WWF-India sees its role in urban work as an attempt to reduce the impact of cities on biodiversity and ecological footprint, both of which have implications for the overall conservation goals of the organisation. Further, given the experience and expertise in dealing with footprint issues, WWF feels there is a greater need to engage with planners, developers and policy makers involved in dealing with urban issues.
IMPACT OF URBANISATION ON BIODIVERSITY
Case Studies From India
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Acronyms

β-HCH  β-hexachlorocyclohexane
BOD  Biochemical Oxygen Demand
CBD  Convention on Biological Diversity
CDP  Comprehensive Development Plan
COD  Chemical Oxygen Demand
CPCB  Central Pollution Control Board
CWC  Central Water Commission
DDE  Dichlorodiphenyldichloroethylene
DDT  Dichlorodiphenyltrichloroethane
EWK  East Kolkata Wetlands
GDP  Gross Domestic Product
GIS  Geographical Information System
HACA  Hill Area Conservation Authority
HUDCO  Housing and Development Corporation
IWMD  Institute of Wetland Management and Ecological Design
IUCN  International Union for Conservation of Nature
INR  Indian Rupee
KMA  Kolkata Metropolitan Area
KMC  Kolkata Municipal Corporation
KMDA  Kolkata Metropolitan Development Authority
kl  kilolitre
kWh  kilowatt hour
LPA  Local Planning Authority
MGI  McKinsey Global Institute
MT  Metric Tonne
NRAPA  Noyyal River Ayacutdars Protection Association
PAH  Polycyclic Aromatic Hydrocarbons
RAAC  Resident Awareness Association of Coimbatore
TANGEDCO  Tamil Nadu Generation and Distribution Corporation
TNPCB  Tamil Nadu State Pollution Control Board
TNSCB  Tamil Nadu Slum Clearance Board
TPD  Tonnes Per Day
TSS  Total Suspended Solids
Executive Summary

Natural resources are under extreme pressure due to the burgeoning human population and rapid urbanisation across the world. Many studies show that increase in the ecological footprint from the changing consumption behaviour, particularly of those residing in cities, continues to negatively impact the environment. This is an emerging challenge and a harsh reality.

Urbanisation in India is occurring at a rate that is faster compared to many other parts of the developing world. The Planning Commission of the Government of India estimates that about 40 per cent of the country’s population will be residing in urban areas by 2030. However, as conurbations and megacities grow, they spawn a disproportionately large footprint in the form of ravaged nature in and around these expanding cities. Therefore, understanding the impact of urbanisation on biodiversity becomes imperative not only from the point of view of conservation, but also for planning sustainable cities. The present report attempts to understand the impact of urbanisation on biodiversity based on the study of two Indian cities—Coimbatore and Kolkata, which are located in important, yet different bio-diverse regions.

Preliminary investigations based on literature reviews and field studies suggest that the rapid urbanisation of both Coimbatore and Kolkata has led to drastic changes in land use, destruction of natural ecosystems, and increase in the demand for natural resources. For instance, geographical expansion of Coimbatore city in recent decades has led to the destruction of the Noyyal river that had once served the city’s water needs. Similarly, the spatial growth of Kolkata has led to drastic changes in the biodiversity of the East Kolkata Wetlands in the city as well as the Sundarbans.

Considering the ecological importance of the area where these cities are located, the study recommends undertaking detailed investigation of the urbanisation trends of these cities, and an assessment of their ecological footprint. Indeed, the study argues from the conservation perspective, as it is important for urban planning to take into account the impact of urbanisation on biodiversity, natural resources, quality of life, and ecosystem services for sustainable urban development.

WWF-India sees its role in the work on urbanisation as an attempt to reducing its impact on biodiversity as well as the ecological footprint; both of which have an implication on the overall conservation goals of the organisation.
Cities are symbols of modernisation. Currently, the world is witnessing an unprecedented rate of urbanisation. Studies suggest that urban population increased from about 3 per cent in 1800 to 14 per cent in 1900 and further to 47 per cent in 1999. However, in a recent study on global urbanisation, the United Nations Population Program estimated that the world’s urban population could reach 53 per cent by 2015, of which 90 per cent of the growth is likely to occur in cities of developing countries.

In India, urban population increased from about 17 per cent in 1950 to 29 per cent in 2007 (Rajashekariah, 2007). Estimates suggest by 2030, nearly 590 million or 40 per cent of the country’s population could be living in cities (MGI, 2011).

DEFINING “URBAN”

India uses a combination of population, density, and employment thresholds in defining “urban”. It classifies an area as urban, based on the population of more than 5,000; density exceeding 400 persons per sq. km., and where 75 per cent of the male workers are engaged in non-agricultural professions.

In this work, “Urbanisation” refers to the general demographic processes by which cities are expanding, “Urban area” refers to the amounts of urban land cover, and “Urban growth” to the expanded area of urban land cover.

However, this rapid growth in urban population accentuates the demand for natural resources, leads to change in land use patterns, causes pollution and loss of biodiversity, alters hydro-geomorphology, and so on. Studies suggest that substantial human-induced environmental changes are linked to urbanisation on a regional scale (Haines-Young, 2000, 2009; Cincotta et al., 2000) and could become an important factor in biodiversity conservation.

Connecting urbanisation and biodiversity

McKee et al. (2003) and Cincotta et al. (2000) predict that most of the urban growth is expected to occur in regions around the world’s biodiversity hotspots 1. By

---

1 Myers (1990) suggest that for an area to qualify as hotspot region, it must (i) contain at least 0.5% or 1,500 species of vascular plants as endemic and have lost 70% of its primary vegetation. The biodiversity hotspot site supports 60% of the world’s plant, birds, mammals, reptiles and amphibian species.
analysing the key demographic variables, Cincotta et al. (2000), reports that nearly 20 per cent of the world’s population lives in biodiversity hotspot regions. Therefore, predicting patterns of urbanisation in areas of high biodiversity are critical for conservation.

Globally, several cities, including Curitiba, Brussels and Singapore are testing new frameworks to assess the urban-biodiversity linkages. For instance, the City Biodiversity Index or Singapore Index, created under the Convention on Biological Diversity (CBD), includes indicators such as birds, butterflies, mammals and plants to serve as tools for assessing stressors that deplete biodiversity.

In India, most studies on urbanisation focus on megacities like Mumbai, Delhi, Chennai, Kolkata and Bangalore, by mostly focusing on issues related to urban economy, politics, and environmental pollution. However, it is the urbanisation of smaller cities and towns, particularly those located in biodiversity rich areas that are of serious concern to conservation (fig 1.1). Yet, there are no studies that enumerate the ground realities of urbanisation and its impacts on biodiversity in India. This study attempts to fill the gap.

Fig 1.1: Rapid infrastructure development cutting through forest areas negatively impacts biodiversity
OBJECTIVES AND SCOPE OF THE STUDY

The primary objective of this scoping work is to study the impact of urbanisation on biodiversity in the two Indian cities of Coimbatore and Kolkata, which are located in different ecological regions and are experiencing varying degrees of urbanisation.

Although the study recognises the importance of ecological footprint in assessing the impact of urbanisation on nature, owing to paucity of time and lack of data, it confines itself to discussing environmental issues that are critical to the cities.

The information provided in this report can be used by planners, environmentalists and policy-makers to influence decisions related to the cities of Coimbatore and Kolkata.

METHODOLOGY

The study adopted a suite of methodologies, which included literature review, field surveys, discussions with informants, focus group discussion, and interviews with individuals and organisations working on urban and biodiversity issues.

Based on the synthesis of core themes that emerged during focus group discussions and fieldwork, selected topics were taken up for detailed investigation within the two cities. Quantitative evidence was used wherever data was available, and in cases where they did not exist or were inaccessible, the study made use of discourses that emerged from the discussions and interviews.

Information on resource use (viz., water, energy, and land) for assessing carbon footprint of the cities was collected from literature, urban local bodies, state departments, and various parastatal agencies. The sources of information are cited throughout the report.
CHAPTER 2

[Image of a building and a riverbank]

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COIMBATORE: A CITY MARCHING INTO ENVIRONMENTAL DISTRESS

Coimbatore, the second largest city in the southern state of Tamil Nadu, is also known as the “Manchester of South India”. The city corporation, which extends over an area of 105 sq. km, is surrounded by the Nilgiri Biosphere Reserve in the North and the Anaimalai and Munnar mountain ranges in the East, all of which constitute the Western Ghats: one of the ten “hottest” biodiversity hotspot regions of the world (fig 2.1). According to the provisional reports of the Census of India (2011), the urban agglomeration of Coimbatore comprises of a population of over two million.

The city of Coimbatore developed from a small village on the banks of River Noyyal during the medieval ages. Originally, formed as part of the Kongu country and inhabited by the Kosar tribes, the area was characterised by the presence of a network

---

2 The city corporation includes, Siganallur Municipalty, Kumarapalayam town panchayat, Sanganoor town panchayat, Teilungupalayam town panchayat, Coimbatore rural, Ganapathy town panchayat and a portion of Vilankurichy town panchayat
of tanks and agricultural lands. In fact, the region served as an important trade route between the coastal areas of Kerala and Tamil Nadu.

By the late nineteenth century, Coimbatore, had transformed itself from a small agricultural village to an important administrative and industrial city, housing some of the major textile units in the country. However, with a majority of textile units shifting into the neighbouring town of Tirupur in the late 20th century, Coimbatore moved up the value chain by diversifying into automobile, electrical, dyeing, and heavy machineries, and recently into education and information technology. Currently, the city has over 30,000 registered industries. However, the industrial growth is not just confined to Coimbatore, but has spread into the neighbouring towns of Coonoor, Ooty, Palakkad, Tirupur, Mettupalayam, and Pollachi, forming an “urban network” that is economically and politically connected (fig 2.2). Tirupur, in particular, has carved a niche for itself in the global garment market (see Box 2.1). The urban network constitutes an important economic hub in the state of Tamil Nadu, after Chennai.

Fig 2.2: Coimbatore and the network of cities

The economic opportunities created by industrialisation of the region led to a vast influx of population from neighbouring areas. This resulted in unplanned urbanisation, environmental degradation, and loss of biodiversity. Here, three inter-related issues concerning urbanisation and biodiversity in Coimbatore are discussed: (i) urban land use (ii) the Noyyal river, and (iii) the human-elephant conflict.
URBAN LAND USE IN COIMBATORE

Human settlements represent the most profound alterations to the natural environment. In particular, urbanisation which involves a wide spectrum of land-based activities and natural resource extraction leads to loss of habitat and destruction of biodiversity. Therefore, geographic understanding of land use change is critical to assess the impact of urban growth on the local environment.

In Coimbatore, urbanisation has led to the conversion of all forms of nature, including forests, agricultural, barren lands and wetlands for urban land use. Analysis of the spatio-temporal growth of Coimbatore shows rapid expansion between 1973 and 2010 (Table 2.1).

### Table 2.1: Urban growth of Coimbatore

<table>
<thead>
<tr>
<th>Year</th>
<th>Area in sq. km.*</th>
<th>Growth in per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>38.28</td>
<td>-</td>
</tr>
<tr>
<td>1989</td>
<td>79.05</td>
<td>105.6</td>
</tr>
<tr>
<td>2004</td>
<td>135.57</td>
<td>71.5</td>
</tr>
<tr>
<td>2010</td>
<td>274.34</td>
<td>102.3</td>
</tr>
</tbody>
</table>

*: area of the metropolitan area of Coimbatore

The present study shows that the urban agglomeration of Coimbatore expanded from 38 sq. km. in 1973 to 79 sq. km. in 1989, and further to 274 sq. km. in 2010, registering over five fold growth, in less than four decades. In terms of spatial pattern, the city developed concentrically during the initial years and later into linear radial development along the major roads (fig 2.3). The review of 2002 land use plan for the city indicated that nearly 75 per cent of land within the corporation limits had developed into urban land use, while the rest was classified as agricultural land, water bodies, vacant areas, and heritage sites.
Fig 2.3: Urban growth of Coimbatore from 1973 to 2010
Indeed, analysis of the built area in Coimbatore city showed that 76 per cent of the land was used for residential purposes, followed by the commercial category which accounted for 13 per cent, and the rest by public institutions such as schools, places of worship, and hospitals (Table 2.2).

However, the built-up area in the city has increased substantially in recent times. Field investigation revealed that the city was expanding along the main arterial roads leading to Sathyamangalam, Metupalayam, Avinashi, Trichy, Cochin, and Palakkad; and along the peripheral areas of Singanallur, Ondipudur, Matuthamalai, Seeranayakanpalayam, Kumarapalayam and Vilankurichi, located close to the forest area.

The rapid growth of Coimbatore can be attributed to the influx of population into the city from the surrounding areas owing to the increase in economic opportunities resulting from industrialisation. For instance, population of the city increased from 0.3 million in 1971 to 0.8 million in 1991 and further to over two million in 2011. Discussions with informed citizens of Coimbatore suggest that many areas within the city that were identified as low-density urban spaces in the 1970s had transformed into medium and high-density areas by the mid 1980s. This was corroborated by the Census Report for Coimbatore (2001) which suggested that the overall population density in the city had increased from 7,727 persons per sq. km. in 1991 to 8,815 persons per sq. km. in 2001.

In conclusion, the urban growth of Coimbatore has significantly altered the city-hinterland relationships. However, if the current trend of industrialisation and urbanisation continues, the need to further accentuate its infrastructure could put considerable strain on the local environment and biodiversity.

---

Table 2.2: Classification of built area in Coimbatore

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Distribution in percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence</td>
<td>190,899</td>
<td>75.97</td>
</tr>
<tr>
<td>Residence, cum-other use</td>
<td>3,202</td>
<td>1.27</td>
</tr>
<tr>
<td>Shop, office</td>
<td>23,718</td>
<td>9.44</td>
</tr>
<tr>
<td>School, college, etc.</td>
<td>447</td>
<td>0.18</td>
</tr>
<tr>
<td>Hotel, lodge, guesthouse, etc.</td>
<td>1,171</td>
<td>0.47</td>
</tr>
<tr>
<td>Hospital, dispensary, etc.</td>
<td>890</td>
<td>0.35</td>
</tr>
<tr>
<td>Factory, workshop, work shed, etc.</td>
<td>7,714</td>
<td>3.07</td>
</tr>
<tr>
<td>Place of worship</td>
<td>596</td>
<td>0.24</td>
</tr>
<tr>
<td>Other non-residential use</td>
<td>7,191</td>
<td>2.86</td>
</tr>
</tbody>
</table>

Source: Business Development Plan for Coimbatore, 2010

---

5 This category included shops, offices, hotels, factories and other forms of commercial establishments
Aquatic ecosystems are critical for maintaining the health of cities. In addition to serving the basic human and biodiversity needs, water acts as a sink, solvent and a medium for transporting sewage and industrial wastes generated in the city. However, over exploitation of natural aquatic ecosystems has undermined its value in most of the Indian cities, including Coimbatore. River Noyyal in the city suffers from a similar fate. This section discusses the impact of urbanisation of Coimbatore on Noyyal river.

River Noyyal originates from the Vellingiri Hills in the Western Ghats of Coimbatore district (fig 2.4). The river, which flows from west to east, travels a distance of 180 km through the five districts of Coimbatore, Tirupur, Erode, Karur, and Trichy, covering an area of 0.35 million ha. The water from the river, which is found to be of potable quality for the first few kilometres, becomes heavily polluted as it traverses through human settlements. In fact, vast stretches of the river in the downstream becomes dry due to the degradation of catchment areas, over extraction of river water for irrigation, and indiscriminate pumping of groundwater for industrial and agricultural purposes. The quality of river water also changes as the untreated and partially-treated sewage from urban settlements and industrial areas are released into it. In fact, the Comprehensive Development Plan for Coimbatore (CDP, 2006) states that only 43 per cent of the households in the city are connected to a sewage system, while the rest either discharge directly into the fresh water ecosystems, including River Noyyal or are connected to individual septic tanks.

4 Noyyal, translates into ‘devoid of illness’ in Tamil
The discharge of effluents and sewage into the river had led to drastic reduction in the quality of surface and ground water within the basin. Studies by the State Public Works Department, Tamil Nadu State Pollution Control Board (TNPCB) and various academic institutions in the state concluded that water in the basin was highly contaminated. A study on the water quality of Noyyal by the Central Water Commission (CWC, 2001) found that most of the water quality indicating parameters had crossed the maximum permissible limits set by the Central Pollution Control Board (CPCB). For instance, the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), the two critical parameters that indicate the quality of water, showed the average values of 150 mg/l and 1,260 mg/l respectively; while the average total solids was 10,000 mg/l; alkalinity, 800 mg/l; and hardness, 4,000 mg/l. Based on the study by Tamil Nadu Pollution Control Board, the accumulated load of some of the critical pollutants in Noyyal river from 1980–2000 are summarised in Table 2.3.

---

**BOX 2.1: TIRUPUR: INDIA’S KNITWEAR CAPITAL**

Tirupur is a rapidly growing industrial city located in the Noyyal river basin. Presently, the city has over 6,000 textile units, and over 700 dyeing units (fig 2.5) generating an estimated US$2.5 billion in foreign exchange, annually.

However, increase in the pollution levels of the river due to discharge of industrial effluents, particularly from dyeing units, has led to serious concerns amongst the authorities. Studies indicate that industries in Tirupur discharge over 100,000 cu. m. of effluents each day. These effluents are characterised by high concentration of bleaching liquids, soda ash, sulphuric acid, hydrochloric acid, azo dyes, sodium peroxide, hypochlorite, and heavy metals such as Cadmium, Iron, Zinc, and Lead. Indeed, many of these chemicals are classified as carcinogens. A study by the Tamil Nadu Pollution Control Board stated that 833,266 tonnes or 76 per cent of the hazardous wastes generated from the state came from Tirupur (*The Hindu*, 2005).

**Fig 2.5: Number of bleaching and dyeing units in Tirupur**

![Graph showing number of bleaching and dyeing units in Tirupur]

*Source: Blomqvist A., sid 139*

The discharge of effluents and sewage into the river had led to drastic reduction in the quality of surface and ground water within the basin. Studies by the State Public Works Department, Tamil Nadu State Pollution Control Board (TNPCB) and various academic institutions in the state concluded that water in the basin was highly contaminated. A study on the water quality of Noyyal by the Central Water Commission (CWC, 2001) found that most of the water quality indicating parameters had crossed the maximum permissible limits set by the Central Pollution Control Board (CPCB). For instance, the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), the two critical parameters that indicate the quality of water, showed the average values of 150 mg/l and 1,260 mg/l respectively; while the average total solids was 10,000 mg/l; alkalinity, 800 mg/l; and hardness, 4,000 mg/l. Based on the study by Tamil Nadu Pollution Control Board, the accumulated load of some of the critical pollutants in Noyyal river from 1980–2000 are summarised in Table 2.3.

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5 CPCB sets a limit of 2200 mg/l for Total Solids; BOD of 100 and COD of 250 for Inland surface water
As a result of the pollution, agriculture in the catchment, which depends on the river for irrigation, is severely impacted. Discussions with farmers in the downstream areas of Noyyal river suggested that the average yield of traditional crops like turmeric, coconut, and bananas had reduced drastically in recent times (see Box 2.2). Many farmers in the region had abandoned agriculture and moved into other jobs. This is corroborated by Appasamy et al. (2000), who in their study showed that the pollution load in the Noyyal River had significantly increased over the years from 1980-2000.

Table 2.3: Aggregate pollution load in the Noyyal River from 1980-2000

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Quantity (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dissolved Solids</td>
<td>2.354</td>
</tr>
<tr>
<td>Chlorides</td>
<td>1.311</td>
</tr>
<tr>
<td>Sulphates</td>
<td>0.125</td>
</tr>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>0.097</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>0.090</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>0.029</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Source: Tamil Nadu Pollution Control Board, 2001

As a result of the pollution, agriculture in the catchment, which depends on the river for irrigation, is severely impacted. Discussions with farmers in the downstream areas of Noyyal river suggested that the average yield of traditional crops like turmeric, coconut, and bananas had reduced drastically in recent times (see Box 2.2). Many farmers in the region had abandoned agriculture and moved into other jobs. This is corroborated by Appasamy et al. (2000), who in their study showed that the pollution load in the Noyyal River had significantly increased over the years from 1980-2000.

**BOX 2.2: ORATHUPALAYAM DAM: A DAM OF DISTRESS**

The Orathupalayam dam on the Noyyal river was built in 1992, with the purpose of irrigating the downstream agricultural land in the districts of Erode and Karur (fig 2.6). However, the discharge of sewage and industrial effluents into the river, since 1997 has rendered the water unfit for irrigation. Studies on the water quality of the dam show very high concentration of heavy metals such as lead, chromium, cadmium, and mercury, which are highly toxic to crops (The Hindu, 2003). During the discussion, Govindasamy, president of the Noyyal River Ayacutdars Protection Association (NRAPA), stated that the pollution of Noyyal river had rendered the agricultural lands, extending up to 3 km on either side of the river, unfit for cultivation. Further, many recent reports attribute the frequent fish kills in the Cauvery river to the release of water from the dam.

Fig 2.6: Orathupalayam dam in the polluted downstream reaches of River Noyyal
studies on the impact of Noyyal river on agriculture concluded that the total irrigated area in the basin had declined from 16,262 ha to 14,262 ha, over time.

A genotoxic study by Rajaguru (2003), on the fish and earthworm in the Noyyal river basin showed extensive damage to their DNA. The study further concluded by stating that groundwater samples in the basin had high concentration of amines that were capable of inducing breakage of DNA strands among humans.

With the river and ground water sources in the region, highly contaminated and unusable, industries and residents of Tirupur import water from the surrounding areas of Palladam, Mettupalayam and Coimbatore, leading to a boom in the water market. For instance, it was found that water was priced between INR 200–INR 260 (US$4–US$5) for a tanker of 12,000 litres. As a result, many farmers in the region had turned into water entrepreneurs. Although this activity was restricted to a 5 km radius during the initial years, falling groundwater levels, and increasing demand had pushed the hunt for water into wider concentric circles. Estimates suggest that industries in Tirupur are supplied with 9,000–10,000 tankers of water every day from places as far as 50 km from the city.

In fact, such unregulated extraction of water has resulted in the groundwater levels falling below 800 feet in many areas within the catchment, drying up the already desiccated land. The problem is further compounded by the reduction of water flow into the river due to the destruction of natural recharge zones in the basin (fig 2.7).

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6 Calculated at 1 USD = 45 INR

Fig 2.7: Noyyal river at Tirupur
URBANISATION AND BIODIVERSITY

The Western Ghats, where the city of Coimbatore is located, is one of the world’s ten “hottest hotspots” of biological diversity. The forests in this region are home to a spectacular array of biodiversity that include over 5,000 species of flowering plants, 139 species of mammals, 508 species of birds, and 179 amphibian species (Daniels, 2007). Prominent among the large mammals found in the region include the tiger (Panthera tigris), leopard (Panthera pardus), Asian elephant (Elephas maximus), sloth bear (Melursus ursinus), ungulates, such as gaur (Bos gaurus), sambar (Cervus unicolor), chital (Axis axis), and the endemic Nilgiri tahr (Hemitragus hylocrius). The floral diversity of the region is characterised by tropical evergreen and semi-evergreen forests that includes several commercially important trees such as teak (Tectona grandis), sandalwood (Santalum album), rosewood (Dalbergia latifolia) and bamboo (Bambusa bambos).

According to Myers et al. (2007), the region has at least 325 globally threatened species, many of which are listed in the IUCN’s Red List.

The Coimbatore forest range is spread over an area of 700 sq. km. (or nearly 10 per cent of the total district area) and flanked by Sathyamangalam, Erode, and Nilgiris Forest Division in the north, and Palghat Forest Division of Kerala in the south. Located within the core zone of the Nilgiri Biosphere Reserve (NBR), Coimbatore forest division is divided into six administrative sub-divisions, namely Bolampatty, Coimbatore, Perianaichenpalayam, Karamadai, Mettupalayam and Sirumugai (fig. 2.8).

The urban growth of Coimbatore and increase in economic activities in the region has had serious impacts on the local environment and biodiversity. In particular, the wildlife in the region are affected by habitat destruction, interruption of their migratory routes, exposure to invasive species, and increasing conflicts with humans.

Fig 2.8: Protected Areas in Coimbatore District

The Protected Area (PA) network in the Western Ghats includes 14 National Parks (NP) and 44 Wildlife Sanctuaries (WLS), and covers a mere 9% of its land area, with a majority of the forest types in this landscape falling outside PAs.
Fragmenting Forests and biodiversity
Habitat fragmentation caused by human induced modification of landscapes threatens the survival of wildlife. In fact, as forests are modified, the survival of wildlife depends upon their ability to use landscapes modified by humans. The mosaic of vegetation in the Nilgiri Biosphere Reserve, Anaimalai, and Munnar forest ranges, located in the vicinity of Coimbatore, provide refuge for large mammals, including elephants. The forest area on the outskirts of the city, serve as migratory corridors for the elephants. Some of the important elephant corridors in the region include the Jaccanari–Vedar, Kallar–Jaccanari, Kallar–Nellithurai, Anaikatti–Veerapandi, Maruthamalai–Thanikandi, and Kalkothi–Walyar corridors⁸ (fig 2.9).

Fig 2.9: Elephant corridors in the Coimbatore forest division

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⁸ The length and the width of these corridors ranges from 0.5–21 km long and 0.2–3 km wide.
The present study shows large scale clearance of forests (legally and illegally) for agriculture, plantations, residential, highways, railways, and other infrastructure projects. Consequently, this has led to fragmentation or destruction of contiguous forest into three separate landscapes as Anaimalai, Periyar, and Agasthyamalai. As a result, elephants are often found stranded and scattered in enclaves looking for food and water or at highways (fig 2.10a) and rail lines that cut across these corridors, exposing them to accidents (fig 2.10b). This has also led to an increase in human-elephant conflicts in the region. The forest department, however in an effort to address the issue of human-animal conflict has recommended for the acquisition of 200 acres of private agriculture lands located in the critical elephant corridor. The proposal is still pending with the government.

Fig 2.10: (a) Elephants crossing the highway at outskirts of Coimbatore

Fig 2.10: (b) Railway tracks: death traps for elephants
Review of the recently submitted Master Plan for Coimbatore suggests that the proposed plan seeks to expand the city into the elephant corridor areas which could further escalate the risks of human-elephant conflict (Box 2.3).

**BOX 2.3: HUMAN-ELEPHANT CONFLICT IN COIMBATORE**

Ongoing studies by WWF-India and records available with the Tamil Nadu State Forest Department show steady increase in human-elephant conflict in the Coimbatore forest range. Records show that 61 human deaths have occurred due to elephants in the last decade. In particular, the fringe areas of Boluvampatti Block-II, Kallar, Kovaiputthur, Madukkarai, Sirimugai, Sadiyaval and Thadagam villages were considered to be a high conflict zone (fig 2.11). The region is prone to frequent crop raids by the elephants. Records showed that the forest department had paid more than INR 1.5 million (US$35,000) as compensation, for 300 crop raids during 2009–10. Discussions with local farmers suggested that peak elephant raids occur immediately after the northeast monsoon and lasts until early March, which coincides with the migratory season of elephants. In order to prevent elephant raids, farmers in the region have erected electric fences (fig 2.12a). However, in many instances, this has led to death of elephants due to high voltage electric shocks.

Further, rapid growth of Coimbatore has led to construction boom in the city leading to a huge demand for bricks and other construction materials. As a result, numerous brick kilns (fig 2.12b) have come up in the outskirts of the city, including the Thadagam Valley, which is one of the corridor areas for elephant, interfering with their free movement.
ENERGY USE AND CARBON EMISSIONS

Energy plays a vital role in sustaining the metabolism of cities. It is also the largest contributor to carbon footprint of a city that leads to climate change. Indeed, studies show that cities consume more than 75% of the global energy and are responsible for 80% of all greenhouse gas emissions. In order to reduce the carbon footprint of cities, it is important to understand the energy use of the city. Information on energy use and carbon emissions for the cities of Coimbatore and Kolkata was compiled based on information collected from various sources, including municipal corporations, public utilities, and literature review.

The analysis of energy use and carbon emissions by different sectors in Coimbatore for 2007–08 showed that the residential category used nearly 650 Million kWh of electricity, followed by the commercial (375 Million kWh) and industrial (145 Million kWh) sectors (Table 2.4). Despite being an industrial city, the relatively less use of electrical energy suggests that industries perhaps depend on alternative sources of energy, which need to be probed further.

Table 2.4: Energy use by different sectors in Coimbatore

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy/Fuel</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Electricity (Million kWh)</td>
<td>645.86</td>
</tr>
<tr>
<td></td>
<td>LPG (MT)</td>
<td>70,874</td>
</tr>
<tr>
<td></td>
<td>Kerosene (kl)</td>
<td>36,234</td>
</tr>
<tr>
<td></td>
<td>Fuel wood (MT)</td>
<td>66,520</td>
</tr>
<tr>
<td>Commercial</td>
<td>Electricity (Million kWh)</td>
<td>375.92</td>
</tr>
<tr>
<td>Industrial</td>
<td>Electricity (Million kWh)</td>
<td>144.19</td>
</tr>
<tr>
<td>Transportation</td>
<td>Diesel (kl)</td>
<td>87,312</td>
</tr>
<tr>
<td></td>
<td>Petrol (kl)</td>
<td>65,310</td>
</tr>
<tr>
<td>Waste</td>
<td>MSW (TPD)</td>
<td>601</td>
</tr>
</tbody>
</table>

Source: ICLEI, Energy and Carbon Emission Profiles of 54 South Asian Cities 2009, and parastatal agencies in Coimbatore

In terms of carbon emissions, Coimbatore generated about 1.27 million TeCO₂, at a per capita emission of 1.37 tonnes, which was marginally higher than the national average of 1.3 tonnes. The residential and transportation sectors contributed 73 per cent of the total carbon emissions (Fig 2.13). However, review of existing business and urban plans for Coimbatore suggests that contributions from these sectors could increase substantially. Further, increasing economic prosperity of the city would not only accelerate the demand for natural resources, but also add to its footprint of the city.
INSTITUTIONAL FRAMEWORK OF GOVERNANCE IN COIMBATORE

In order to understand the role of state and its various agencies in the governance of Coimbatore and in addressing the various issues related to its environment and natural resources, the study mapped the institutions and its functions. The results are summarised in table 2.5.

In Coimbatore, like many other cities of similar size in the state, municipal corporations and various state agencies play an important role in planning the urban programmes, including land use, providing basic public services, urban infrastructure, environmental protection and so on.

Table 2.5: Institutions and their role in the governance of Coimbatore

<table>
<thead>
<tr>
<th>Function</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic and Social development</td>
<td>Government of Tamil Nadu</td>
</tr>
<tr>
<td></td>
<td>Coimbatore District Small Scale Industries Association (CODISSIA)</td>
</tr>
<tr>
<td></td>
<td>Confederation of Indian Industries (CII)</td>
</tr>
<tr>
<td></td>
<td>Indian Chamber of Commerce and Industry (ICCI)</td>
</tr>
<tr>
<td>Water supply and Sewerage</td>
<td>Tamil Nadu Water Supply and Drainage Board (TWAD)</td>
</tr>
<tr>
<td></td>
<td>Coimbatore City Corporation</td>
</tr>
<tr>
<td>City Planning</td>
<td>Local Planning Authority (LPA)</td>
</tr>
<tr>
<td></td>
<td>Hill Area Conservation Authority (HACA)</td>
</tr>
<tr>
<td>Roads, Highways and other transport infrastructure</td>
<td>Coimbatore City Corporation</td>
</tr>
<tr>
<td></td>
<td>National Highway Authority of India</td>
</tr>
<tr>
<td></td>
<td>Highways Department, Government of Tamil Nadu</td>
</tr>
<tr>
<td>Municipal Waste</td>
<td>Coimbatore City Corporation</td>
</tr>
<tr>
<td></td>
<td>Village and town municipalities</td>
</tr>
<tr>
<td></td>
<td>Health Department, Government of Tamil Nadu</td>
</tr>
<tr>
<td>Environmental Protection</td>
<td>Tamil Nadu State Pollution Control Board (TNPCB)</td>
</tr>
<tr>
<td></td>
<td>Coimbatore City Corporation</td>
</tr>
<tr>
<td>Urban Forest</td>
<td>Coimbatore District Forest Office</td>
</tr>
<tr>
<td>Slum Upgradation</td>
<td>Tamil Nadu Slum Clearance Board (TNSCB)</td>
</tr>
<tr>
<td></td>
<td>Housing and Development Corporation (HUDCO)</td>
</tr>
<tr>
<td>Sanctioning of building plans</td>
<td>Coimbatore City Corporation</td>
</tr>
<tr>
<td></td>
<td>Local Planning Authority</td>
</tr>
<tr>
<td></td>
<td>Town Municipality or Village Panchayat</td>
</tr>
<tr>
<td></td>
<td>Hill Area Conservation Authority (HACA)</td>
</tr>
<tr>
<td>Urban amenities including parks, lakes and playground</td>
<td>Coimbatore City Corporation</td>
</tr>
<tr>
<td></td>
<td>Resident Awareness Association of Coimbatore (RAAC)</td>
</tr>
<tr>
<td>Energy</td>
<td>Tamil Nadu Generation and Distribution Corporation (TANGEDCO)</td>
</tr>
<tr>
<td></td>
<td>Private windmills</td>
</tr>
</tbody>
</table>

*This table does not discuss the role of different ministries in the Government of India in the governance of Coimbatore city.

Detail analysis of the results, suggests functional overlap between different agencies, operating at different scales in the city. However, the city corporation emerged to be the most important institution responsible for dealing with environment, planning, development, within the city.
KOLKATA: URBANISATION AND IMPACT ON ECOLOGICAL SYSTEMS

The city of Kolkata (erstwhile Calcutta), like most metropolitan cities in the country, expanded rapidly in recent decades. Located on the western bank of the Hooghly river, a branch of River Ganga, the city of Kolkata is spread over an area of 185 sq. km. (fig 3.1), and supports a population of about 5 million. The urban agglomeration which comprises of the city and its suburbs supports over 15 million people in an area of 1,950 sq. km. According to the World Urbanisation Report (2005), Kolkata is the third largest metropolitan area in the country and thirteenth most populous area in the world.
The city of Kolkata evolved from a small trading post during the early eighteenth century to a bustling city by mid-nineteenth century. The city’s history is intimately related to the British East India Company, which first arrived in 1690, and to British India, of which it became the capital in 1772 and remained until 1912.

During the early 19th century, Kolkata witnessed huge industrial investments by the British and later by Indian businessmen in jute, textiles, chemicals, heavy engineering, cement, pharmaceuticals, food processing, leather and metallurgical supplies. As a result, the city came to be recognised as Asia’s most important commercial and industrial hub outside Japan by the mid-nineteenth century, whose dominance continued until recently.

Consequently, this led to considerable strain on the natural environment of Kolkata and its surrounding areas. Indeed, as a growing metropolitan in a developing country, Kolkata confronts substantial urban pollution, traffic congestion, poverty, overpopulation, and other logistic and socioeconomic problems. This report discusses three inter-related issues of (i) effect of urbanisation on land use in the city, (ii) problems related to the East Kolkata Wetlands due to urbanisation and (iii) the influence of urbanisation on the Sundarbans delta, to explain the impacts of urbanisation on the environment of Kolkata.

**URBAN GROWTH OF KOLKATA**

The industrialisation of Kolkata was accompanied by rapid urbanisation. The economic opportunities that followed Kolkata’s industrialisation led to massive influx of population from the neighbouring states of Bihar, Orissa, and the northeastern parts of the country.

The Kolkata Metropolitan Area (KMA) is spread over 1,800 sq. km. and comprises of, (i) the conurbation area, stretching in a linear manner along the east-west bank of Hooghly river and (ii) the rural areas lying as a ring around the conurbation area. The present composition of the KMA is presented in Table 3.1.

<table>
<thead>
<tr>
<th>Categories of Area</th>
<th>Number</th>
<th>Area (sq. km.)</th>
<th>Total Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Corporations</td>
<td>3</td>
<td>271.3</td>
<td>14.6</td>
</tr>
<tr>
<td>Municipalities</td>
<td>38</td>
<td>615.5</td>
<td>33.2</td>
</tr>
<tr>
<td>Non-Municipal Areas</td>
<td>77</td>
<td>200.1</td>
<td>10.8</td>
</tr>
<tr>
<td>(NMA)/Census Towns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out Growths</td>
<td>16</td>
<td>18.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Rural Area</td>
<td>445</td>
<td>746.3</td>
<td>40.3</td>
</tr>
<tr>
<td><strong>TOTAL KMA</strong></td>
<td></td>
<td><strong>1,851.4</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

*Source: Comprehensive Development Plan for Kolkata (2006)*

The KMA consists of three municipal corporations (including Kolkata Municipal Corporation), 38 local municipalities and 77 non-municipal areas including 24 village local bodies (KMA, 2011). The suburban areas of KMA includes parts of districts of North 24 Parganas, South 24 Parganas, Howrah, Hooghly and Nadia (Sahdev and Nilima, 2008). Spatially, the urban agglomeration expanded from 144 sq. km. in 1970 to 633.2 sq. km. in 2010 (Table 3.2).
Fig 3.2: Urban growth of Kolkata, 1970-2010

Source: Deutsches Zentrum fur Luft- und Raumfahrt, Earth Observation Center (DLR-DFD)
Indeed, the spatial growth pattern of the city show that major expansion occurred towards the east and south, by mostly converting large tracts of marshy areas, wetlands and agricultural land (fig 3.2). In general, the urban growth of Kolkata showed a strong correlation with the population growth in the city.

Historical records show that the population of Kolkata, began to expand rapidly from the 1900s, coinciding with the industrial expansion of the city. For instance, the population increased from 8.7 million in 1971 to over 15 million in 2010 (fig 3.3), and continue to expand further. Analysis of the Population Census for Kolkata (2001) showed that the KMA had a population of 14.72 million people in an area of 1,851 sq. km,\(^9\), at an average density of 7,950 persons per sq. km. The Kolkata Municipal Corporation (KMC), which is spread in an area of 271.3 sq. km., supported a population of 4.6 million (31.2 per cent), while the urban agglomeration had a population of 6.91 million (47 per cent) in 615.5 sq. km. Discussion with experts working on the city suggested that the population within the urban agglomeration had increased dramatically in the recent decades.

**THE EAST KOLKATA WETLANDS**

The East Kolkata Wetlands (EKW), a designated Ramsar site\(^10\), is spread over an area of 12,500 ha (Table 3.3). The area comprises of intertidal salt marshes, salt

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (sq. km.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>144.0</td>
</tr>
<tr>
<td>1990</td>
<td>196.6</td>
</tr>
<tr>
<td>2000</td>
<td>339.9</td>
</tr>
<tr>
<td>2010</td>
<td>633.2</td>
</tr>
</tbody>
</table>

*Source: DLR-DFD (2010), Germany*

Historical records show that the population of Kolkata, began to expand rapidly from the 1900s, coinciding with the industrial expansion of the city. For instance, the population increased from 8.7 million in 1971 to over 15 million in 2010 (fig 3.3), and continue to expand further. Analysis of the Population Census for Kolkata (2001) showed that the KMA had a population of 14.72 million people in an area of 1,851 sq. km,\(^9\), at an average density of 7,950 persons per sq. km. The Kolkata Municipal Corporation (KMC), which is spread in an area of 271.3 sq. km., supported a population of 4.6 million (31.2 per cent), while the urban agglomeration had a population of 6.91 million (47 per cent) in 615.5 sq. km. Discussion with experts working on the city suggested that the population within the urban agglomeration had increased dramatically in the recent decades.

**Table 3.3: Land use classification of East Kolkata Wetlands**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area in hectares (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water bodies</td>
<td>5,852.14 ha (46.81)</td>
</tr>
<tr>
<td>Agriculture land</td>
<td>4,959.86 ha (38.92)</td>
</tr>
<tr>
<td>Garbage disposal Site</td>
<td>602.78 ha (4.73)</td>
</tr>
<tr>
<td>Settlement Area : Urban</td>
<td>91.53 ha (0.73)</td>
</tr>
<tr>
<td>Rural</td>
<td>1,234.99 ha (9.69)</td>
</tr>
<tr>
<td><strong>TOTAL AREA</strong></td>
<td><strong>12,500.00 ha</strong>(^*)</td>
</tr>
</tbody>
</table>

*Additionally 241.30 ha are being added to the system for making the system integral*

*Source: Natai Kundu, Urban Waste Management through productive activities in East Kolkata Wetlands (2009)*

\(^9\) The population of Kolkata accounts for nearly 60% of the urban population of West Bengal.

\(^{10}\) Ramsar sites are wetlands of international significance governed by the Ramsar Convention. The treaty seeks to conserve wetlands through sustainable utilisation. The convention recognises the importance of ecological functions of wetlands, their economic, cultural, scientific and recreational value. The EKW was designated as a Ramsar site in 2002.
meadows, and water treatment areas such as sewage farms, settling ponds, and oxidation basins. The EKW is broadly divided into four major sub-regions—freshwater fishponds, brackish fishponds, garbage farms, and paddy lands.

Analysis of the land use classification of EKW shows that water bodies constitute nearly half of the total area (5,852 ha), followed by agriculture (4,959.8 ha), human settlement (1,326.5 ha) and garbage disposal site (603 ha) (fig 3.4).

**Fig 3.4: Classified map of East Kolkata Wetlands**

*Source: Subhro Sen, WWF-India*
The East Kolkata Wetlands supports over 100 plant species and rare mammals such as marsh mongoose (*Atilax paludinosus*), small Indian mongoose (*Herpestes javanicus*), Indian civets (*Viverra zibetha*), and the threatened Indian mud turtle (*Lissemus punctata*). The region is also known to sustain over 40 species of local and migratory birds, including kingfishers (*Alcedo arrhis*), grebes (*Podiceps nigricollis nigricollis*), cormorants, egrets, terns, eagles, and sandpipers. The floral diversity of EKW include phytoplanktons and a variety of aquatic macrophytes (Table 3.4).

**Table 3.4: Biodiversity of East Kolkata Wetlands**

<table>
<thead>
<tr>
<th>Types</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytoplankton</td>
<td>30 Genera</td>
</tr>
<tr>
<td>Macro floral variety</td>
<td>155 Genera</td>
</tr>
<tr>
<td>Aquatic macrophytes</td>
<td>43 Genera</td>
</tr>
<tr>
<td>Bank flora</td>
<td>39 Genera</td>
</tr>
</tbody>
</table>

*Source: IWMED, 2004*

The massive influx of population into Kolkata, as discussed earlier, led to an insatiable demand for urban space. This resulted in large scale reclamation of all forms of nature, including the EKW (fig 3.5). This as altered the natural drainage in the city, causing frequent floods. Sinha (1988) states that although the original growth of Kolkata followed the flood-safe levels along the banks of the Hooghly
Kolkata: Urbanisation and Impact on Ecological Systems

river, recent growth of the city ignores natural gradient leading to an increase in the frequency of flooding.

The EKW receives about 3,500 tonnes of municipal waste and 680 million litres of sewage daily (Suutari, 2009). The partially treated sewage from the EKW is used for fish rearing and irrigation of agricultural lands within the wetland area. Currently, some 300 large fish farms and ponds connected by major and secondary canals produce 13,000 tonnes of fish annually. The small scale plots within the EKW produce an average of 150 tonnes of vegetables per day (Bandopadhay, 2004). IWMED (2004) identifies 24 species of vegetables and crops, five species of fruit plants and 10 species of ornamental plants that are cultivated in the garbage farm of EKW. Yet, studies by Dey (2009) suggest that only about 30 per cent of the total waste water generated by the city is used for aquaculture or irrigation, and the remaining 70 per cent flows directly into the Bay of Bengal.

However, despite the recommendations made by the special committee for waste management to prevent the reclamation of EKW for garbage dumping, it still continues unabated.

URBANISATION OF KOLKATA AND ITS IMPACT ON THE SUNDBARBANS

The Sundarbans, which lies around 100 km to the south-east of Kolkata in the 24-Paraganas District of West Bengal, is formed by the confluence of Padma, Brahmaputra and Meghna rivers. Spread over an area of 9,600 sq. km., Sundarbans is bound by the Ichamati–Raimangal rivers in the east, Hooghly river in the west, Bay of Bengal in the south, and Dampier–Hodges line in the north (fig. 3.6).

The most prominent feature of Sundarbans is the ubiquitous mangrove forests, which accounts for 85 per cent of all mangrove forests found in India. Champion (1936) classified Sundarbans as moist tropical seral forests, comprising of beach and tidal forests. The Indian side of the Sundarbans consists of the Matla, Goashaba, Chhotahardi, Mayadwip, Chamta, Gona, and Baghmara forest blocks, which are bound by the Matla and Bidya rivers on the east and Raimangal river on the west.

In terms of biodiversity, Sundarbans serves as an important refuge for several endangered and threatened mammals including the tiger (Panthera tigris), smooth-coated otter (Lutrogale perspicillata), and great Indian civet (Viverra zibetha). The region also has several smaller predators such as the jungle cat (Felis chaus), fishing cat (Prionailurus viverrinus), and leopard (Prionailurus bengalensis). It is home to over 150 avian species, including the white-rumped vulture (Gyps bengalensis), greater adjutant stork (Leptoptilos dubisu), osprey (Pandion haliaetus), and the grey-headed fish-eagle (Ichthyophaga ichthyaetus), many of which are threatened or critically endangered. In terms of floral diversity, Sundarbans consists of 64 plant species, including Rhizophora species, Ceriops species, Bruguera gymnorrhiza, Aegiceras corniculatum, Heritiera fomes, Kandelia kandel, Nypa fruticans, Sagina apetala, and Sonneratia caseolaris (Chaudhuri and Choudhury, 1994).

In recognition of its high biodiversity and the occurrence of endangered and threatened species, the Sundarbans was designated as a UNESCO World Heritage site in 1987.
Fig 3.6: Map of Sundarbans Biosphere Reserve

Source: Anurag Danda, WWF-India
However, urbanisation of Kolkata and its neighbouring areas have had severe impact on the Sundarbans. Construction of various infrastructure (Box 3.1) and increasing demand for natural resources from the city and its neighbourhood have led to large scale deforestation of mangroves, siltation and pollution (Bhattacharyya, 1998; Sanyal et al., 2007; Sinha et al., 1996).

**BOX 3.1: FARAKKA BARRAGE AND Sundarbans**

The Farakka barrage project, taken up for augmenting the navigational status of the Kolkata port in 1975, has brought significant increase in the freshwater discharge in its distributaries. As a result, the rivers in the eastern sector have lost connection with the Ganga–Bhagirathi system in the course of time and are now fed only by the tide. This has resulted in significant changes in the fish diversity.

Studies by Dhaneesh and Kumar (2010) argue that the western sector of the Sundarbans showed the presence of more economically important fish species, while the eastern sector was populated with the commercially insignificant varieties. The study attributed the variations in fish diversity to ingestion of seawater and the resultant increase in salinity that led to reproductive failures and increase in mortality due to loss of primary food supply.

Many studies show pronounced ecological change is occurring in Sundarbans due to unprecedented discharge of untreated domestic and industrial effluents carried by the tributary rivers, as well as disposal of contaminated mud from the Haldia Port Complex, a major oil disembarkment terminal in eastern India. The delta has become susceptible to pollutants like organochlorine, pesticides, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, hexachlorocyclohexane isomers, Dichlorodiphenylchloroethylene (DDE), Dichlorodiphenyltrichloroethylene (DDT), β-HCH, and heavy metals (Sarkar et al., 2007; Guzzella et al., 2005; Binelli et al., 2007). These pollutants are slowly changing the estuary’s geochemistry and affecting the local coastal environment.
From an eco-toxicological point of view, the impact of such pollutants is getting more pronounced. Zuloaga et al. (2010), providing a comprehensive account of congener profiles of polycyclic aromatic hydrocarbons (PAHs) in intertidal bivalve molluscs (*Meretrix meretrix, Macoma bimaculata*) of the Sundarbans, showed that molluscs in the region recorded significantly higher levels of PAHs. The problem is compounded further by the lack of dilution due to inadequate fresh water getting into Sundarbans. Hazra (2010) suggests that of the eight rivers that dominate the landscape, only Rivers Hooghly and Ichamati–Raimangal carries fresh water flow of some significance.

**ENERGY USE AND CARBON EMISSIONS**

In Kolkata, analysis of energy usage for 2007–08 for various sectors showed that industries use about 3 million tonnes of coal and wood and over 500 million units of electricity (Table 3.5). The residential category showed the highest usage of electricity (about 1,200 million kWh) followed by the commercial sector (1,000 million kWh) and industrial sector (500 million kWh).
The city emitted 9.33 million TeCO₂, at a per capita emission of 1.80 tonnes for 2007–08. In terms of sectoral emissions, it was found that more than half of the total emissions (54 per cent) came from the industrial sector (fig 3.7). This can be explained by the presence of heavy manufacturing industries in the city, with many using obsolete technologies.

**Table 3.5: Energy use by different sectors in Kolkata**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy/Fuel</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Electricity (Million kWh)</td>
<td>1,196.06</td>
</tr>
<tr>
<td></td>
<td>LPG (MT)</td>
<td>75,997</td>
</tr>
<tr>
<td></td>
<td>Kerosene (kl)</td>
<td>292,240</td>
</tr>
<tr>
<td></td>
<td>Fuel wood (MT)</td>
<td>0</td>
</tr>
<tr>
<td>Commercial</td>
<td>Electricity (Million kWh)</td>
<td>984.54</td>
</tr>
<tr>
<td>Industrial</td>
<td>Electricity (Million kWh)</td>
<td>503.16</td>
</tr>
<tr>
<td></td>
<td>Coal/Wood (Tonnes)</td>
<td>2,929,348</td>
</tr>
<tr>
<td>Transportation</td>
<td>Diesel (kl)</td>
<td>488,955</td>
</tr>
<tr>
<td></td>
<td>Petrol (kl)</td>
<td>117,987</td>
</tr>
<tr>
<td>Waste</td>
<td>MSW (TPD)</td>
<td>4000</td>
</tr>
<tr>
<td>Others</td>
<td>Electricity (Million kWh)</td>
<td>0</td>
</tr>
</tbody>
</table>

The residential and transportation sectors together contributed 37 per cent of the total carbon emissions in the city. However, the geographical expansion of the city and changing lifestyles could contribute to significant increase in the carbon emissions.
CONCLUSION

The study on the impact of urbanisation on biodiversity of Kolkata and Coimbatore showed that rapid growth of these cities has led to the destruction of natural ecosystems and an increase in the ecological footprint. However, these variations dependent on the location, patterns and processes involved in urbanisation (Box 4.1). From a conservation perspective, it is important that urban planning takes into account aspects of biodiversity including human-animal conflict, ecosystem services and long-term sustainability of nature-society relations.

BOX 4.1: URBANISATION TRENDS IN INDIA

Cities in India are transforming the country’s economy more than ever before. The country’s urban population grew from 290 million in 2001, to an estimated 340 million in 2008, or 30 per cent of the total population. This is expected to change to 590 million or 40 per cent of the population in the next two decades. In 2008, urban GDP accounted for 58 per cent of the overall GDP.

A study by McKinsey Global Institute (MGI), on India’s urbanisation suggest that the country could have 68 cities with a population of more than a million, 13 cities with more than 4 million people, and 6 megacities with population of over 10 million by 2030. It estimates that urban areas could generate about 70 per cent of the country’s GDP by 2030. This is expected to drive a near fourfold increase in India’s per capita income between 2008-30. The study predicts that five states of, Tamil Nadu, Karnataka, Gujarat, Punjab and Maharashtra will have more people living in urban areas than the rural, by 2030.

These economic growth trends will unlock many new growth markets including infrastructure, transportation, health care, education, and recreation.

Source: Compiled from: India’s urban awakening: building inclusive cities, sustaining economic growth, McKinsey Global Institute, 2010

Such scale of urbanisation, as concluded in the study, indicates an urgent need to assess and address the ecological footprint of cities. For instance, it is projected that India would build anywhere between 700–900 million sq. m. of residential and commercial space, approximately 350–400 km of metros and subways and

11 Although no calculations were done for the ecological footprint, owing to the scope of the study and paucity of data in some cases, when this is seen in the larger context, the observation is quite evident.
20,000–25,000 km of road lanes a year. This would mean a drastic increase in the demand for resources such as energy, water, waste disposal sites, that could have severe impact on the local environment and biodiversity\textsuperscript{12}. The problem could be further exacerbated by the changing lifestyles of average urban citizens that are becoming more resource intensive in the recent times.

Developing sustainable cities requires creation of new governance structures and changes in the behaviour of citizens. This will not happen just by pointing out problems, but by showing solutions that are affordable, easy and replicable. The concept of ecological footprint can explain the urbanisation-environment linkages, the understanding of which would assist in suggesting effective sustainable solutions. The study suggests,

i. Continuation of the work initiated in one of the two cities, Coimbatore\textsuperscript{13} or Kolkata, to conduct a detailed study for understanding how urbanisation impacts biodiversity and the local environment, and its link to the ecological footprint of the city. The study recommends a demonstration project, to map and analyse various factors contributing to the ecological footprint of the city and provide policy guidelines for specific sectors and municipalities for reducing the footprints. Currently, a study of this nature is absent for any Indian city. A study on the ecological footprints could demonstrate to the local authorities/planners the advantages of considering these issues in planning urban programmes and in suggesting solutions for making their city more sustainable.

ii. WWF-India can help develop tools, methodologies, inspiring examples and educational materials that can be accessible to wider audiences, including policy makers, researchers and lobbyists. At an organisational level, it can lobby for legal obligations to integrate the concept of footprint into city level planning and policy development. Additionally, capacity building on the relevance of footprint in cities across different levels of political, economic and cultural institutions to which WWF has access, can be developed to facilitate the development of innovative solutions to urban challenges.

WWF-India sees its role in urban work as attempting to reduce its impact on biodiversity and ecological footprint, both of which have an implication on the overall conservation goals of the organisation.

\textsuperscript{12} These problems are likely to be more pronounced in rapidly expanding cities, located in the vicinity of biodiversity rich areas.

\textsuperscript{13} Coimbatore has certain institutional advantages including close relationship with the government, local presence and a bureaucracy/political class that is open to new ideas.


Hydrology Research Station., 1996. Pollution studies in Noyyal–Orthapalayam Reservoir Project. Final Report, Department of Fisheries, Chennai


