present, however, it winds along in a fairly well defined bed between stretches of low lying grounds on either side. On the north the high cliff are scored with deep ravines, and on either bank there is much irregular broken ground. Proceeding in the same direction, the Gomti separates *pargana* Miranpur on the south-west from Baraunsa on the north-east. Here, too, it ordinarily runs between well defined banks, although in the west of Baraunsa there are some low lying riparian strips of cultivation. The banks on the south side in *pargana* Miranpur are generally of a similar nature, but in places they sink and the soil is crumbly, considerable damage being done in years of heavy rainfall. In the east of this *pargana* the scour from the uplands is considerable, and large ravines have formed, while here and there the constant erosion has caused much land to be thrown out of cultivation. The river in these two *parganas* passes by Chandaur and Sultanpur. Then it passes on towards the south-east and separates Aldemau from Chanda, passing Paparghat, Dera, Dhopap, Aldemau, Kadipur and Dwarka.

In this part of the district the course of the river is tortuous and irregular. In Aldemau the ground in the vicinity as far as the village of Katwari is much cut up by ravines, passing through a block of high light land, which easily lends itself to erosion. In Chanda the banks are similar, being high and in places precipitous. In the north of the pargana where the ground along the river is light and high lying, ravines have frequently been formed and some land has gone out of cultivation in consequence. The drainage of the land in its neighbourhood is carried down to the river by numerous natural channels. Except in years of abnormal rainfall,

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the Gomti gives no trouble, yet damage is frequently caused by floods and their consequent effects. Some years of high discharge have been recorded by the CWC (Table-1).

The lower segment of the river – from d/s of Sultanpur to the confluence with the Ganga

The lower segment of the river remains mostly perennial due to discharge from the tributaries. Sai river is the major tributary in the lower stretch which rises in the Hardoi district and for a considerable portion of its course separates the districts of Lucknow and Unnao. Bending south and passing to the west of the town of Raebareli, it turns east, striking the southern border of the old cantonment in the city. It passes out Raebareli at village Kanhpur in *pargana* Salon. The total course of the river in the district Raebareli is about 100 kms in length. The banks of Sai are in many places precipitous.

Water Availability in the River

About 7390 x 10^6 m^3 water of the Gomti river is annually discharged into the Ganga river. About 80 per cent of the discharge flows during the monsoon season (Rao, 1975). Average annual water yields due to rainfall in the Gomti Basin has been found to be 7390 million cubic meter with specific yield/discharge of 244,000 m^3/km^2 and 234 m^3/sec. The run-off for individual basins can be significantly different from the national average. For example, the run off in the Gomti Basin is ~ 250 mm yr-1, compared to ~1600 mm yr-1 in the upper Gandak. Estimates show that an average flow of the Gomti river is 1,500 million litres per day (MLD). During rains, it reaches 45,000 MLD while in summer it falls to 500 MLD. The available discharge in the river Gomti as per C.W.P.C. at Lucknow during lean period is around 500 MLD while in the monsoon, the discharge is around 55,000 MLD. For most of the period the discharge on an average is around 1,500 MLD only. In fact at times in the dry season, the river water level goes down to such an extent that there is need to request the State Irrigation Department to augment supplies to meet the drinking water needs.

Table-1: Years of high discharge recoded by the Central Water Commission.

Gauge Site	District	Maximum Water Level (m)	Year	Danger Water Level (m)
Neemsar	Sitapur	129.08	1958	126.80
Bhatpurwa Ghat	Sitapur	115.55	1960	114.30
Hanuman Setu	Lucknow	110.85	1971	109.50
Sultanpur	Sultanpur	89.45	1971	84.73
Janupur	Jaunpur	77.73	1971	74.06

Source: Central Water Commission Data (Collected from Department of Irrigation, UP)

The river Gomti continues to be the main source of water supply to Lucknow, Jaunpur and other habitations downstream including many farmers. A number of tube-wells have been also bored near the river-bed to exploit groundwater. Every day, the Lucknow city

draws around 250 MLD of water from Gomti, while 300 MLD is withdrawn from the groundwater.

Water augmentation plan

Gomti flows are being occasionally augmented by Sharda Canal System through Lucknow branch on the right and Kheri branch on the left through escapes to the extent of 100 cusecs. Both Lucknow branch and Kheri branch run simultaneously and alternately as per the roaster. Sharda flows can be pumped into Gomti in the upper reaches (Fig. 8). But during non-monsoon there will not be adequate flows in Shards as all flows are diverted into Sharda Canal at Banbasa. There was a plan to link Gomti river to a 100 KM long canal with well fed Sharda river which was conceived to feed surplus water to it. The plan envisaged a constant supply of water from the Sharda, which receives plentiful water from its Himalayan source. The link was planned between Pilibhit and Pallia in Lakhimpur-Kheri district and it was hoped it would solve the perennial problem of a rapidly drying Gomti. The work was assigned to the state irrigation department. The state advisory committee had approved the preparation of the feasibility report on linking the two rivers. However, the project was later rejected on technical grounds. The construction of an underground tunnel of 100 km was against the natural flow regime of the region. However, it is suggested to re-examine this and look for some connection with the Sharda Canal in the upper catchment of the Gomti river in Pilibhit district.

It is also advisable to restore the drainage of Gomti river especially in the upper catchment. A series of small check-dams can be created in the head region of the tributaries so that water ultimately flows to the river.

Land Use Cover in the Gomti Basin

Decreasing forest cover and wetlands are cause of major concern in the entire Gomti basin. In the last 100 years, there has been severe reduction in forest cover due to increasing demand and urbanization. This has affected flow of water in Gomti river adversely. Most of the tributaries originate from water bodies or forests and reduction in their density has caused reduction in water availability in the river. In the Gomti Basin, majority of forests are of open types and less dense. Except Pilibhit and Kheri, all the districts falling under the basin are deficient in green cover. While the amount of forest cover in UP is 9.01% of the total geographical area, the total forest cover in the Gomti Basin is just 4.10% (Table-2 & 3). This indicates that the basin is deficient in total green cover. Ideally, the green cover in the basin can be increased to 12%, but this will require three times increase in the existing green cover. This calls for a massive plantation drive in the basin. There are ample lands available by the side of the river which can be utilized for forestation. LANDSAT satellite data of 1978 and LISS III sensor data of 2008 shows that in a width of 1000 m along Gomti river, built up area has increased while the forest and plantation area including water bodies has decreased (Fig.9) This trend further increased and the forest cover and water bodies have decreased substantially.

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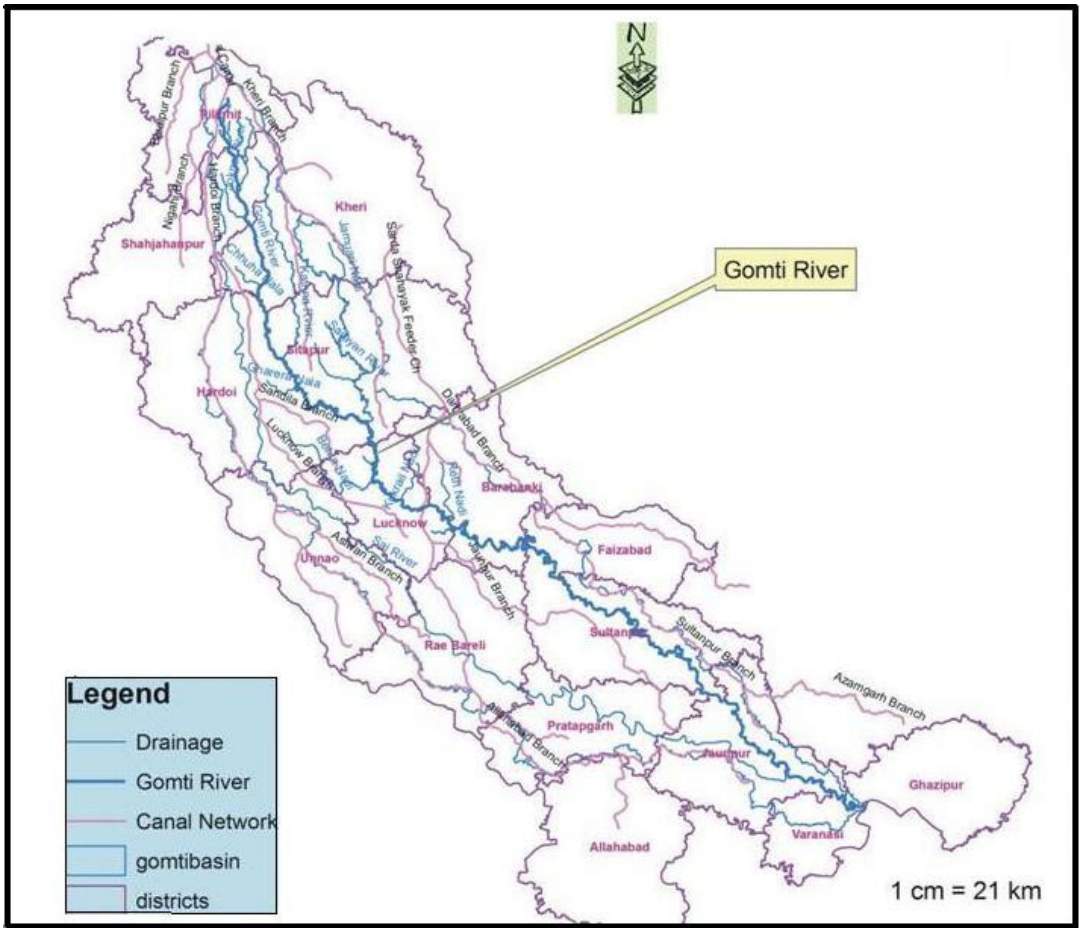

Fig. 8: Canal and drainage network of Gomti Basin.

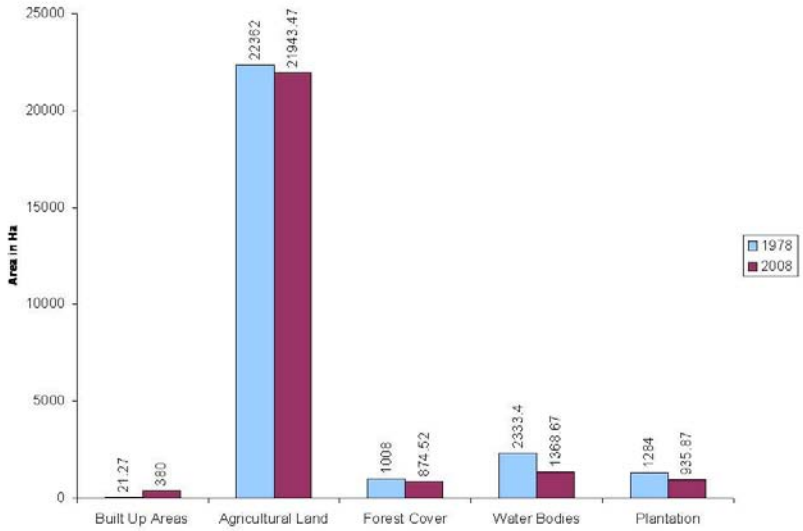

Fig. 9: Land use change of Gomti river buffer area from 1978 to 2008 up to Behta river upstream of Lucknow.

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Table- 2: Land use categories in the Gomti Basin.

Land use	Percentage
Forest Cover	4.10
Agricultural Land	65.5
Built-up Habitat/Settlements	13.3
Fallow Land	9.5
Barren Uncultivable Land	3
Barren Cultivable Wastelands	2.5
Pastures	0.98
Water Bodies	2.10

Based on 2010 Google Satellite Image

Table- 3: Extent of Forest cover and wetlands in the districts falling under Gomti Basin.

Districts	Geog. Area (sq. km.)	Forest Cover (sq. km.)			Total Forest Cover	% Forest cover	No of wetlands
		Dense	Moderately dense	Open			
Pilibhit	3499	290	204	203	697	19.91	18
Kheri	7680	366	502	446	1314	17.11	71
Shajahanpur	4575	20	54	44	118	2.58	43
Hardoi	5986	–	7	118	125	2.08	156
Sitapur	5743	–	15	201	216	3.76	89
Lucknow	2528	–	115	183	298	11.78	53
Faizabad	2341	–	5	51	56	2.39	27
Barabanki	4402	–	18	157	175	3.97	56
Unnao	4558	–	34	197	231	5.07	88
Rae Bareli	4609	–	6	91	97	2.10	86
Pratapgarh	3717	–	28	67	95	2.55	47
Sultanpur	4436	–	18	157	175	3.94	64
Jaunpur	4038	–	13	42	55	1.36	26
Varanasi	1535	–	1	11	12	0.78	35
Ghazipur	3377	–	4	43	47	1.39	26

Water Quality Status of River Gomti

Gomti is facing severe problem of pollution due to discharge of sewage and industrial effluent. The earlier assessment of water quality carried out by Department of Irrigation, UP in 1991 and 1996 respectively shows high level of pollution in Lucknow and Jaunpur (Table-4). The Central Pollution Control Board (CPCB) monitors the surface water quality of Gomti river and its tributaries – Gomti at Sitapur upstream, at Lucknow upstream and downstream, at Varanasi and Sai at Unnao after drain outfall on routine basis. Parameters measured are Physical (temp., pH, EC), bacteriological (total coliform and faecal coliform) and organic pollution (DO, BOD) and COD. The water quality data for the year 2002 has been scrutinized and the observations are summarized in Table-5 & 6. Variation in DO content (mg/l) measured at Gaughat and Barrage (based upon 2004 to 2008 data) and DO-BOD profile in Lucknow stretch of the Gomti River as monitored in March– April 2011 has been illustrated in Fig. 10 & 11 respectively.

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Table- 4: Water quality for Gomti River monitored by Department of Irrigation, UP in 1991 and 1996.

River Gomti (Average Value)						
Sampling sites	1991			1996		
	DO (mg/l)	BOD (mg/l)	Total Coliform (MPN/100 ml)	DO (mg/l)	BOD (mg/l)	Total Coliform (MPN/100 ml)
Dadnamau Sitapur	7.5	2.6	6600	8.44	2.4	2708
Lucknow U/s Gaughat	7.85	2.6	5050	8.3	2.3	3070
Lucknow D/s Pipraghat	2.9	11.7	228000	2.8	12.8	332499
Jaunpur D/s	7.2	3.0	24000	6.3	5.4	50033
Gomti before Meeting Ganga Rajwari	8.5	2.9	20500	6.9	4.4	8522

Table- 5: Classification of designated best use of water quality done by CPCB in 2002.

Location	Desired level	Existing level	Critical parameters
Gomti between Kheri and u/s of Sitapur	C	C	
Gomti between Sitapur and u/s of Lucknow	C	C	
Gomti between d/s of Lucknow to u/s of Jaunpur	C	E	DO, BOD, TC
Gomti between d/s of Jaunpur to u/s of Varanasi	C	D	BOD, TC
Gomti d/s of Varanasi	C	D	BOD
Sai at Unnao	D	D	

Source: CPCB, 2002

Table- 6: Pollution level in different stretches of the river as outlined by CPCB in 2002.

Location	pH	EC (umhos/cm)	DO (mg/l)	BOD (mg/l)	COD mg/l)
Lucknow u/s	8.2	111	7.8	2.2	18
Lucknow d/s	8	153	6	5	41
Sitapur	8.2	132	8.3	2.3	2.3
Jaunpur	8.3	149	7.9	3	13
Varanasi	8	315	8	2.6	13
Sai at Unnao	8	134	8	3	18

Table- 7: Water quality data for river Gomti (summer average March to June for 1994-2010 data).

LOCATIONS	Width	DO	BOD	DO	BOD
		(mg/l) 1994		(mg/l) 2010	
NEEMSAR	1/2	8.4	0.8	8.32	2.12
BHATPUR	1/2	8.1	0.4	8.05	3.37
GAUGHAT	1/2	8.9	2.5	8.35	3.34
MOH.MEK D/S	1/2	0.6	10.3	3.15	10.50
PIPRAGHAT	1/2	0.4	11	1.40	13.25
GANGAGANJ	1/2	4.7	9.4	3.37	4.00
SULTANPUR D/s	1/2	7.6	3.2	8.07	3.65
JAUNPUR D/s	1/2	8.2	2.2	7.72	4.01

(Source: CPCB Delhi)

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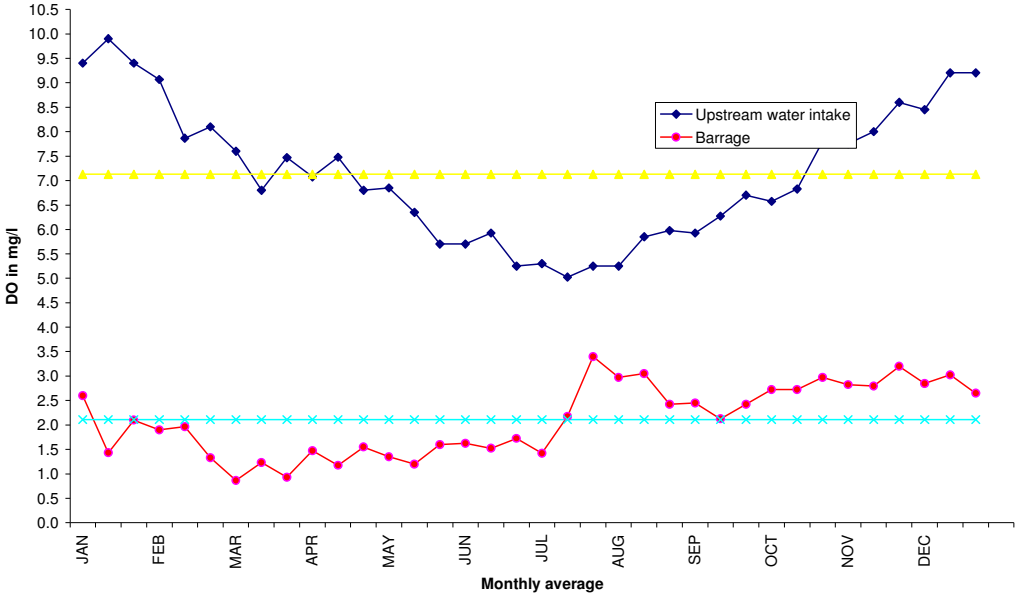

Fig. 10: Variation in DO content (mg/l) measured at Gaughat and Barrage (based upon 2004 to 2008 data).

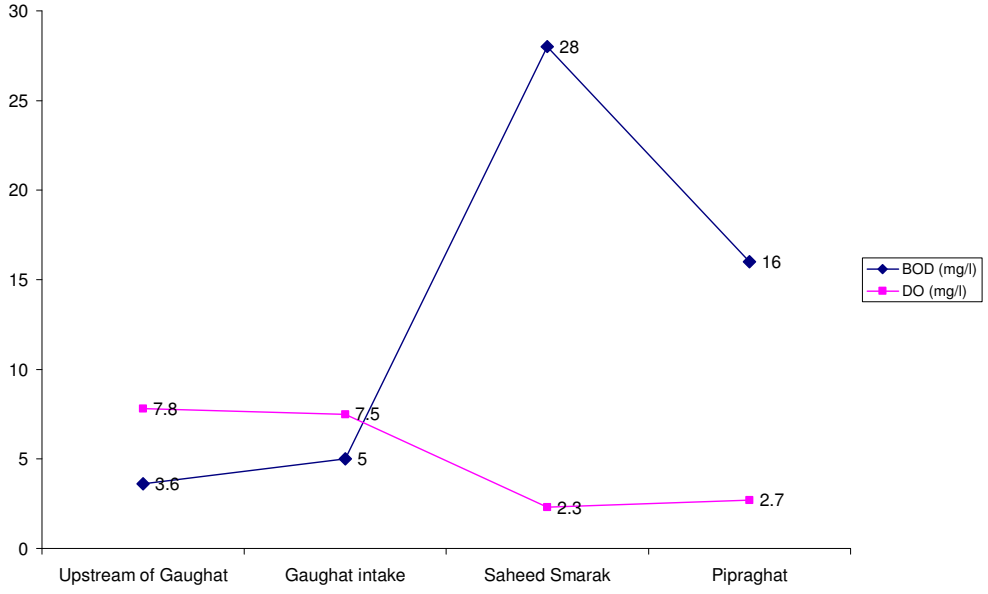

Fig. 11: DO-BOD profile in Lucknow stretch of the Gomti River as monitored in March–April 2011.

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CPCB had taken up a project to assess the water quality of Gomti in its entire stretch and identify its major polluting sources during 2007-08 (Table-7). The results show that before the confluence of River Sarayan, the water quality of Gomti conforms to the designated best use category B except for faecal coliform. Presence of faecal coliform can be attributed to open defecation all along the bank of river. Yet the river maintains the pristine water quality and it was observed that river water is directly used by the local villagers in that area.

Water quality of Gomti gets affected after confluence of Sarayan. Sarayan was observed having COD level of 35 mg/l and BOD of 5.6 mg/l while its DO level was observed as 2.7 mg/l (Table-8). Sarayan receives the sewage and industrial effluents from Sitapur city. Discharge of industrial waste water and untreated sewage into the river is the main cause of poor water quality of Sarayan. DO level of Gomti depletes to 6.9 mg/l from 8.0 mg/l after meeting Sarayan. The COD level increases to 18 mg/l and BOD to 3.0 mg/l while the fecal coliform concentration increases about 100%. Water quality of Gomti d/s confluence of Sarayan upto u/s Lucknow does not indicate any appreciable change, as there is no other polluting source in this stretch of the river.

Table- 8: Status of water quality of river Gomti and its tributaries as reported by CPCB.

Location	**COD (mg/)**	**BOD (mg/l)**	**TDS (mg/l)**	**DO (mg/l)**	**Cl (mg/l)**	**Total Coliform MPN/100**
Before confluence of Sarayan (Koda, Hardoi)	6	1	194	7.95	3.8	1.7×10^4
Sarayan before confluence with Gomti	35	5.6	218	2.68	5.7	
After confluence with Sarayan, Sitapur	18	2.5	272	6.93	3.8	2.7×10^4
u/s of Gaughat, Lucknow	18	3.1	264	6.69	5.7	3.4×10^4
At water intake, Gaughat, Lucknow	20	2.2	312	6.02	4.7	5×10^3
Hanuman Setu, Lucknow	18	2.6	342	3.00	7.6	5×10^3
Pipraghat, Lucknow	37	5.5	355	2.06	6.0	2.3×10^4
Before confluence of Reth at Tirgaon	15	2.4	274	3.89	7.0	8×10^4
After confluence with Reth and Loni, Salempur	27	2.9	246	4.11	12	5×10^4
Kadu Drain at Bahadur Dadar before confluence with Gomti	14	1.4	322	10.65	24	---
Gomti at Bahadur Dadar before confluence with Kadu Drain	11	2.3	260	5.34	8	1.1×10^5
Gomti after confluence with Kadu Drain	11	2.2	242	5.70	9	8×10^4
u/s of Kunwar Bridge, Sultanpur	12	2.6	280	5.97	9	1.3×10^5
d/s of Kunwar Bridge, Sultanpur	20	3.7	297	6.04	9	7×10^4
u/s of Jaunpur, Badalpur	13	2.8	254	7.57	10	1.3×10^5
d/s of Jaunpur, Railway Bridge	14	1.2	300	7.83	10	8×10^4
Before confluence with Sai, Rajepur	13	1	285	8.47	12	2.3×10^4
After confluence with Sai, Sirkoni	17	1	285	8.01	11	5×10^4
Sai before confluence with Gomti, Sirkoni	12	1	242	8.46	5	---
Before confluence with Ganga, Ghazipur Road	13	1.4	254	7.80	8.7	5×10^3

Water quality in Gomti deteriorates in its Lucknow stretch. COD and BOD, the indicator of organic pollution increase from 20 to 37 mg/l and from 2.16 to 5.5 mg/l, respectively, between Gaughat to Pipraghat. With the increase in organic pollution load the DO level reduces to as low as 2.0 mg/l, while the faecal coliforms phenomenally increase to 1.3×10^4 MPN/100ml. Reason for deterioration of water quality may be attributed to direct disposal of untreated sewage from Lucknow city and dumping of garbage along the river bed. The water quality of the Gomti River at Lucknow and Jaunpur has been found quite unsafe. According to the World Health Organization (WHO) standards, there should not be more than 5,000 bacteria in 100 ml of water. But in the Gomti River between Daliganj bridge and Hanuman Setu (bridge), the bacteria count has soared to 1.75 lakh per 100 ml of water. Rough estimates show that 25 nullahs, including Sarkata, Pata nullah, and Wazirganj, pour around 350 MLD of wastewater daily into the Gomti.

Water quality of Gomti which deteriorates due to mixing of untreated sewage and industrial effluent up to Lucknow improves as a result of self purification process between Pipraghat to u/s of confluence of River Reth as the River meanders through a stretch of about 30 kms, the DO level improves up to 3.89 mg/l , while COD level decreases to 15 mg/l and BOD to 2.4 mg/l. The DO-BOD profile of river Gomti for Lucknow stretch is presented in the Fig. 11. It is understood that in the upstream of the city the quality of river water is better. As a result of discharge of Nagariya drain into the river, the deterioration starts which continues with the addition of discharges of other city drains.

Reth carrying the waste water from Barabanki city further deteoriates the water quality of Gomti. After meeting Reth, COD level of Gomti increases to 27mg/l and BOD to 2.9 mg/l and DO level becomes 4.1 mg/l. Increase in DO level is due to mixing of high DO water of Reth and Loni. Self purification process of river reduces its organic pollution level and increases its DO level as it meanders up to d/s of Jagdishpur where Kandu Nallah carrying wastewater from Jagdishpur industrial area joins Gomti. Kandu Nallah does not have much impact on water qaulity of Gomti because of its little flow as compared to Gomti. Water quality of Gomti does not fluctuate much up to Sultanpur. However, the bacteriological pollution remains high at all locations. Impact of Sultanpur city is clearly visible on water quality of River Gomti. Untreated sewage of city meeting with River Gomti deteoriates water quality as the river traverses through the city. Dumping of garbage along river bank and disposal of other filthy material into the river also affect the water quality of river. As the River leaves Sultanpur city, COD level increases to 20 mg/l, BOD to 3.7 mg/l with DO level of 6.0 mg/l.

Due to self purification process between d/s Sultanpur to u/s Jaunpur city, COD level comes down to 13 mg/l, BOD to 2.8 and DO level increases to 5.7 mg/l, while the coliform increases. This reflects, significant contribution from village areas in terms of coliform count. Jaunpur city also contributes pollution to Gomti as there is no sewage treatment scheme for the city sewage. Most of the city sewage is discharged to Gomti although it does not have noticeable impact on water quality of Gomti due to its small volume. The level of dissolved Oxygen in different stretches of Gomti river from its origin to confluence in the Ganga river as monitored during the expedition is shown in the Table-9 and the variation is illustrated in Fig. 12.

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Table- 9: Level of Dissolved Oxygen (D.O.) in mg/l in different stretches of Gomti river.

Sampling Locations	**DO mg/l)**
Fulhar Lake, Madho Tanda	6
Gomti Gurudwara	4
Banda, Shajahanpur	4.8
Ekkotarnath	6.2
Sonasirnath Ghat	5.9
Anta Peer, Puwayan	6.8
Madhinath, Maigalganj	6.8
Imli Ghat, Ravindra Nagar	7.5
Rudravrat, Sitapur	7.5
Rajghat, Naimish, Sitapur	5.4
Kudia Ghat, Lucknow	4.2
Saheed Smarak, Lucknow	2.3
Haidergarh, Barabanki	5.6
Sitakund Ghat, Sultanpur	7
Dhopap, Lambhua, Sultanpur	6.8
Gopighat, Jaunpur	4
Hanuman Ghat, Jaunpur	3.7
Jamaitha, Jaunpur	4.5
Sai-Gomti Sangam, Jalapur	5.5
Markandeyay, Kaithi	3.5

Table- 10: Classification of surface water quality in the Gomti river based on sampling done in March – April 2011.

River stretch	**Existing class**	**Desired class**	**Critical parameters**
Between Kheri & u/s of Sitapur	C	C	-
Between d/s of Sitapur & u/s of Lucknow	C	C	-
Between d/s of Lucknow to u/s of Barabanki	E	C	DO, Total Coliform, BOD
Between d/s of Barabanki to u/s of Sultanpur	D	C	DO, Total Coliform
Between d/s of Sultanpur to u/s of Jaunpur	E	C	DO, Total Coliform, BOD
Between d/s of Jaunpur to u/s of Varanasi	D	C	DO, Total Coliform
Between d/s of Varanasi till confluence in Ganga at Kaithi	D	C	DO, Total Coliform

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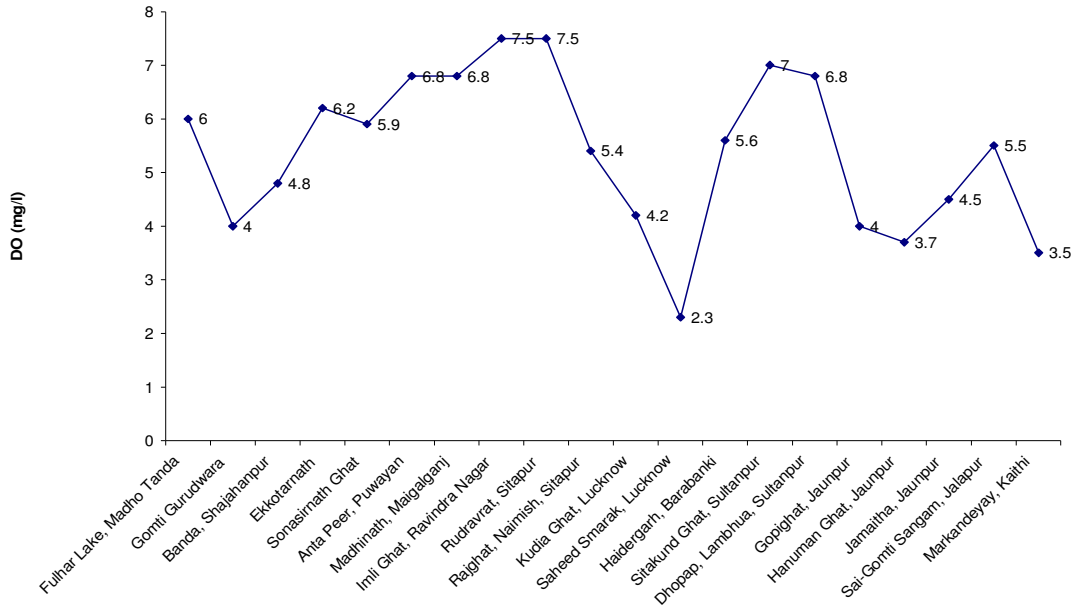

Fig.12: DO profile in the different stretches of the Gomti River, from origin to the confluence in the Ganga River.

Restoration Plan for the Gomti River

The above study leads to suggest some important action strategies to be taken up on priority basis for Gomti river.

- Demarcate the entire flood-plain, right from the origin to the confluence with the Ganga.
  - Freeze its land-use by buffering. No violation of the land-use change.
- Remove the illegal encroachments in the flood-plain. Declare 500 m from river midstream as no construction zone. To be used only for plantation.
- Declare the origin as well as confluence of all 24 major tributaries as *"Eco-fragile areas"*.
- Massive plantation drive for the next ten years along the banks. There are ample lands available by the side of the river which can be utilized for forestation.
  - Create *river gardens* along the banks which will help in developing micro-ecosystems for birds, insects and other flora and fauna.
  - The park will help in developing bonding of local people with the river, which otherwise is getting marred day by day.
  - Identify business groups, educational institutions, banks, NGOs who could adopt 500 meter stretch of the river.
  - Give them the river banks with proper regulatory codes for developing forests/gardens. No concrete structure.
- Remove the silt deposited in the riverbed along the major settlements (this was brought from the sewers) in Lucknow, Jaunpur and Sultanpur.

- Don't install large STP. Use decentralized treatment within the zones and use the water for non-potable purposes. Use standard low cost treatment in the drain itself.
- Strict monitoring of the 56 sugar factories located around the river in Sitapur and above. They cause major pollution load in the river. Also there is no mechanism to arrest non-point source water pollution which leads to frequent death of fishes in the river.
- Proper arrangement of sanitary landfills in Sitapur, Lucknow, Sultanpur and Janupur. In no situation, solid wastes to be dumped in the river.
- There is heavy dependence on groundwater and the water levels are falling rapidly**.** Insufficient management of irrigation water with intensive usage and unsustainable cropping patterns is leading to rapid decline of groundwater in the Gomti Basin. There is no system to review increased irrigation water demand due to the change in cropping pattern for each micro-basin. Water management for the water intensive crops is so poor that farmers use almost two times the water required for irrigation for crops such as paddy, sugarcane, wheat and potato. Also, groundwater is treated completely separately from surface water and there is almost negligible planned conjunctive use of groundwater and surface water.
- Declare it *"State River"* of UP, as the river originates in UP (Pilibhit) and merges with the Ganga in UP (Ghazipur), there is no inter-state conflict/issue with regard to declaring it State River.
  - This will be a great initiative to revive the river culture of the Awadh in a bid to restore the beauty and sanctity of this river.

Conclusion

In this paper, an attempt has been made to reclassify the designated best use of water quality based upon river expedition carried out from March 27 to April 2011 in the entire stretch of Gomti River at 30 different segments. Based on the observation of the river expedition, a restoration plan is also prepared. Older satellite pictures were consulted to prepare land use maps in the Gomti basin and compare them with the recent satellite maps. It is observed from the expedition that there is no flow in the initial reach of Gomti in about 60 km length during non monsoon months. Gradually, the stream which is even dry at many places, starts growing feebly. LANDSAT sensor satellite data of 1978 and LISS III sensor data of 2008 shows that in a width of 1000 m along Gomti, built up area has increased while the forest and plantation area including water bodies has decreased.

The result of sampling indicates that the stretch between d/s of Lucknow to u/s of Barabanki, and between d/s of Sultanpur and Jauanpur is most polluted with designated class E. The water quality between d/s of Jaunpur till confluence in Ganga at Kaithi, Ghazipur has been put in class D. Over the years, the water source in the tributaries feeding the river has shrunk, reducing the flow in the river. This has been further coupled with discharge of untreated wastewater through more than 50 major drains in its course. In Gomti river, habitat deficiencies in river channels and floodplains arising due to large scale land use change, reducing wetlands and forest cover and deteriorating water quality downstream due to discharge of domestic and industrial wastewater is having a cumulative impact on water quality and quantity of the river. In many segments, there have been drastic drop in river's biodiversity with decreasing variety of fishes and aquatic plants. There have been major drop

in population of freshwater turtles. Finally the study outlined a restoration plan of the river with important action strategies to be taken on priority basis for its immediate conservation and restoration.

Acknowledgements: Funding support of ISRO-SAC project under RESPOND program as well as assistance from Lok Bharti, UP State Water and Sanitation Mission, State Water Resource Agency and Ground Water Department, UP in field studies is greatly acknowledged.

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