

Chapter 2

Applying Remote Sensing and GIS in Study of Physical and Cultural Aspects of Varanasi District

Abstract The city of Varanasi (Benaras) lies on a bend of Ganga river (Ganges), one of the largest rivers of the World. In this chapter, various physical i.e. geological, physiographic, drainage, climatic characteristics, condition of ground water, land use etc, as well as cultural aspect like transportation and communication facilities, solid waste generation etc. through remote sensing and GIS are very well presented. On the basis of relief variation, geology and drainage characteristics the area has been divided into three main physiographic divisions i.e. Upper Ganga-Varuna Plain, Varuna-Gomati Interfluence and Ganga-Varuna Interfluence. In this study it is found that the current water supply system is not adequate to supply to around 1.6 million people in the city. There is a substantial gap between the recommended norm and the actual water supply. Land use land cover (LULC) map is prepared using remote sensing data (IRS-1C/1D-LISS-III) of 2008, in which five important classes are delineated i.e. agricultural field, fallow land, vegetation, built-up area, and water bodies. In Varanasi district there are 85 Ganga ghats with typical structure on the river Ganga which are frequented by a large number of pilgrim's everyday for taking a holy dip in river Ganga. The city along the Ghats has facing the severe serious problems of solid waste management due to congested lanes. These physical and cultural aspects are directly and indirectly used in the main themes of the study.

Keywords Varanasi • Ganga river • GIS • Remote sensing data • IRS-1C LISS-III • Land use land cover • Solid waste management

2.1 Locational Extent of the Area

The city of Varanasi (Benaras, Benares) lies on a bend of river Ganga (Ganges), one of the largest rivers of the World. It is the oldest living city in the world. Varanasi district, covering between 25°10' and 25°37' N latitude and 82°39'–83°10' E, lies in eastern Uttar Pradesh of India (Rai and Mohan 2014). The city cover over an area of 1454.11 sq. km, it has a total population of 1,878,100 (as year 2001 census report) persons (976,045 males and 902,045 females). It is bounded by Bhadohi district in the west, Jaunpur district in north-west, Ghazipur district in the north and north east,

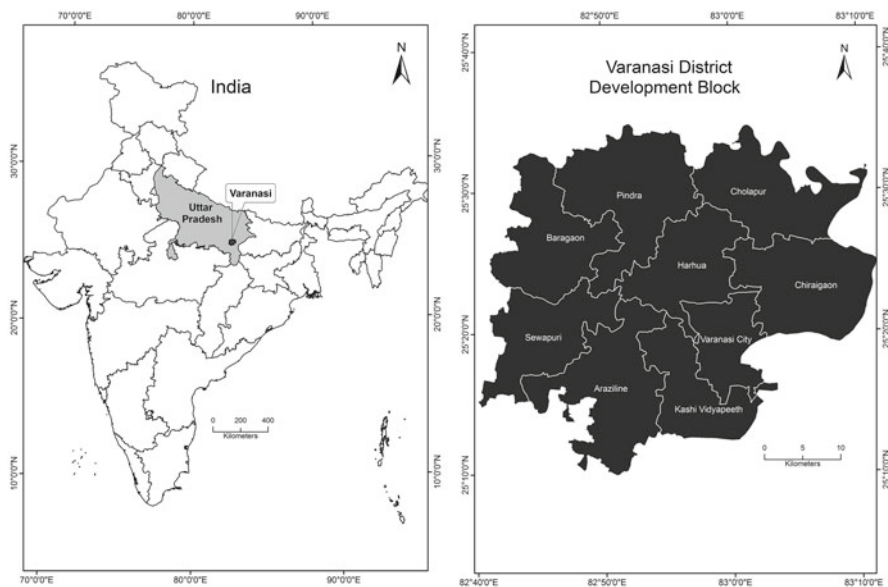


Fig. 2.1 Location map of the study area

Chandauli district in the east and Mirzapur district in the south (Fig. 2.1). The Ganga river forms its natural boundary in the east and south east while northern boundary is noticeable by the river Gomti. The Grand Trunk Road (NH2) passes through the city linking the study area with prominent northern and eastern cities of the country. From administrative point of view, the district comprises two tahsils namely, Pindra and Varanasi Sadar which are further sub-divided into eight development blocks namely Baragaon, Pindra, Cholaipur, Chiragaon, Harhua, Sewapuri, Araziline and Kashi Vidyapeeth comprising of 1336 villages. This holy city is also known as Kashi (the city of light). The ancient city of Varanasi is inimitable in its architectural, artistic and religious expressions of traditional Indian culture which is existing even today. The city has been well-known for knowledge along with art works, cottage and textiles industries ever since pre-Buddhist times. Silk weaving and sari making, wood and terracotta handicrafts, toy making, particular painting forms, etc., are vivid the example of continuing historic-cultural tradition.

The numerous Hindu temples and the ghats of river Ganges are the places of interest in Varanasi. The Vishwanath temple is considered as the eternal abode of Lord Shiva on earth. Another place to be visited is Sarnath, an ancient Buddhist site, Banaras Hindu University (A Central University), a seat of oriental and modern learning can be counted as a place to be visited. Study area as viewed on IRS-1C LISS III remote sensing data is shown in the Fig. 2.2.

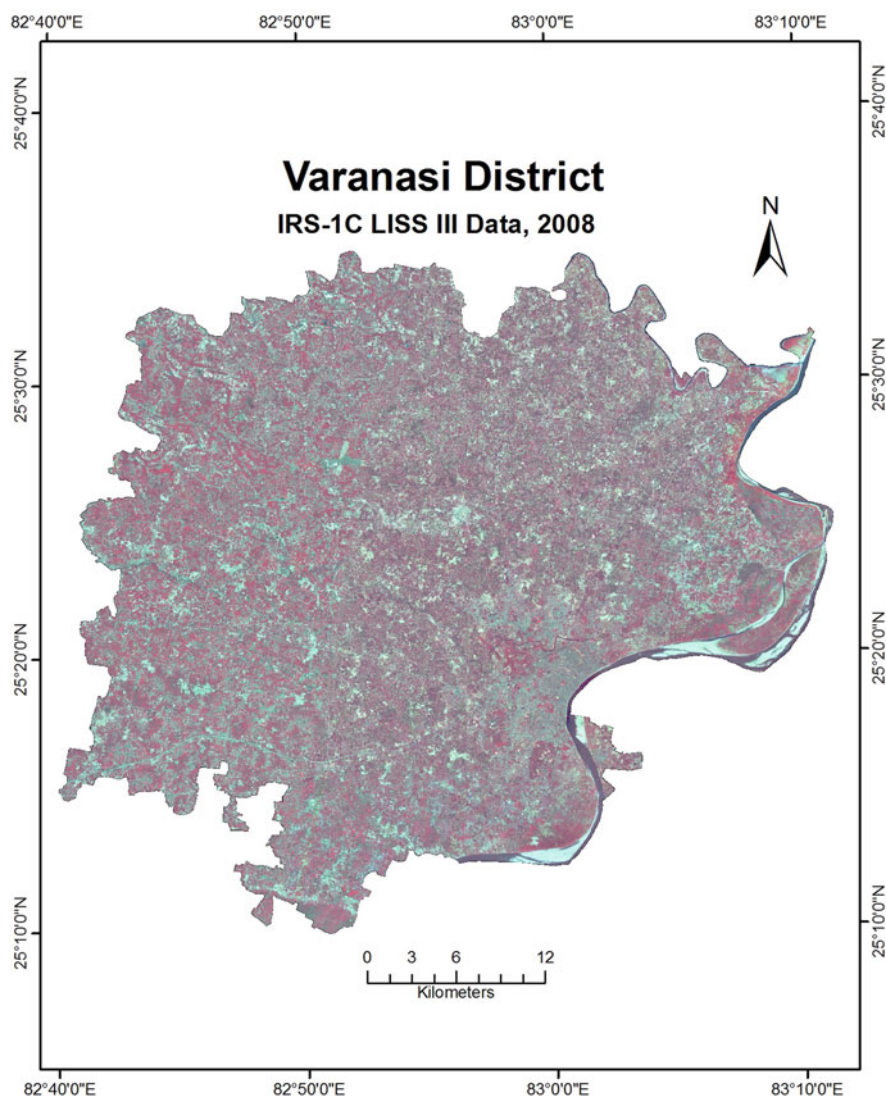


Fig. 2.2 Varanasi district as viewed on IRS-1C LISS III data, 2008

2.2 Geology of the Area

Varanasi is part of the Ganga flood plain, underlain by the alluvial deposits of quaternary age. The older alluvium of the Ganga valley from slightly elevated land surface of the area. This deposit is supposed to be middle to upper Pleistocene and lies well above the highest flood level of the rivers of the area. The newer alluvium generally occupies the lower elevation and is constrained to the flood plains of the

present day river along their channels and consists of fine to medium grained sands, silts and minor amount of clays. However, there is not always a clear delineation line between older alluvium and newer alluvium. The Older alluvium is dark coloured and generally rich in concretions and nodules of impure calcium carbonate. These concretions are of various shape and size and are known as 'Kankar'. The Varanasi older alluvial plain represents the oldest geomorphic surface occurring at highest tectonic level in the Gangetic plain. The study area placed between the Ganga in the south and the Gomti in the north with the river Varuna flowing in central part imprinting upon the geology of the areas as it's comprises of inter-bedded layers of sand, silt and clay sometime associated with 'Kankar' and clay (Rai and Mohan 2014).

2.3 Physiographic Divisions

On the basis of relief variation, geology and drainage characteristics the area has been divided into three main physiographic divisions:

- (i) Upper Ganga-Varuna Plain,
- (ii) Varuna-Gomati Interfluence and
- (iii) Ganga-Varuna Interfluence.

2.3.1 *Upper Ganga-Varuna Plain*

Upper Ganga-Varuna plain is extent over nearly 31.05 % of the district. Varanasi district stands on the left bank of river Ganga and lies in the heart of the middle Ganga Valley. The river Varuna reaches from western side along the Dhaukalganj lying in Bharagaon development block and drains in Pindra and Harahua development blocks. The area designates a near level surface having alluvium deposits may be separated into: (a) low land and (ii) upland. Low land known as 'Tarai' is the recent creation of river floods and afresh deposited alluvium soil, while 'Bhangar' (upland) lying outside the flood limits is ended by older alluvium (Rai and Mohan 2014).

2.3.2 *Varuna-Gomati Interfluence*

The Varuna-Gomati interfluence covers about 40.84 % of the total area of the district. It is yet again classified into two units: (i) upper region (Uparwar) and lower land (Tarai). The upper region recognize in the northern and western parts of the

district where no flood arises even in the rainy season also. The low land (Tarai) has further been classified into: (i) flooded areas along the river Varuna, and (ii) flooded areas along the river Gomati and its tributaries. Towards the side of the river Varuna in Varuna-Gomati interfluence, the village namely Sirisi, Barthara, Kalan, Parnapur, Amauli, eastern part of Jalhuapur, Mustafabad, Ambapur, Dhobahi, Shidasa Goberha, Rampur etc. are regularly flooded during the monsoon season locally called as tari villages alluvium (Rai and Mohan 2014).

The eastern part of Bela, Azagara, Bartharakhund and Rampur etc. are flooded by the river Nand a tributary of the river Gomati in the period of heavy downpour. Northern part of Rajwari and Tekuri, western part of Dhauradhara and eastern part of Azgara etc. are also inundated. Hathi nala another branch is frequently flooded in rainy season causing much damage of the life and property to the villages Azgara, Benipur etc. A very small area of the villages Akatha, Baraipur and northern part of Hiranpur covered by Narokhar, Tal along the river Varuna is also inundated in rainy season (Rai and Mohan 2014).

2.3.3 *The Ganga-Varuna Interfluence*

The region covers the areas of Sewapuri, Araziline and Kashi Vidyapeeth development blocks lying in the western and southern part of the district. It covers about 28.11 % of the total areas of the district. It can further be sub-divided into two parts:

- (i) The Upper Plain of Ganga-Varuna Interfluence, and
- (ii) The Flood Zone

Over all, Varanasi district establishes its 4.79 % of the total land along the river banks to be flooded frequently in monsoon season causing damage to human life and property both. The uplands are designated as Bhargar and low lying areas liable to inundation in the rainy period are known as Khadar (known as Tarai) with newer alluvium deposited by the rivers during the floods (Rai and Mohan 2014).

Geomorphological map of the study area is prepared through remote sensing satellite data and the area are divided into 5 important geomorphological class i.e. alluvial plain, point bars, sand bars, river island with alluvial deposits and river island with sand deposits (Fig. 2.3). The study area is associated to the flood plain deposit, so that no other geomorphological features are recognized.

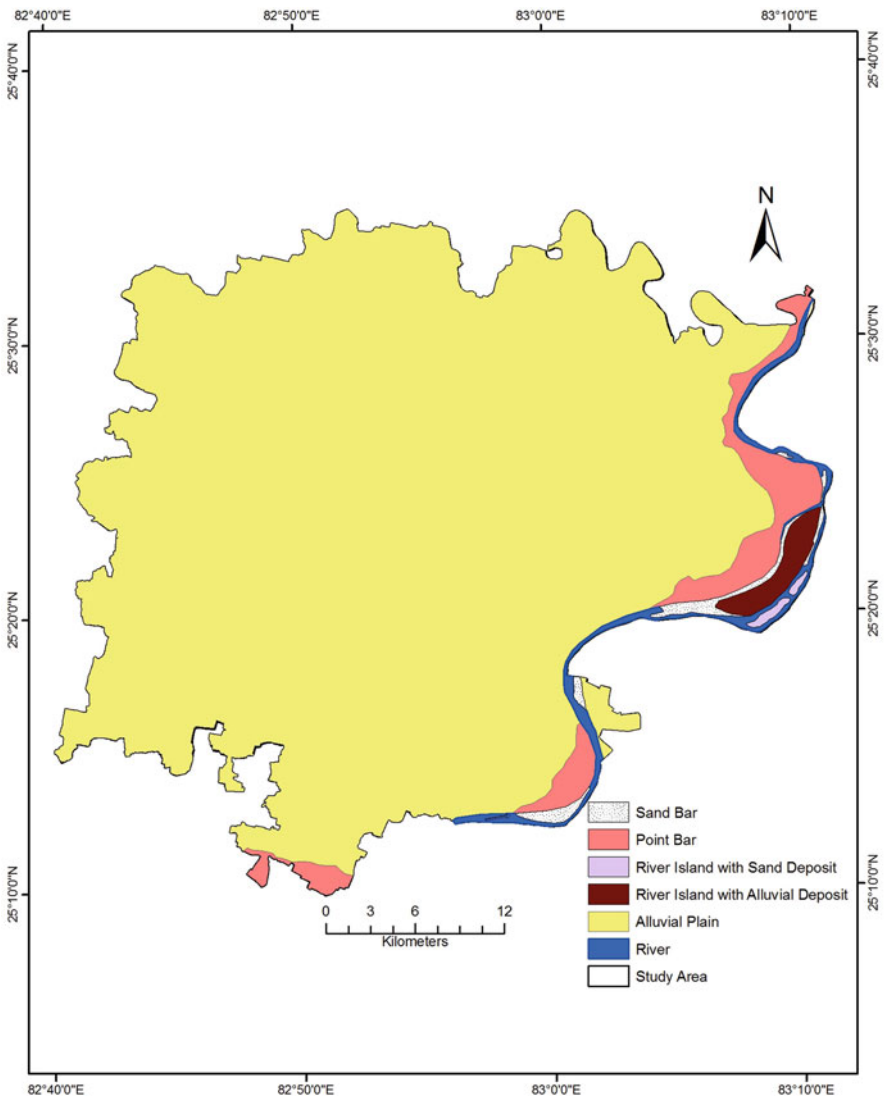


Fig. 2.3 Geomorphological features in Varanasi district

2.4 Drainage and Water Ponds

The drainage plays very important role in shaping the physical characteristics of the area under study. The river Ganga with its tributaries forms the drainage pattern of the study area. The river Ganga is an important source of drinking water as well for irrigation also. The existing water bodies are extracted through IRS-1C LISS III remote sensing data of 2008 (Fig. 2.4).

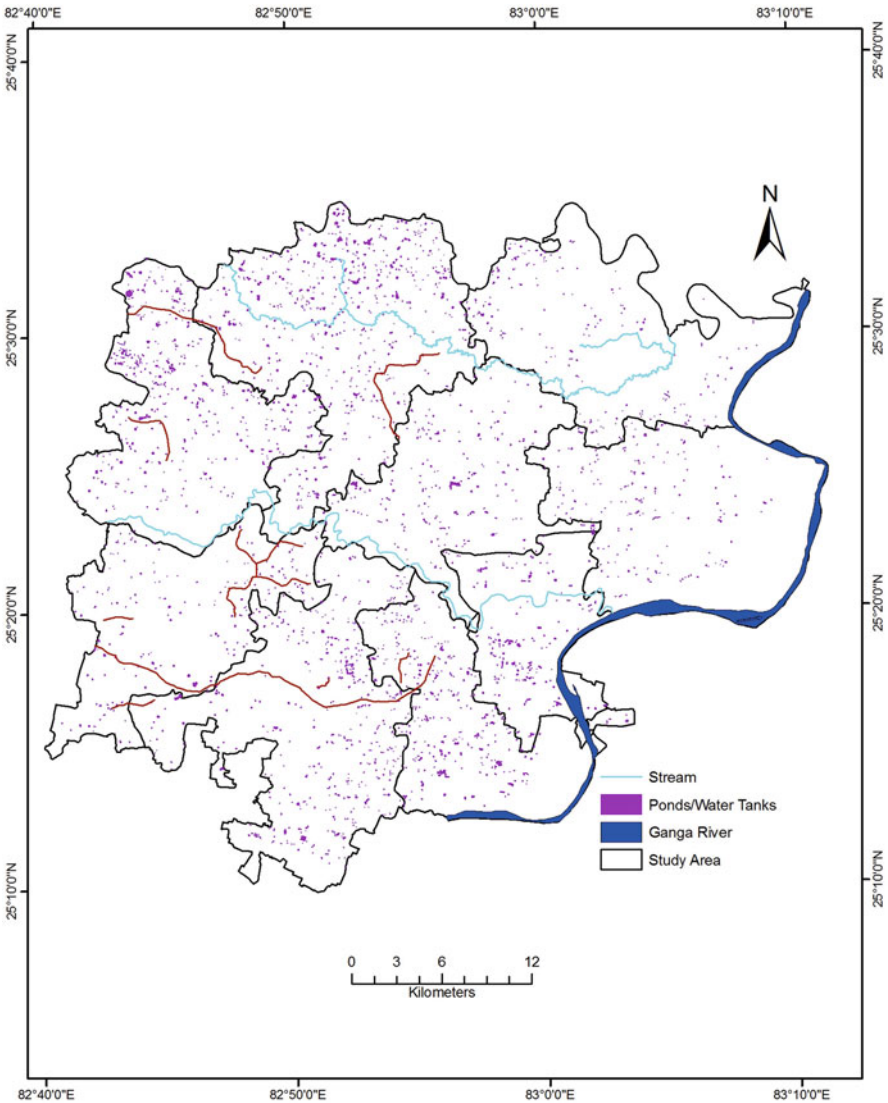


Fig. 2.4 Existing water bodies in Varanasi district (Extracted from IRS-1C LISS-III Data, 2008)

2.4.1 The Ganga River

The River Ganga is the main drainage line of the study area which forms the southern boundary of Kashi Vidyapeeth development block is flowing from the eastern side of the Varanasi city. The Ganga touches the Varanasi district at village Tandi where a stone quarry is situated on the confluence of Subba Nala and the Ganga.

The river flow towards the east in Araziline development block and takes a turn towards the north where the city of Varanasi is located on high platform formed of pebbles and Kankars. Its religious and ritual significance is well established as it takes a westward turn near Barthara Kaalan in Chiraigaon development block and Paranapur in Cholapur development block known as Paschimvahini Ganga, where thousands of people take bathe on the day of Makar Shankranti. From Chandrawati to Kaithi (in Cholapur development block) it flows northward, resembling to its flow at Varanasi, thus Kaithi is known as Up-Kashi. The rivers Varuna and Gomati are the main tributaries of the Ganga (Rai and Mohan 2014).

2.4.2 The Gomati River

The River Gomati, a meandering river touches the Varanasi district near village Bhadwan in Cholapur development block and forming its northern boundary (33 km) emerges into the Ganga flowing through the village Niyardih, Babatpur, Azagara, Dhaurhara, Tekuri, Rajwari and Kaithi. Its main tributary is the river Nand which joins river Gomati at Ajgara village (Rai and Mohan 2014).

2.4.3 The Varuna River

The Varuna a perennial river, divides the Varanasi district into two part and joins the river Ganga near Sarai Mohan east of Varanasi city after flowing for nearly 40 km. vis Akohra, Kundi, Gaharwar, and Koirajpur villages. It has no important tributary excepting Bisuhil. Throughout its course, the river Varuna has a impartially high bank which is scoured on either side by many ravines (Rai and Mohan 2014).

2.4.4 The Assi River

Assi is a small local rain fed stream, the old historical southern boundary of Varanasi, highly polluted and congested, chocking due to encroachment. The Ganga, Varuna and Assi are the three natural streams which finally receive the storm water flows into the city of Varanasi. A number of interconnected ponds play a significant role in the drainage of the storm water one of the prominent rivers of our country (Rai and Mohan 2014).

The Nand is non-perennial tributary of the river Gomati. It originates from a low-lying land (Tal) of Karikhiyon in Pindra development block and flows towards the east, debouches in to the river Gomati after traversing a distance of 35 km. Through there are a number of unnamed nullahs, which join the river but they are dry throughout the year except in the rainy season. Hathi nala, a tributary to the river Nand, is

disastrous sufficient in the rainy season but in the summer it is entirely dried up (Rai and Mohan 2014).

2.5 Climatic Characteristics of the Varanasi District

Climate is the most vital factors which determine the pattern of land utilization. It strongly influences the activities of man. The attributes of climate i.e. rainfall, temperature, pressure, wind direction and velocity and humidity have a good affinity with agricultural patterns. Since crop producing ability of an area depends largely upon climatic and soil condition, so the role of these elements cannot be overlooked for the purpose of ascertaining the agricultural activities.

The area under study lies in the sub-tropical monsoonal climate which is divided into the following three seasons:

- (i) A cool dry season of northerly winds from October to February.
- (ii) A hot dry season from march to mid-June and
- (iii) A hot wet season of south-westerly wind from mid-June to September.

2.5.1 *Temperature*

From October onward till February the weather progressively crystallises into dry cool season with average temperature fluctuating from 15.46°C to 26.03°C when cold waves sweep over the area from west or north-west, nights becomes chilly and foggy sometimes giving frosty weather also. The western disturbances (Cyclones etc.) bring rainfall through small in quantity in this season which is very valuable to the Rabi crops.

By March, the day and nights go on becoming warmer in the region and heat continues to increase. From April, the weather quickly turns warmer and finally the hot and dry summer season sets in which is reflected in general by a sharp increase in temperature and relative humidity.

In the study area, temperature begins to fall rapidly from November and in January (The coldest month) the maximum temperature comes down to 23.06°. The average seasonal temperature varies from 24.65°C to 35.05°C but when the sun heat becomes oppressive followed by boiling sun rays and westerly hot winds (locally known as 'Loo'), mercury often to a maximum of 42.43°C. Generally the monsoon bursts in the study area during the third week of June. These hot winds naturally finish by mid-June with the arrival of south-west monsoon. Some times during this period in implication with cold waves, western disturbances carry the minimum temperature upto one or two degree above the freezing point normally liable for occurrence of frost.

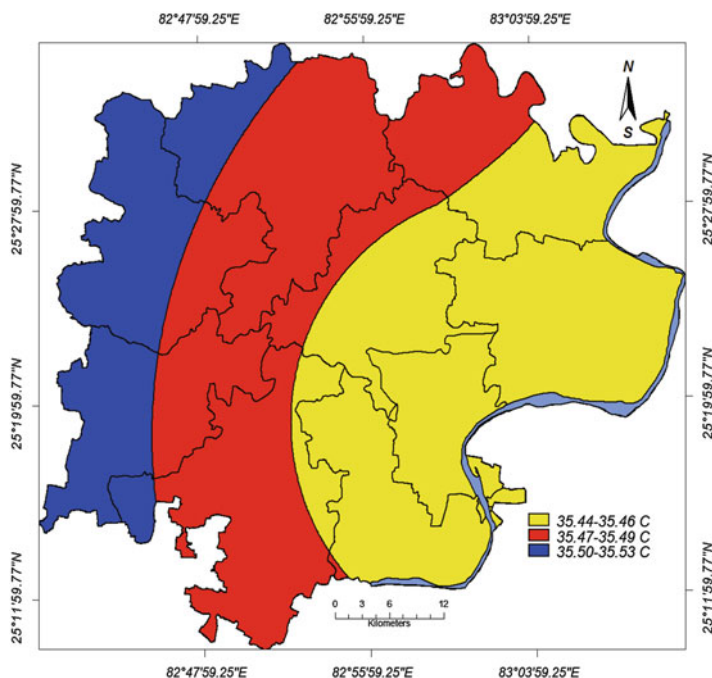


Fig. 2.5 Average distribution of temperature (in degree centigrade) in Varanasi district (1991–2010)

The hot wet season of south-westerly wind in the area starts from the third week of June and continued upto the end of September. Decrease in mean temperature upto a minimum of 27.20°C and maximum of 30.13°C, increase in relative humidity, high precipitation and low monthly range of temperature etc. are the important features of this season. Figure 2.5 shows the average temperature of Varanasi district of last 20 years.

2.5.2 Precipitation/Rainfall

The rainy season in the district usually instigates by the end of June and stays till the end of September. This is the utmost essential period for agriculture as it receives nearly 113.47 cm annual rainfall. The moisture content in the soil either by infiltration or capillary rise is fulfilled by rainfall and it is the major ecological factor in agricultural operations starting from cultivating to sowing, growth and maturing of all the crops. Most of the 'Kharif' crops depend on rainfall while occasional winter rainfall favours Rabi crops although it is mostly dependent on irrigation. Figure 2.6 shows the average rainfall condition of Varanasi district of last 20 years. Normally the monsoon starts in the study area from the third week of June and ends by the

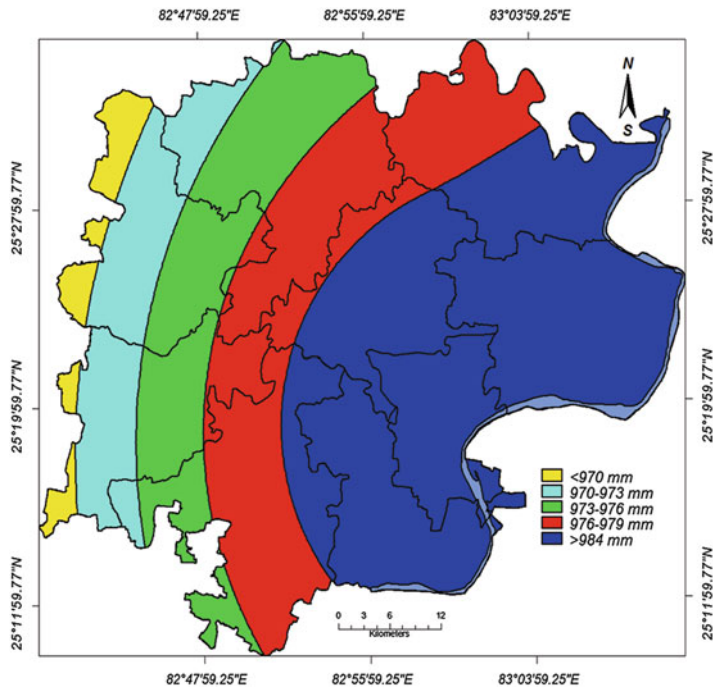


Fig. 2.6 Average distribution of rainfall (in mm) in Varanasi district (1991–2010)

September. Rainfall was consistently dispersed throughout the area. In 2009, the total annual rainfall is recorded as 102.5 cm of which about 90 % is attributed to monsoon periods (Table 2.1).

2.6 Ground Water: Present Status and Prospects

Varanasi is short of water. The current water supply system is not adequate to supply to around 1.6 million people in the city. There is a substantial gap between the recommended norm and the actual water supply. The city obtains a total of 270 million liters water from the river Ganga and ground water source.

The city, a part of central Ganga alluvial plain, is underlain by the quaternary alluvium containing fine to coarse grained sand, clay and clay with Kankar. The alluvium belongs to the quaternary group of pleistocene system of the recent geological age. To be specific, the older alluvium is middle to upper pleistocene and the newer alluvium is latest (Krishnan 1960).

Study of the upper 120 m of alluvium based on archives of tube wells in the area designates the presence of the two distinct sedimentary horizons, namely (i) back-swamp clays comprising Kankar at places lying immediately below the land surface

Table 2.1 Climate data of Varanasi district, 2010

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Average high °C	19	24	31	37	38	36	32	31	31	31	27	22	29.9
Average low °C	8	12	17	22	25	27	26	26	24	21	15	11	19.4
Precipitation (mm)	19.3	13.5	10.4	5.4	9.0	100.0	320.6	260.4	231.6	38.3	12.9	4.0	1025.4

Source: B.H.U., Varanasi, 2010

and having an average thickness of about 50 m and (ii) the underlying meander-belt deposits containing of mixed populations ranging from fine to coarse sands, having an average thickness of around 60 m. In these two unconsolidated alluvial horizons, ground water arises in the pore space in the zone of saturation (Pathak 1977).

These two ground water bodies are hydraulically separated where the back swamp deposits are thick but are likely to be interconnected where they are comparatively thin. These two types considerably differ in their capacity to absorb water at the land surface and to transmit water to the zone of saturation. The back-swamp clays are usually dense and impervious and cover the entire area. These clays are enormous and comprise Kankar and thin lenses of fine-grained sands. Because this material is generally too fine grained to transmit water readily, it prevents the downward percolation of water from the land surface and also confines water in the underlying meander-belt sand deposits. These deposits constitute a ground water reservoir from which very large supplies of water can be recovered perennially for irrigation, municipal and industrial purposes. The shallow ground water in the back swamp deposits (clay and Kankar beds) is mostly unconfined and its static water level is only a few metres below the ground level. It supplies water to a good number of dug wells, bore wells and wells fitted with small pumps used both for domestic or irrigation purposes. The meander belt sand deposits from the main ground water body in the area and supply water to a large number of tube wells used for irrigation, industrial and domestic purposes. The deep ground water body, measured to be hydraulically continuous, is known to be confined locally. The piezometric surface of the deep body varies and is generally identified to be deeper in comparison to the static water level of shallow water body. It should be stated that the ground water table in the city has gone down to 4.6 m (15 ft) below the level it used to be prior (Mohan et al. 2011).

As the texture and thickness of the meander-belt deposits differ significantly, their water yielding capability also fluctuates from place to place. Most of the tube wells in the city originate water from meander-belt deposits. These tube wells yield (30–60) L s⁻¹ water. A few tube wells which originate water from the thin disengaged sand lenses in back-swamp clay yield less than 15 L s⁻¹ (Mohan et al. 2011).

In 1999, the Municipal Corporation (now Nagar Nigam) completed a survey and recognized 5000 wells in the city. However, present state-of-art is scruffy; it is identified that about 2200 wells are in a workable condition. Observably the rest of the wells were occupied with wastes, garbage's etc. (Mohan et al. 2011).

2.6.1 *Current Status of Water Supply*

State government department, Varanasi Jal Sansthan is affianced in the supply of drinking water to the people living in the city of Varanasi. This Jal Sansthan draws drinking water from two sources: (a) the river Ganga and (b) ground water.

Bhadaini Intake Works is pumping a total of 1.25×10^5 m³ d⁻¹ raw water of the river through its six pumps, four each with a capacity of 40 m³ min⁻¹ and two each

with $30 \text{ m}^3 \text{ min}^{-1}$. The pumped raw water is sent to the Bhelupur Water Works, situated at about 1.5 km away from the water drawing point, for its chlorination and purification. The treated water is supplied to the inhabitants of the city through a network of pipelines the total length of which is about 575 km. This water supply system was laid way back in 1892 by James Princep. Sometimes, because of failure of electricity supply the Bhadaini intake works fail to pump up water from the river to its full capacity and because of which the problem becomes acute. At limited places, quite often, public of the city increase a hue and cry about mix up of water with sewage because of leak in the pipes. The various gastro-enteric diseases and other health hazards support this type of claim (Mohan et al. 2011).

Along with the river water, a total of $1.45 \text{ m}^3 \text{ d}^{-1}$ of ground water is extracted from 118 deep bore tube wells installed in different localities of the city to supply to the growing demand of water. Further, a total of 2347 hand pumps were also set up at different parts of the city. Jal Sansthan of Varanasi has classified the city area into 16 zones (11 zones within the city spread between Ganga and Varuna and five zones in the trans-Varuna area (located to the other side of the river Varuna, as a western extension of the city) for the management and distribution of water supply. The trans-Varuna is dependent completely on ground water resource (Mohan et al. 2011).

With all types of water supply put together, Jal Sansthan delivers a total of $2.70 \times 10^5 \text{ m}^3 \text{ d}^{-1}$ water. With such a volume of supply, each person in the city gets 169 L d^{-1} water, which is far less the WHO's norm of 270 L d^{-1} . Thus one fifth of the population of the city is not supplied with drinkable water (Mohan et al. 2011).

The river Ganga is an imperative source of drinking water in the city, but the level of water goes down for several reasons, below the intake points. Jal Sansthan finds it very tough to drink $1.25 \times 10^5 \text{ m}^3 \text{ d}^{-1}$ water not only during spring and winter but also during some period of rainy season. Population growth in a geometric series could be measured responsible in the area (Mohan et al. 2011).

2.6.2 Available Resources

The city, a part of Central Ganga Alluvial Plain, is underlain by the Quaternary Alluvium comprising fine to coarse grained sand, clay and clay with Kankar. The alluvium belongs to the quaternary group of pleistocene system of the recent geological age. To be precise, the Older Alluvium is Middle to Upper Pleistocene and the Newer Alluvium is recent (Krishnan 1960; Mohan et al. 2011)

Study of the Upper 120 m of alluvium based on records of tube wells in the area specifies the presence of the two distinct sedimentary horizons, namely (i) back-swamp clays comprising Kankar at places lying instantly below the land surface and having an average thickness of approximately 50 m and (ii) the underlying meander-belt deposits containing of mixed populations ranging from fine to coarse sands, having an average thickness of about 60 m. In these two unconsolidated alluvial

horizons, ground water occurs in the pore spaces in the zone of saturation (Pathak 1977; Mohan et al. 2011).

These two ground water bodies are hydraulically unglued where the back swamp deposits are thick but are possible to be interrelated where they are comparatively thin. These two types significantly vary in their capacity to absorb water at the land surface and to transmit water to the zone of saturation. The back-swamp clays are generally dense and impervious and cover the entire area. These clays are massive and contain Kankar and thin lenses of fine-grained sands. Because this material is normally too fine grained to transmit water readily, it prevents the downward percolation of water from the land surface and also restrains water in the underlying meander-belt sand deposits. These deposits constitute a ground water reservoir from which very large supplies of water can be recovered perennially for irrigation, municipal and industrial purposes. The shallow ground water in the back swamp deposits (clay and Kankar beds) is usually unconfined and its static water level is only a few metres below the ground level. It supplies water to a good number of dug wells, bore wells and wells fitted with small pumps used both for domestic or irrigation purposes. The meander belt sand deposits form the main ground water body in the area and supply water to a large number of tube wells used for irrigation, industrial and domestic purposes. The deep ground water body, considered to be hydraulically continuous, is known to be confined locally. The piezometric surface of the deep body varies and is generally known to be deeper in comparison to the static water level of shallow water body. It should be mentioned that the ground water table in the city has gone down to 4.6 m (15 ft) below the level it used to be earlier. The ground water level was at a general depth of 12 m–18 m (40–60 ft) in the year 2005; while in the year 2006 it was between 17 m and 21 m (55–70 ft) deep (Report 2006; Mohan et al. 2011).

As the texture and thickness of the meander-belt deposits differ significantly, their water yielding capacity also differs from place to place. Most of the tube wells in the city derive water from meander-belt deposits. These tube wells yield (30–60) L s^{-1} water. A few tube wells which derive water from the thin disconnected sand lenses in back-swamp clay yield less than 15 L s^{-1} .

In 1999, the Municipal Corporation (now Nagar Nigam) completed a survey and identified 5000 wells in the city. But, a recent survey described only 2204 wells in presence. Obviously the rest of the wells were occupied with waste, garbage etc. (Mohan et al. 2011).

2.6.3 Ponds as a Source of Recharge

The essential source to sustain ground water body, in fine to coarse-grained sands of the older alluvium, is rainfall that seeps down to the ground water table. Other sources contain infiltration from river, return seepage from agriculture irrigation. The annual average precipitation (50 years average) in the city is 1076 mm. In the year 2008, the city desired for rains and witnessed a rainfall of only 300 mm. There

is no recognized system of ground water recharging in the city i.e. developments of water bodies, ponds and tanks etc. Most of the rainwater goes wastes and join the river Ganga ultimately (Mohan et al. 2011).

In Varanasi, there used to be many ponds and tanks dating back to ancient time. Also serving as the holy places for holding Hindu religious rituals, they also played a vital role in rainwater collection and thereby helped as sources for ground water renewal. Total 118 ponds and tanks in the city have been documented (Fig. 2.7).

However, due to rapid development of the city, most of these sacred ponds have been wiped out from the map of the city. Our investigation has shown that 44 ponds were substituted by settlements. This shows complete ignore of environmental conservation to accommodate growing population. Public unawareness of the importance of these ponds inferior the situation by completely or somewhat filling up many of the existing ponds with garbage and waste (Mohan et al. 2011).

Providentially at the request of avid citizens and environmentalists, the city authorities have arranged a list of 54 ponds and tanks which in need of urgent rehabilitation; the plan has not been efficiently applied though. These 54 ponds may soon die out if instant rehabilitation measures are not executed. Only about half a dozen of them have water all over the year. The Central Government has shown deliberation in the very direction and released a sufficient fund for the conservation and beautification of water bodies of Varanasi (Mohan et al. 2011).

2.6.4 Pollution

Pollution of the ground water in the Varanasi city is generally sourced from loads of garbage. The solid and liquid wastes generated out of the household and industrial actions are dumped and unconfined in uncontrolled sites. On an average, 661 million tons of solid wastes in a day are made in the city, but only 87% of which is collected for ultimate disposal, and the rest is left uncollected. This is mostly due to lack of effective labor strength and fleet of vehicles for collection, transportation and disposal of solid wastes. These wastes are disposed of in the low lying areas of the city where the tanks, ponds and Ganga river are situated, which were once main sources of ground water recharge in the city. In order to know the consequence of wastes on ground water quality, water samples from 6 sites (hand pumps) around garbage dumps were studied. At two sites (Aurangabad and Badi Gaibi), samples were collected in two different (summer and rainy) seasons and the outcomes are recorded in Table 2.2. The ground water from these two sites appears to be unexceptionally affected by the solid waste dump in terms of chemical contents. Nevertheless, the turbidity is far above acceptable limit, slightly close to the maximum permissible limit. The hardness exceeds a value higher than double the adequate limit but still below the permissible limit. Unpredictably, the water is free of coliform (Mohan et al. 2011).

Table 2.2 Quality of ground water in summer and rainy seasons, 2009

Parameters	Value				Acceptable limits (CPWB, N. Delhi ^a)	Maximum Permissible limits (CPWB, N. Delhi ^a)		
	Site 1		Site 2					
	Summer season	Rainy season	Summer season	Rainy season				
1. Alkalinity	188	182	192	180	200	600		
2. pH	7.94	7.02	7.03	7.17	6.5–8.5	9.2		
3. Total dissolved solid	356	342	416	387	500	1500		
4. Conductivity (umhos)	1.2	10	1.6	10	–	–		
5. Hardness	438	408	406	428	200	600		
6. Chloride	61	52	55	46	200	1000		
7. Sulphate	16	16	18	12	200	400		
8. BOD Biologic oxygen demand	0.2	0.4	0.6	0.4	Less than 4			
9. COD Chemical oxygen demand	1.2	4.0	3.6	4.4	–	–		
10. Total suspended solid	15	35	19	29	100	–		
11. Total coliform (MPN/100 ml)	NT	N.T	NT	N.T.	10	10		
12. Turbidity (NTU)	10	05	10	02	2.5	10		
13. Fae cal coliform (MPN/100 ml)	NT	N.T.	NT	N.T.	Nil	–		
14. Nitrate	0.01	0.8	0.04	0.8	4.5	45		

Note:

(i) All the results are expressed in mg/l except pH

(ii) *N.T.* not traceable, *NTU* nephelometric turbidity units

(iii) The test has been done in the laboratory of U.P. Pollution Control Board, Varanasi

(iv) The two sites selected were rather in the midst of waste dumps and its water are under use by the inhabitants for domestic purposes

(v) Site 1: Aurangabad, Site 2: Badi Gaibi

(vi) ^aCPCB- Central Pollution Control Board, New Delhi. ADSORBS/3/1978–79 (Mohan et al. 2011)

The ground water in rainy season has to some extent lower alkalinity, TDS, turbidity, chloride and conductivity but higher TSS, COD, and nitrate. The water from Aurangabad has higher TDS, hardness, COD, and pH and that from Badi Gaibi has higher alkalinity, chloride, sulphate, TSS and turbidity. These spatial differences might be the consequence of seepage from different solid waste disposal (Mohan et al. 2011).

During the last rainy season (July-August) water samples were taken from hand pumps surrounded by waste dumps on 4 sites keeping in view the likely impact of

Table 2.3 Quality of ground water from site 3 Nakhigat, site 4 Benia Bagh, site 5 Pichasmochan and site 6 Nagwa police Chowki, 2009

Parameters	Value				Acceptable limits (CPWB, N. Delhi ^a)	Maximum Permissible limits (CPWB, N. Delhi ^a)
	Site 3	Site 4	Site5	Site 6		
1. pH	7.5	7.2	7.5	7.1	6.5–8.5	9.2
2. TDS	316	648	624	600	500	1500
3. Hardness	172	152	160	164	200	600
4. Chloride	16	168	168	164	200	1000
5. Sulphate	5.0	90	50	Nil	200	400
6. Floride	Nil	Nil	0.8	Nil	–	–
7. NO ₃ (Nitrate)	5.0	20	25	Nil	4.5	45
8. NO ₂ (Nitrite)	Nil	0.01	0.15	Nil	0.1	–
9. Calcium	26	29	30	24	–	–
10. Magnesium	26	20	21	26	–	–
11. Iron	0.3	0.4	0.3	1.0	–	–
12. Colour	<5	<5	<5	10	–	–
13. Taste/Odour	Unobjectionable	Brackish	Brackish	Brackish	–	–
14. Turbidity	Nil	1.2	3.6	12	2.5	10

Note:

- (i) All the results are expressed in mg/L except stated otherwise
- (ii) The test has been done in laboratory of U.P. Jal Nigam, Varanasi
- (iii) The sites selected are in the midst of waste dump and its water is under use by the inhabitants for domestic purposes
- (iv) ^aCPCB-Central Pollution Control Board, New Delhi. ADSORBS/3/1978–79 (Mohan et al. 2011)

the dumps on the ground water quality. The parameters measured were again 14; the investigation was completed in the laboratory of the U.P. Jal Nigam. The outcomes acquired are shown in the Table 2.3. TDS is well above the standard limit though within permissible limit in ground water from 3 of the 4 sites premeditated. The color (except at Nagwa Police Chowki), taste/odour (brackish) and pH are more or less normal. So are the calcium, magnesium and iron contents. Among the 4 sites, iron is noticeable at Nagwa Police Chowki site (Mohan et al. 2011). Here, the water is considered by highest quantity of turbidity (12 NTU) in all 6 sites but is devoid of fluoride and nitrate. Ground water from Aurangabad and Badi Gaibi has higher chloride level than the water from the other 4 sites. Sulphate is maximum at Beniabagh. In the final investigation, only conspicuous result is the presence of NO₂, which is beyond the acceptable limit at Pisachmochan site. No doubt, there is a marked difference in the chemical parameters of water at different sites. In fact,

the impact of solid waste dump, in general, is not beyond permissible limit which may be attributed to the deep (more than 150 ft) boring of hand pumps (Mohan et al. 2011).

In the Ganga Action Plan Phase-I, the construction of municipal sewage treatment plants in various segments of the city area i.e. Konia-Dinapur (in the northern sector) and Bhagwanpur (in the southern sector) was taken up. The treated sewage water, being plant nutrient, is extensively applied to irrigate crops in the area within surrounding area of treatment plants. Insistent leaching of the dissolved nitrate content of the liquid wastes downwards through the permeable irrigated soil to the top saturated aquifer horizon possibly induced enrichment of nitrate content in ground water of the city. Moreover, poor sewerage and drainage facilities, seepage of human excreta from very old septic tanks, and use of nitrogenous fertilizer might have also contributed to nitrate enrichment in the ground water (Mohan et al. 2011).

In total, pollution of ground water in the city is usually from urban and industrial wastes. However, the use of chemical fertilizers and pesticides in agricultural fields in the nearby sub-urban sectors for cultivation purposes has also increased the problem. A large variation of chemicals is being used by farmers in the crop fields to eliminate various types of crop pests, including insects and other organism. These pesticides find their way to ground water through percolation. Research on pollution of ground water in other parts of India has been stated copiously (Roychowdhury et al. 1999; Ahmed et al. 2001), but that of Varanasi is unusual (Rana et al. 2003; Singh et al. 2006). Varanasi is popular in the Indo-Gangetic plain for the production of vegetables and fruits. Thus, there was a rather long history of use of fat accumulative, highly toxic banned cyclodiene organo-chlorine pesticides in the city for agricultural farming purposes and also to retain public hygiene (Rana et al. 2003; Singh et al. 2006).

The higher amounts of aldrine in the groundwater in rural areas appear to be related to its extensive use in plant protection of cereals, vegetables and fruits for the last few decades. The relative concentrations of cyclodiene organo-chlorine pesticides in ground water were in the following order: aldrine>chlordane>diel-drine>heptachlore and its epoxide. The study (Rana et al. 2003; Singh et al. 2006) specified that the banned cyclodiene organo-chlorine pesticides so far analyzed both in the rural and urban areas have crossed the FAO/WHO (World Health Organization) limit of water quality and contamination of these cyclodiene pesticides is in alarming stage for human and livestock consumption and the possibility of their accumulation in food chain cannot be ignored (Mohan et al. 2011).

The higher amount of aldrine in groundwater in urban area seemed to be associated to its widespread use in house hold purpose and plant protection of vegetables in kitchen gardens as well as public health programs through local municipality (Rana et al. 2003; Singh et al. 2006). UNICEF described the presence of 'arsenic in the ground water of southern parts of the city at a level up to 499 ppb far beyond the limit (10 ppb) set by the WHO and Bureau of Indian Standard for the potable water. The joint investigation committee comprising the representatives of Chief Medical Officer, Nagar Nigam and Jal Sansthan analyzed the ground water in the city and claimed that 75 % of the water supplied through tube wells was safe and the rest was unsuitable for drinking purpose, through a orthotolidine test on quantity of chlorine

in the water. But, the National Institute of Communicable Disease (NICD) has rejected this type of test by stating that the test lacks scientific basis. Nagar Nigam does not carry out coliform test to measure *E. coli* organism. The ground water in the first and second strata is polluted from nitrate and faecal coliform organisms. Banaras Hindu University in the southern part of the city fulfills its demand of water from the third strata occurring at 200 m below ground level through deep bores (Mohan et al. 2011).

The Central Government has initiated a plan in 1986 namely 'Rajiv Gandhi National Drinking Water Mission' to provide safe drinking water. The Mission has been entrusted to analyze the samples of ground water with respect to the levels of iron, fluoride, nitrate and total dissolved solid (TDS). Unfortunately, under this mission not much could be implemented in the State of Uttar Pradesh due to apathy of the State Government.

Although crisis of water is prevalent in the whole city, the southern part is suffering more owing to lowering of ground water each year. Brij Enclave colony in Varanasi is a densely populated area of the southern part of the city.

Here, ground water table dropped by 2.13 m (7 ft) in 2006 from a level of 17.68 m (58 ft) in 2005 (Mohan et al. 2011).

Report of the State Ground water Department states that the ground water in the city of Varanasi is depleting at a rate of 23 cm /a⁻¹ (Report 2006). Lowering of ground water in the southern part is nine times faster than the rest part of the city. The Central Government has recently asked State Governments to prepare an integrated development plan for a well-planned township under the proposed 'Jawahar Lal Nehru Urban Renewal Mission', so that it might meet the demand of rapidly growing population for the next 25 years. The State Government has submitted its detailed feasibility report to the Central Government for integrated development of the proposed 'Greater Varanasi', which includes the southern part of Varanasi city also. Therefore, the southern part, the most affected part in terms of water supply, might be developed as a township under the Mission (Mohan et al. 2011).

2.7 Soils

Soils are the most valuable resources for the luxuriant growth of natural vegetation and agricultural plants. Crop plants, to a great extent depend upon the good quality of soil. Generally, soils in the study area are part of alluvial soil. Soils in the study area are extracted through IRS-1C LISS III data of 2008 by applying image processing supervised classification method (Fig. 2.8). The soils of Varanasi district can be divided into four types depending upon their texture composition and formation process as the rivers have played a major role in it:

- (i) Ganga Sandy Loam
- (ii) Western Low Land Soil
- (iii) Western Upland Soil
- (iv) Loamy Soil.

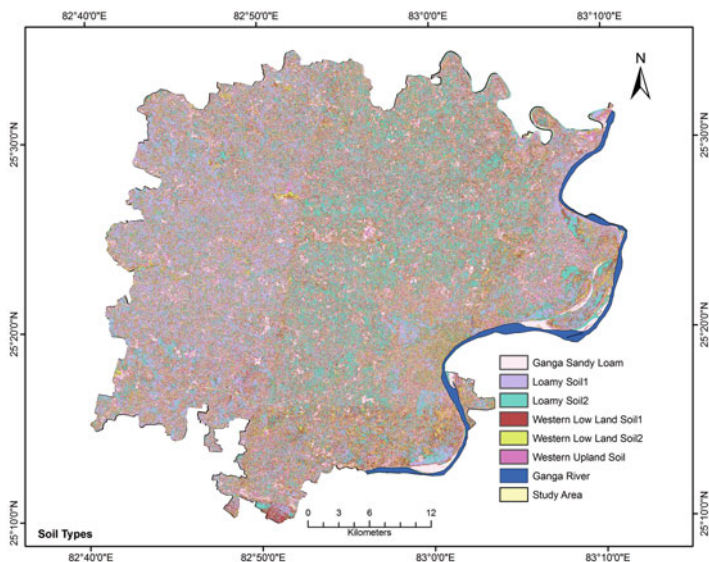


Fig. 2.8 Soil in Varanasi district prepared through IRS-1C LISS III satellite data, 2008

2.7.1 *Ganga Sandy Soil*

It covers 25 % of the area along the bank of the river Ganga and lower part of the river Gomati especially lying in the inundated or flooded areas in the rainy season. Sandy soil has either sands or a mixture of small fine particles of soil suitable for Zaid crops.

2.7.2 *Western Low Land Soil*

It occupies the northern part of the district along the Gomati river and its tributary. It is a fertile loamy soil and neutral in character varying from brown in colour with sufficiently mature profile. There are certain usar and semi usar (barren land) patches scattered here and there in Cholaipur and Chiraigaon development blocks. They are unclassified and lack in well development profiles. These are moderately alkaline in nature with a pH value of 8.2.

2.7.3 *Western Upland Soil*

It is a stiff clay loam type of soil and covers most of the areas of the district inter-mixed with alluvial soil in different parts. In some scattered patches this soil is affected by saline or salt affected locally called as Reh or salt affected soil. In these

patches this patches, hard formation can be seen at a depth of about 5 m below the ground which restricts infiltration of rain water (Rai and Mohan 2014).

2.7.4 Loamy Soil

This soil is found in the northern part of the Cholapur development block along the bank of river Gomati. The soil consists of fine and coarse sand. It is deficient in plant nutrients with low water holding capacity.

In general, the soils of the district may broadly be divided in to two major types:

- (i) Khadar and
- (ii) Bhangar

A Khadar (newer alluvium) covers the flood plains in the vicinity of the rivers including their reaches and also old beds. It is replenished annually by new deposits. The soil naturally remain moist as its derives moisture from the river through seepage in dry season and are capable of growing Rabi and Zaid crops without irrigation. These are locally known as Tari and are classified as Ganga sandy soils consisting of fine silts along the rivers Ganga and Gomati. The newer alluvial soil contains low percentage of humus content and nitrogen. Being more silty in texture it is highly friable and favorable for the Bhadai (Kharif), Rabi and Zaid crops (especially root crops). Under secured irrigation facilities, some of the areas with this soils are producing rice too, especially the early varieties (Rai and Mohan 2014).

The Bhangar is older alluvium with no flood effect except the low lying areas in patches which are either termed as Tal or consist of impervious clay layer found in the sub soil. It is often heavier with higher proportion of clay. Being sticky and usually not well drained it is richer in lime content and kankar and is more suitable for rice cultivation. The low lying areas which hold water for a long time and become dry in winter season is good for cultivation of Rabi crops (Rai and Mohan 2014).

2.8 Land Use and Natural Vegetation

For a long time human existence was based on plough and pastoral activities. It has almost destroyed all the forest covers lying earlier in the study region by direct cutting, burning and grazing. Presently the area under forest is almost negligible. The total area under forest was only 22 ha in year 2001. Only in the Tari region of the district it is observed in its natural form. In cultivated areas it is found in the form of gardens, groves and trees planted under social forestry. Mango and Banyan trees are observed throughout the region. Transplantation of trees under social forestry programme has started in the study area along the railway lines, canals and roads on vacant lands of Gram Panchayats. Munj, sarpat and some local grasses and bushes along the rivers and undulating lands provide a scenario of the natural vegetation

through their natural panorama is distributed and altered now days by the inhabitants to fulfill their growing demand for building materials and other domestic users (Rai and Mohan 2014).

With growing population and limited land resources the significance of land use planning is obvious. Land has limited carrying capacity beyond which there will be degradation and forfeiture in yield due to too much use (Rai and Mohan 2014). In order to meet various demands of the growing population the land degrading trend needs to be checked.

The revenue department divides land uses in following categories: (i) Land place to non-agricultural uses, (ii) Barren and uncultivable land, (iii) Pastures and grazing land, (iv) Land under trees and orchards, (v) culturable waste land, (vi) current fallow, (vii) Fallow other than current fallow, (viii) Net Sown area, (ix) Forest.

Using IRS-1C LISS III remote sensing data of 2008, land use land cover (LULC) map is prepared using image processing supervised classification technique, in which five important classes are delineated i.e. Agricultural field, Fallow land, Vegetation, Built-up Area, and Water Bodies (Fig. 2.9). The Study area mainly comes under the Ganga plain having high fertile soils, so that maximum area comes under very good agricultural land. Forested area is being reduced by pushing the frontier of agriculture. On the other side good agricultural land is being grabbed by urban sprawls, industrial expansion and expansion of urban settlements and infra-structural development. Table 2.4 shows the area statistics of important land use

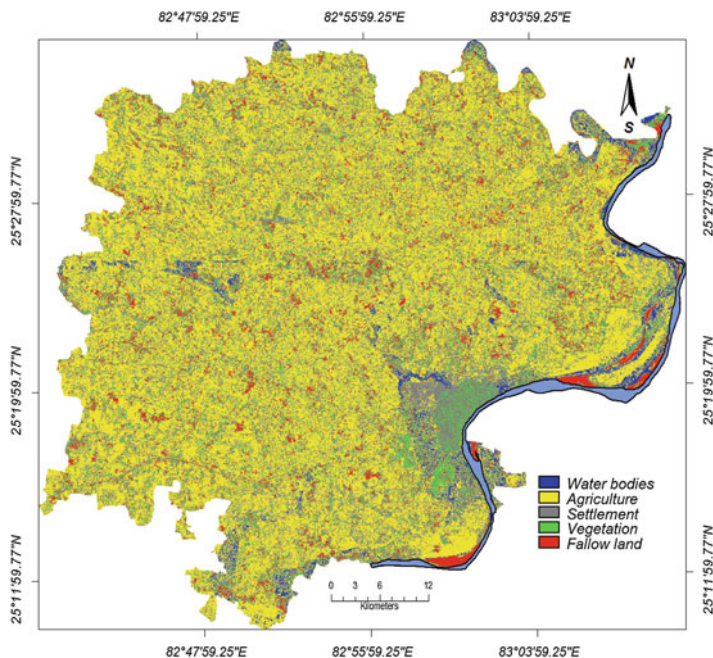


Fig. 2.9 Land use/land cover of Varanasi district, 2008

Table 2.4 Area statistic (in hectares) of different land use categories in Varanasi district

Year /Block	Barren cult. waste	Present fallow land	Other fallow land	Barren land	Land put to non – Agri. use	Pastures	Area under bush, forest & garden
2006–2007	3014	20,846	2264	2150	25,556	10	2996
2007–2008	2932	20,945	2314	2151	25,600	24	2964
2008–2009	2153	22,182	2410	2247	26,097	23	2961
Blockwise, 2008							
Baragaon	183	2464	112	299	2400	3	258
Pindra	234	2546	160	199	2713	0	281
Cholapur	104	2705	212	153	2137	2	311
Chirai Gaon	534	2480	225	519	3439	1	266
Harhua	205	1740	207	146	1973	2	221
Sevapuri	290	1837	152	155	2430	13	544
Arajiline	181	2474	243	159	2880	0	459
Kashi Vidya Peeth	140	4776	483	273	3935	2	479
Total rural	1871	21,022	1794	1903	21,907	23	2819
Total urban	282	1160	616	344	4190	0	142
Total district	2153	22,182	2410	2247	26,097	23	2961

Source: Statistical Handbook, Varanasi District, 2009

features in the Varanasi district. The district covered by 2961 ha forest and dense bushes. However, it is quite below than the standards of ‘Natural Forest Policy’ which said that 33 % of land should be covered with forest so that greenery may be conserved.

2.9 Transportation Network and Connectivity

Varanasi is very well interconnected by road network, rail and air with rest of the country. Important cities like New Delhi, Lucknow and Allahabad are approximately 750 km, 260 km. and 125 km. away from here. There are three national highways i.e. NH-2, NH-56 and NH-29 and four state highways i.e. SH-87, SH-73, SH-74 and SH-98 passing through the city. The network linkages provided by the National highways are:

- (i) NH 2- G.T. Road from Mughal Sarai to Allahabad;
- (ii) NH 29- Varanasi to Gorakhpur, Kushinagar; and
- (iii) NH 56- Varanasi to Lucknow via Jaunpur.

These national highways and state highways have high passenger traffic as these roads deliver a good connectivity to the adjacent areas in the U.P. state as well as to metropolitan cities like Delhi and Kolkata. The Grand Trunk (GT) road or NH2

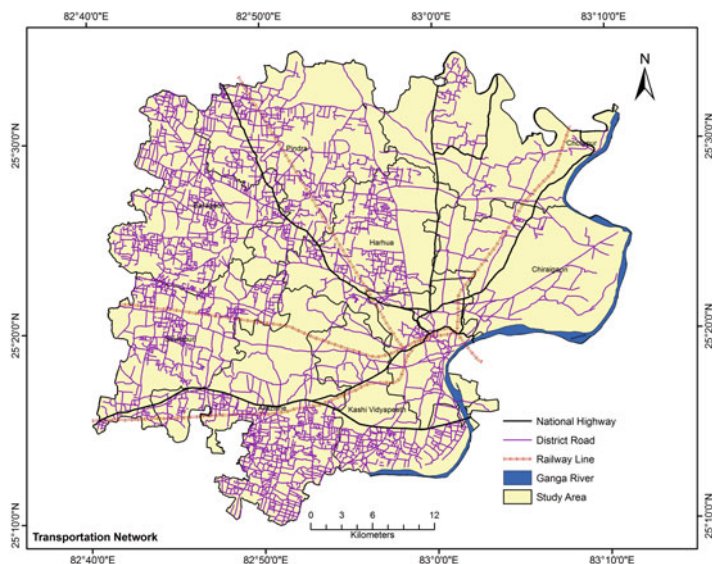


Fig. 2.10 Transportation network in Varanasi district

forms the main transportation backbone of the city. A bypass is being built along the Eastern edge of the city to release the burden off NH 2. Another ring road is constructed along the western edge of the city to divert the traffic and deliver better connectivity to the recent developments coming up in the Trans Varuna Region.

Varanasi is well joined by railway lines. There are three rail lines entering to the city from Lucknow, Bhadoi and Allahabad and is diverted in two lines to Gorakhpur and Mughal Sarai. The city lies on Delhi-Kolkata rail route of North Eastern Railways, which is the broad gauge. A rail line connects the town with Sarnath. The other cities having good connectivity through railways are Patna, Guwahati, Chennai, Mumbai, Gwalior, Meerut, Lucknow, Kanpur and Allahabad. The town also has an airport at a distance of about 24 km away from the city. Flights facilities from Varanasi to Agra, Bhubaneshwar, Kolkata, Delhi, Gorakhpur, Khajuraho, Lucknow, Raipur and Kathmandu (Nepal) are available. It is on a consistent aviation route of Delhi to Kolkata and Bhubaneshwar. It is also the flying gateway to Nepal. Transportation network of Varanasi district has been extracted from IRS-1C LISS III satellite data in conjunction with IKONOS satellite data. Figure 2.10 shows the transportation network of Varanasi district. Table 2.5 shows that block-wise distribution of road network on the basis of rural population. Total 2610 km and 2615 km of metalled road are calculated in the year 2003–2004 and 2008–2009 respectively in which 1701 km of metalled road belongs to P.D.W. (public development work) in 2008–2009. In the rural and urban area of Varanasi, total length of metalled road is 1999 km and 616 km respectively.

Table 2.5 Block-wise distribution of road network on the basis of village population

Year/Development block	Length of metalled road (km)		No. of villages connected with all seasonable road (Population Wise)		
	Total	P.W.D	Village of <1000 population	Village of 1000–1499	Villages of > 1500
2003–2004	2610	1696	433	169	267
2008–2009	2615	1701	433	169	267
Development block-wise, 2008–2009					
1 Baragaon	243	216	57	17	34
2 Pindra	240	178	55	25	34
3 Cholapur	219	155	44	21	26
4 Chirai Gaon	265	196	39	19	40
5 Harhua	233	172	67	27	25
6 Sewapuri	203	172	58	16	24
7 Araziline	289	237	64	18	43
8 Kashi Vidhyapith	307	253	49	26	41
Total Rural	1999	1579	433	169	267
Total Urban	616	122	0	0	0
Total District	2615	1701	433	169	267

Source: Statistical Handbook, Varanasi District, 2009

2.10 Communication and Educational Facilities

Development block wise distribution of communication facilities are shown in the Table 2.6 As for communication means concern, post office, PCO telephone etc. are comes under this category. In the Varanasi district, a total of 145 post offices, 1737 PCO, 10,941 telephone connections are available in the rural area whereas 135 post offices, 3088 PCO, 81,824 telephone connections are present in the in urban area. Total railway station/hault is predictable in the rural and urban area of Varanasi district is 15 and 06 respectively. Number of bus station in rural and urban area is 167 and 06 respectively.

Total 145 post office are located in the villages area of each development blocks, 296 post offices are located at the distance of <1 km, whereas only 58 post office are located at the distance of >5 km from the villages. Likewise, total 750 PCO are found in the villages whereas 820 PCO are identified at the distance of >5 km (Table 2.6). Distance wise different communication means in each development block are shown in the Table 2.7.

Educational facilities in the rural part of Varanasi district are not very good. Not any single university is established in rural development blocks but educational facilities in the city area are very good. Three important universities i.e. Banaras Hindu University, Mahatma Gandhi Kashi Vidyapith and Sampurna Nand Sanskriti University are located in the Varanasi city. Development block wise status of educational facilities on per lakh population is shown in the Table 2.8. It was found that maximum 13 primary school on per lakh population were found on Kashi Vidyapith

Table 2.6 Block-wise distributions of communication facilities in Varanasi district

Year/Development block	Post office	Telegram office	PCO	Telephone	Railway station/hault	Bus station
2003–2004	280	26	4294	94,140	21	173
2008–2009	280	26	4825	92,765	21	173
Development block-wise, 2008–2009						
1 Baragaon	20	3	148	1626	0	50
2 Pindra	23	1	184	1487	3	9
3 Cholapur	18	2	301	1542	2	17
4 Chirai Gaon	20	0	217	1366	0	12
5 Harhua	18	0	192	1322	1	8
6 Sewapuri	16	1	240	962	2	28
7 Araziline	18	3	302	1185	4	34
8 Kashi Vidhyapith	12	2	153	1451	3	9
Total rural	145	12	1737	10,941	15	167
Total urban	135	14	3088	81,824	6	6
Total district	280	26	4825	92,765	21	173

Source: Statistical handbook, Varanasi district, 2009

block whereas minimum 4.2 primary school on per lakh population were found on Baragaon development block in year 2008–2009 but total 3.2 higher secondary school and 13 middle school have been identified on Baragaon development and 28.1 and 13 higher secondary and middle school on per lakh population were found for Kashi Vidyapith block respectively. District as a whole, 9.7 primary, 29.3 higher secondary and 9.7 middle schools on per lakh population have been identified in the year 2008–2009 respectively.

2.11 Solid Waste Generation and Management

Any waste that is not in the form of gaseous or liquid state, such waste is known as solid waste. Any solid material that is disallowed by society is called solid waste. Solid wastes arise from human and animal activities and are normally discarded as useless or unwanted. In other words, solid wastes may be well-defined as the organic and inorganic waste materials formed by various activities of the society and which have lost their value to the first user. The quantity of municipal solid waste has increased enormously with improved lifestyle and social status of the populations in urban area (Sharholly et al. 2007). The anaerobic decomposition by microorganisms brings about degradation of most of the solid waste.

This results in the emission of carbon dioxide (CO₂), Methane (CH₄), and other toxic gases (Suchitra 2007 and Mc Bean et al. 1995). These air pollutants cause a plethora of health problems to the nearby residents (Shah 2007). During land filling of solid waste, continuous pressure results in the quizzing of a contaminated liquid

Table 2.7 Distance-wise distributions of different communication means in each development blocks

Development block	In Village					< 1 km					1-5 km					> 5 km				
	Post office	Letter box	Telegram office	PCO	Post office	Letter box	Telegram office	PCO	Post office	Letter box	Telegram office	PCO	Post office	Letter box	Telegram office	PCO	Post office	Letter Box	Telegram Office	PCO
Baragaon	20	20	3	67	32	32	3	6	80	79	57	40	6	5	6	84	6	5	6	84
Pindra	23	23	1	79	76	76	11	12	73	73	13	54	27	17	17	164	27	17	17	164
Cholapur	18	18	2	108	13	13	3	4	109	109	37	25	2	3	3	101	2	3	3	101
Chirai Gaon	20	21	0	86	11	11	0	5	104	103	14	25	3	0	0	121	3	0	0	121
Harhua	18	18	0	96	62	62	4	9	82	82	67	36	0	6	6	97	0	6	6	97
Sewapuri	16	16	1	100	10	10	1	6	113	113	49	38	15	42	42	130	15	42	42	130
Araziline	18	18	3	130	86	86	19	6	108	108	101	37	4	5	5	94	4	5	5	94
Kashi Vidhyapith	12	12	2	84	6	6	3	14	75	75	85	18	1	26	26	29	1	26	26	29
Total	145	146	12	750	296	296	44	62	744	742	423	273	58	104	105	820	58	104	105	820

Source: Statistical Handbook, Varanasi District, 2009

Table 2.8 Block-wise distribution of status of educational facilities on per lakh population

S.No.	Development block	No. of primary school on per lakh population			No. of higher secondary school on per lakh population			No. of middle school on per lakh population		
		1990–1991	2002–2003	2008–2009	1990–1991	2002–2003	2008–2009	1990–1991	2002–2003	2008–2009
1	Baragaon	3.4	5.7	4.2	2.7	4.9	3.1	5.6	13	13
2	Pindra	3.1	6.6	6.6	12.2	23.5	26.5	3.1	6.6	6.6
3	Cholapur	4.9	6.8	6.8	15.4	27.7	32.1	4.9	6.8	6.8
4	Chirai Gaon	2.7	9.7	9.7	11.9	20.5	32.3	2.7	9.7	9.7
5	Harhua	4.2	9.6	9.6	12	20.4	32.4	4.2	9.6	9.6
6	Sewapuri	5.7	10.1	10.1	14.5	26.5	24	5.7	10.1	10.1
7	Araziline	3.4	9.0	9	11.1	21.7	28.6	3.4	9.0	9.0
8	Kashi Vidhyapith	2.3	13.0	13	14.0	21.1	28.1	2.3	13.0	13.0
Total		3.4	9.7	9.7	12.6	22.5	29.3	3.1	9.7	9.7

Source: Statistical Handbook, Varanasi District, 2009

Table 2.9 Annual trend of solid waste generation in the Varanasi city

Year	Solid waste generated (Tones)
1991	165,375
1994	172,100
1997	182,500
2002	200,750
2008	219,000

Source: Nagar Nigam, Varanasi, 2009

as leachate (Suchitra 2007). Leachate is a liquid emanating from a solid waste land disposal site that contains dissolved, suspended and microbial contaminants. The leachate has high organic contents, soluble salts and other constituents capable of polluting groundwater. This polluted water is unfit for drinking purpose and causes jaundice, nausea, asthma, miscarriage and infertility.

In Varanasi district there are 85 Ganga ghats with typical structure on the river Ganga which are frequented by a large number of pilgrim's everyday for taking a holy dip in river Ganga. About 100 narrow lanes not wider than 1.8 m having houses and commercial establishment on both sides leading to 85 ghats. The city along the Ghats has facing the severe serious problems of solid waste management due to congested lanes. Table 2.9 shows the total annual generation of solid waste during the period 1988–2007.

At present total quantity of wastes in Varanasi city is about 650 metric tones (MT) per day (Table 2.10) of which largest amount of about 425 MT solid waste generated by household or residential areas followed by Slaughter houses, construction waste, hospital and dispensaries waste and slum waste and solid waste generated daily by shops and vegetable/ fruit markets and worship places (temples etc.).

Table 2.10 Waste generated by different actions in Varanasi city

Type of waste	Quantity of waste generate (Metric Tons)
Household	425
Shops and offices	20
Hotels, lodges, guesthouses	15
Vegetables/Fruit Markets	20
Fish/ Meat Market	5
Place of worships	20
Construction waste	25
Hospitals and dispensaries	25
Slum Waste	25
Industries, workshops, work sheds	15
Slaughter houses	35
Beef Shops	10
Total	650

Source: Nagar Nigam, Varanasi, 2009

Table 2.11 Collection sites of solid waste in the Varanasi city

1. Vidyapeeth	14. Nadesar	27. Khatikana
2. Cantt.Railway Station	15. Andhrapul	28. Shivpur Hospital
3. Circuit House	16. Jaitpura	29. Bakkrabad
4. Kamalgarha	17. Azadpark	30. Adamkuan
5. Golgadda	18. Bhadaun	31. Macchodari
6. Kabirchura	19. Chowk	32. Sonia
7. Harthirath	20. Kotwali	33. Kunjigarh
8. Benia	21. Harai Sarai	34. Godaulia
9. Prachi	22. Rewari Dashhashwamedh	35. Nagar Nigam
10. Aurangabad	23. Fatman	36. Rewari
11. Akashwani	24. Bhelupur	37. Shivala
12. Durgakund	25. Kabir Nagar	38. Pitarkunda
13. Harishchandra	26. Senpura	39. Kaligarh

Source: Nagar Nigam, Varanasi, 2009

Out of which 450 metric tones (collection efficiency is 69 %) is collected daily in an unscientific manner. And the average generation rate of municipal solid waste is 0.59 kg/capita/day. Rapid growing population and change in life styles of the people are amicable factors in waste generation.

Varanasi city has a total number of 39 secondary waste collection points (Table 2.11 and Fig. 2.11). These solid waste collection sites have been located through GPS (Global Positioning System) in the year 2010.

The total number of open dumps either abandoned or in use is 74. All these open dumps are within the city limits. Some of the 39 sites are clubbed along with the

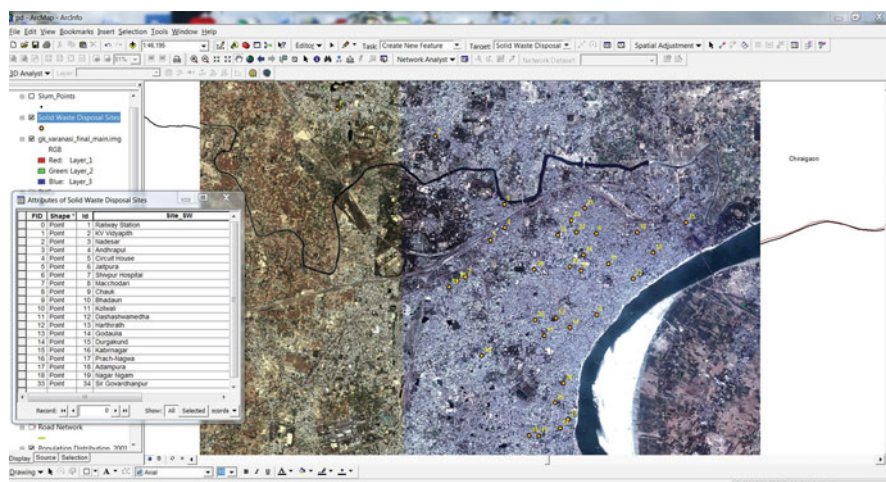


Fig. 2.11 Selected solid waste collection sites in Varanasi city identified through GPS, 2010

nearly sites to reduce the number to 28. Solid waste is being dumped on private lands e.g. all open dumps in Sigra ward are on private land. Few dumps in Nagwa ward, Jaitpura ward, Sicrol ward and Sarnath ward are also on private land. On the bank of the River Ganga, there are 9 sites where waste is being dumped. All the religious activities which are being carried out along the Ganga River result in waste generation, which is dumped along the river; a large proportion of which is flowers and waste generated from the temples. On the other hand, wastes through the hospitals and nursing homes are highly toxic as it contains hazardous materials endangering our natural environment. As for as the proper collection and disposal of hospital wastes are concerned the Nagar Nigam has given clear cut instructions to the hospitals, nursing homes and pathological centres of the city to manage their own system for scientific disposal of the wastes. Sorry to say that have of them complied over the suggestion of the Nagar Nigam.

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