Biodiversity in Bengaluru

A manual for journalists reporting on urban biodiversity

MONGABAY INDIA

CITIZEN MATTERS ಬೆಂಗಳೂರು

BENGALURU SUSTAINABILITY FORUM

CONTENTS

Abstract

Bengaluru is today the fourth largest city in India and one of the fastest growing cities in the world. This rapid urbanisation brings with it a host of environmental problems such as pollution, loss of green cover and large scale biodiversity loss. Media coverage has largely focused on issues such as pollution and sanitation while little attention has been paid to the impact of urbanisation on biodiversity in the city. This manual attempts to help journalists understand and tell stories of the city s biodiversity. We provide an overview of what biodiversity means, how urbanisation impacts biodiversity and how the city s growth interacts with its wild spaces as well as the people depending on them. The focus is on Bengaluru, but we hope journalists across urban landscapes in India will find it useful.

Why does biodiversity matter?

Why does biodiversity matter?

We tend to think of biodiversity as referring to wildlife in rainforests of the Western Ghats, or tigers in Central India. We think of wildlife sanctuaries and protected areas in remote and isolated parts of India. But biodiversity is a much broader concept encompassing all diversity in living organisms on the planet. This diversity can refer to ecological functions that different organisms perform such as predators or herbivores, habitats that different organisms occupy or genetic diversity that make up living beings around us. For many people biodiversity has an intrinsic value. Many believe that other living beings that we share the planet with, have a right to exist regardless of whether human beings have any use for them. Indeed, this view often called the Rights of Nature, is a today a legal theory that is attaining much support from conservationists and indigenous communities worldwide[1]. But governments and international bodies worldwide also recognise the utilitarian value of biodiversity.

Ecological value: Biodiversity is key to healthy ecosystems and maintaining ecological equilibrium, the balance between different species in nature. Animals, plants, microorganisms and fungi perform many ecological roles and maintain what is called the trophic web, where some organisms like plants play the role of producers synthesising energy directly from the sun. Others play the role of consumers, such as herbivores eating plants and carnivores eating herbivores. Others like fungi and microorganisms play the role of decomposers. Trophic webs are made even more complex by the role that organisms play in helping primary producers like plants grow and spread. For instance, plants rely on bees and other insects to pollinate them or birds and bats to disperse their seeds ensuring greater genetic diversity. This is not a direct and linear relationship but rather must be imagined like an intricate spider web. Removing a single organism can cause some trophic webs to collapse. But removing multiple organisms particularly when their role is poorly understood can be disastrous.

Human Health: The importance of biodiversity and protecting ecosystem health has perhaps never been stark as in the time of the CoVid 19 Pandemic. Studies show that many infectious disease outbreaks in the 21st Century including CoVid 19 are increasingly going to be zoonotic in nature, that is transmitting from animals to humans[2]. As natural habitats are fragmented for expanding cities, wild animals are going to come in close contact with human beings allowing disease carrying bacteria and viruses to jump from their wild hosts to us. India has recently seen a number of such outbreaks. The Kyasanur Forest Disease spread by ticks that jumped from Bonnet Macaques to humans living on the periphery of forests in Karnataka, Goa and Maharashtra[3]. The Nipah virus potentially jumped from fruit bats to humans and spread through the highly urbanised state of Kerala[4]. A 2017 study by researchers from multiple institutions predicted that India was one of the countries at highest risk from zoonotic diseases. The study also predicted that urban built up areas were among the most susceptible environments for spread of zoonotic diseases[5]. High human density and

crowded conditions also help zoonotic diseases spread more easily in cities[6].

Biodiversity and Livelihoods: The World Economic Forum estimates that over half the world's GDP, approximately 44 trillion dollars, is moderately or highly dependent on nature and its services and is therefore exposed to nature loss. Construction, agriculture and food beverage industries are most susceptible to biodiversity loss[7]. Biodiversity in food systems is particularly crucial for livelihoods of some of poorest communities in our country today. For instance, India's fisheries sector is highly dependent on a biodiverse marine ecosystem. A range of organisms from phytoplankton to apex predators like sharks help maintain fish populations that are crucial for fishing communities. Agriculture in India, depends not just on rains, but healthy insect populations that provide pollination services

and natural pest control. The IPBES 2019 Global Assessment Report on Biodiversity and Ecosystem Services, found that nearly 75 percent of all agriculture in the world depends on insect pollinators[8]. Rural and indigenous communities also depend on a diverse set of natural food plants for their nutritional needs and pastoral communities depend on diverse grassland ecosystems for maintaining livestock. Other industries directly dependent on biodiversity include the pharmaceutical industry; nearly 50 percent of the world's prescription drugs use plant molecules while 70 percent of cancer drugs are natural or inspired by nature.

Biodiversity, Natural Disasters and Climate Change: Amidst the carnage and loss of the 2004 Indian Ocean Tsunami, intact mangrove forests emerged as the only real protection for coastal regions in India, Sri Lanka and South-

Biodiversity is vital for human well-being.

east Asia. Since then, researchers have found a wealth of information pointing to the importance of biodiversity and natural habitats in protecting human being from natural disasters, which will only increase with climate change, and reaching carbon sequestration goals. Studies by The Nature Conservancy and the World Bank have found that coastal ecosystems like mangrove forests and coral reefs offered vital protection against high wave action and flooding during storms and cyclones[9]. A 2017 study found that simply protecting and efficiently managing and crucially restoring forests, grasslands and wetlands globally could help reduce 37 percent of CO2 emissions by 2030[10].

Biodiversity and Culture: Biodiversity is intricately linked to human culture and identities. Our cultural practices are shaped by the environment we live in. Animals and plants find sig-

nificant place in religious, spiritual and ritualistic practices such as food preparation and harvest festivals. Studies have found the presence of local fauna and flora in ancient religious texts around the world. Even national symbols of most countries around the world feature species that have cultural value in that region. Cultural practices are not only shaped by biodiversity but also influence local biodiversity. A well-documented example of this are sacred groves found across India, including big cities like Bengaluru[11]. In modern, urban settings cultures have evolved to allow people to engage and interact more with nature, through activities such as trekking, hiking, tree walks and birdwatching. Although it is impossible to put a monetary value to cultural significance of biodiversity, this culture and attachment to nature, outdoor spaces and certain animals and plants has a major influence on local governance and decision making[12].
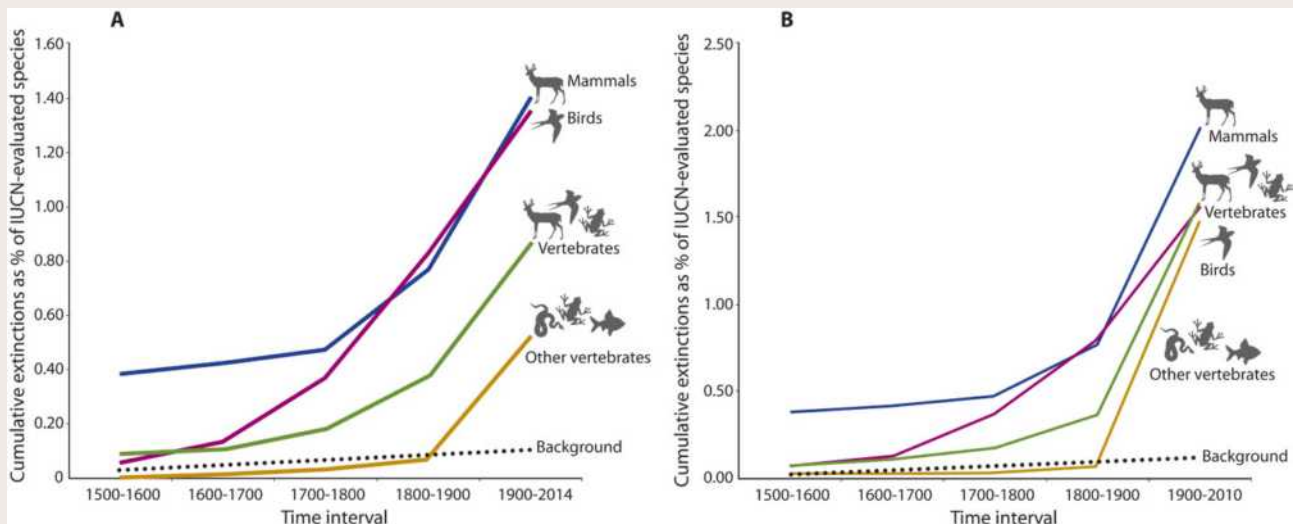
The Age of the Anthropocene

This growing recognition of the importance of biodiversity is happening alongside large scale biodiversity loss in the world. We now live in a time period that some scientists call: The Anthropocene, from the Greek words *Anthropo* meaning *of human* and *Cene* meaning *period*. It is the epoch where human activities are the dominant force influencing climate, air, water and the other living creatures with whom we share the planet. Many researchers believe the Anthropocene coincides with the beginning of the Industrial Era. Large scale agriculture, the use and extraction of coal as a source of energy, global industrialisation, and a burgeoning human population of 7.9 billion people has placed unprecedented pressures on the earth s carbon cycle, land and water resources and perhaps the most visible victim of the Anthropocene, biodiversity.

Scientists warn that we have now entered the Sixth Mass Extinction in the Earth s long biological history.

Mass extinctions are periods in Earth s history, when a majority of the planet s biodiversity was wiped out by one or multiple events. Previous mass extinctions are theorised to have been caused by massive volcanic eruptions that decreased oxygen levels in the ocean and atmosphere, widespread glacial events or even large comets crashing into the earth. But the Anthropocene Extinction is distinct in two ways.

One, the period over which the Earth s biodiversity is disappearing is extremely short. We are losing wildlife in a span of one or two centuries as opposed to one or two millennia. Second, whole groups of species are under threat of extinction directly because of human actions. Fossil fuels burnt for energy, leading to carbon build-up is warming the planet, changing seasons and shrinking specialised habitats that animals and plants rely on. Expanding agriculture, mining, commercial fisheries and unregulated hunting have further added to these pressures. Ac-
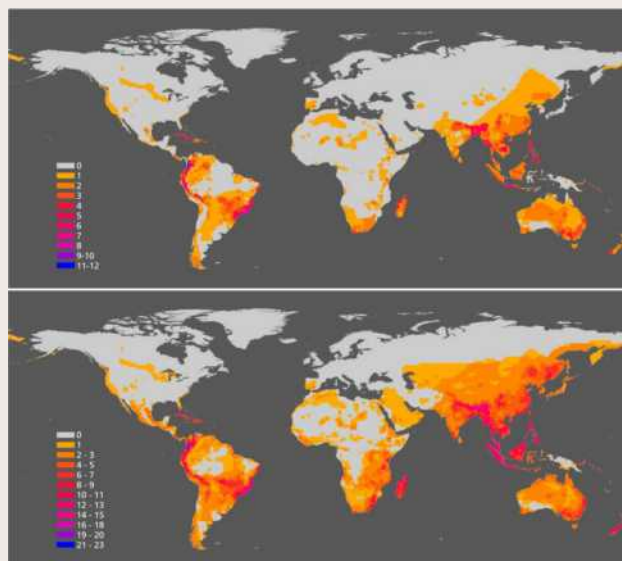

Graphs show cumulative vertebrate species recorded as extinct or extinct in the wild by the IUCN since 14th Century. Dashed black curve represents the number of extinctions expected at current rate. (A) Highly conservative estimate. (B) Conservative estimate.
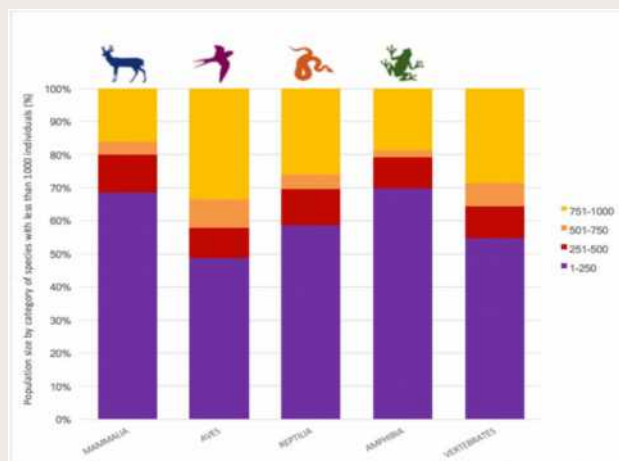
cording to a report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) one million species may be at risk of extinction[13].

Among the many human activities, scientists have identified urbanisation as the major driver of large scale biodiversity loss today. Urbanisation is the phenomenon where large numbers of human beings come to live in small, concentrated areas that become cities. In every civilisation, cities are seen as the hallmark of power, the centres of trade and commerce, art and architecture. The difference between the world we live in now and the civilisations of the past, are the scale and number of cities that human beings have created.

 Terrestrial vertebrate species are on the brink of extinction globally

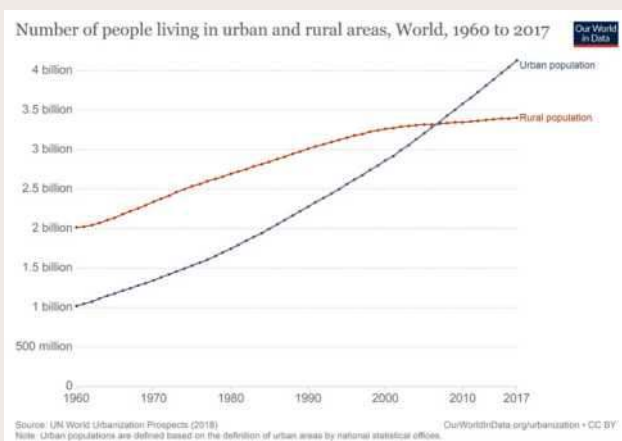Distribution of terrestrial vertebrate species on the brink of extinction

A Planet of Cities

Rapid large scale urbanisation coincides with the beginning of the Anthropocene. Until the beginning of the 19th Century, over 90 percent of the world's population was still rural. The United States was one of the earliest countries begin urbanising in 19th century. By 20th century nearly 40 percent of the US was living urban areas and by beginning of the 21st century nearly 80 percent of the country lived in urban areas. Other countries particularly in the global south were much slower to urbanise but the mid-20th Century saw all this change[14].
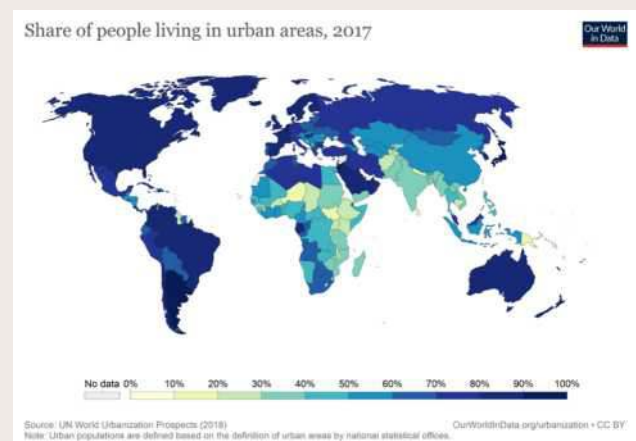
According to a 2018 report by the Department of Economic and Social Affairs of the United Nations, approximately 4.1 billion people, that is nearly 55 percent of the world's population lived in cities. By 2030, the UN report projects that the global urban population will be 5.3 billion and by 2050, nearly 70 percent of the world's population will be urbanised. But some researchers consider the UN's figures an underestimate and believe that their definition of what is an urban centre is inadequate.

The European Commission defines urban populations as those living in urban centres (or cities) with a minimum of 50,000 people and a population density of at least 1500 people per square kilometre and urban clusters (areas close to cities and interacting with the city for economic and social reasons) with a minimum of 5,000 inhabitants plus a population density of at least 300 people per square kilometre. For instance, Bengaluru with a population density of 4381 people per square kilometre would be an urban centre and Mysuru with a population density of 476 people per square kilometre would be part of an urban cluster. Based on these definitions, the European Commission estimates that 52 percent of the world population lives in urban centres, 33 percent in urban clusters and only 15 percent of the world lives in truly rural areas.
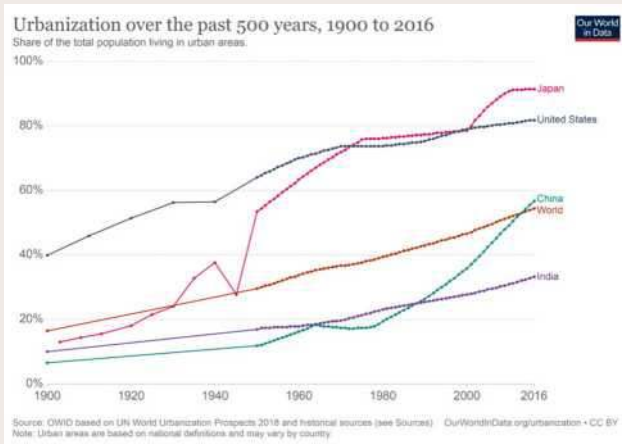
Regardless of the definition employed, both agencies and indeed most researchers in the world agree that developing regions particularly in Asia and Africa are amongst the most urbanised in the

Number of people living in urban areas globally from 1960-2017

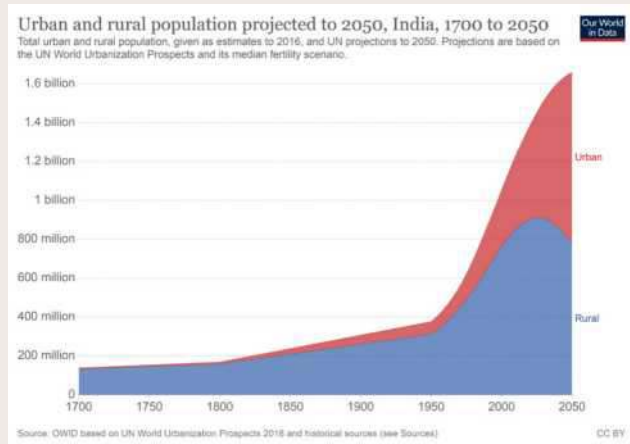Percentage of populations living in urban areas globally in 2017

Urbanisation trends globally between 1900-2016

Urban vs Rural population projections for India

world. The European Commission estimates that nearly 89 percent of the Asias population lives in urban centres or urban clusters. The city is basically vital for these populations economic growth.

The Indian Scenario

Urbanisation has been much slower within Asia with the exception of Japan. In 1980, 23 percent of Indias population and 19 percent of Chinas population was living in urban areas. But today, 33 percent of India and over 55 percent of Chinas population lives in urban areas. Although slower than China to urbanise, researchers suggest that India will catch up by 2030, and nearly half of the countrys population will be urban with a projected 840 million people living in cities.
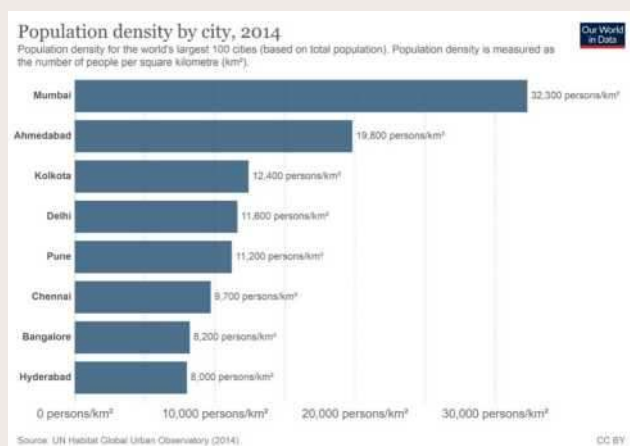
This urbanisation will take on two forms. As global trade, formal education and technological advances increase, much of the worlds rural population are migrating to cities in search of better economic opportunities. But most of the worlds cities are also at carrying capacity or indeed bursting to seams. To accommodate a growing urban population, new cities will also pop up. According to the Cities and Biodiversity Outlook report released by the Secretariat of the Convention on Biological Diversity, UNEP, there will be three times

as many urban areas in 2030 compared to 2000[15].

The Delhi metropolitan area, is Indias most populous city and the worlds second most populous city with 26 million people, while Mumbai with a population of 21.5 million people is the 2nd most populous city in the country[16]. India is projected to add four megacities, Bengaluru, Ahmedabad, Chennai and Hyderabad, by 2030[17]. The Government of India has also pledged to create 100 new Smart Cities by 2040[18]. Considering that globally cities contribute to 80 percent of the worlds GDP and in India cities contribute approximately 63 percent of the countrys GDP, projected to rise to
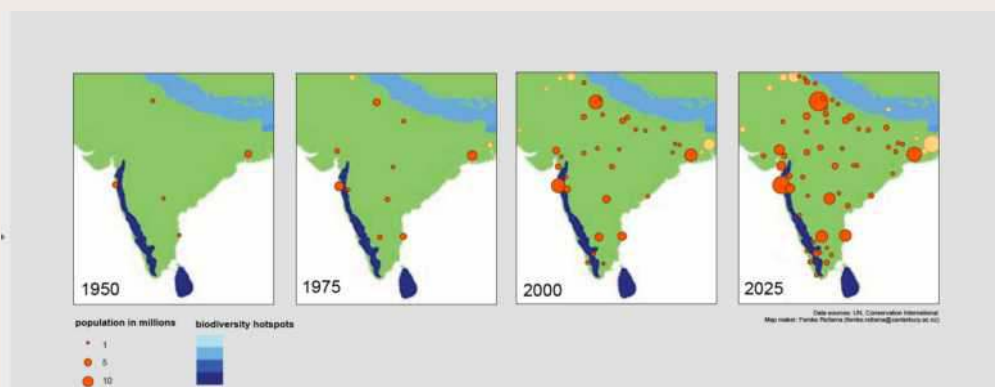

Population densities of Indian cities as of 2014

75 percent by 2030, it is clear that cities are not going anywhere[19].

This scale of urbanisation driven by economic pressures, means that India s crowded cities are jostling for space with natural habitats as they grow. The Nature Conservancy s report *Nature in the Urban Century* has found that around 58 percent of India s protected areas are urban adjacent, i.e., within 50 kilometres of an urban centre. By 2030, this figure is likely to increase by 15 percent. Cities are also often built near or even in place of biodiverse habitats such as grasslands, wetlands and rivers. This can have massive impacts on nature, environmental health, and biodiversity, particularly in tropical countries like India, which hold much of the world s biodiversity. Between 1992 and 2000, urban expansion caused the loss of 190,000 square kilometres of wild lands globally, that is 16 percent of all natural habitat on the planet. The report goes on to predict that by 2030 urban growth could threaten 290,000 square kilometres of natural habitats. In India, the report predicts that if business goes on as usual, 5,823 square kilometres of habitat could be lost to urban growth[20].

These dire statistics bring us to the role that the media can play in documenting how growing urbanisation impacts biodiversity, and highlighting the diversity of life that can be found even in the most crowded cities of India. With pristine natural habitats shrinking ecologists have turned their attention to the diverse lifeforms that are adapting and sometimes even thriving in lakes, parks, vacant lands, home gardens and forest patches leftover in cities. While there has been media attention on pollution, waste management and sanitation woes in cities, there has been little focus on how urbanisation interacts with biodiversity.

This booklet aims to give journalists an overview of biodiversity in urban spaces, issues that need urgent coverage and resources to help cover these issues. The focus is on the city of Bengaluru, but we hope the learnings are transferrable to other urban spaces in India.

Urban population centres (red circles) will increase in and around biodiversity hotspots like the Western Ghats (in blue) by 2025 in India. Yellow circles refer to population centres outside India.

The City of Many Names

Over the years Bengaluru has been given many names: Garden City, Pensioners Paradise, Silicon Valley, and a rather more acerbic Garbage City. These changing names hold a clue to the city s transformation and state of its environment today. Both the geological and human history of Bengaluru have played a role in shaping the city s biodiversity.
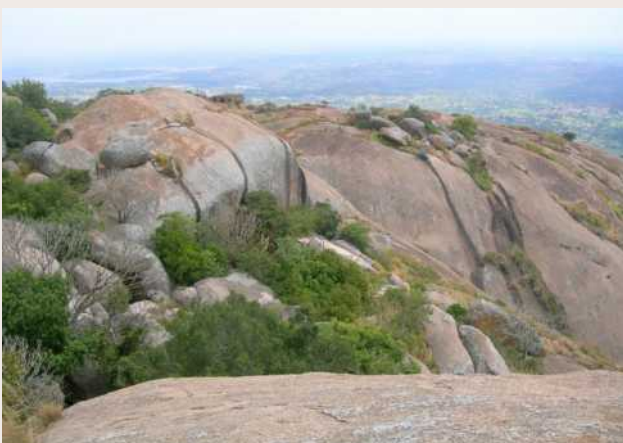
Jungles, Grasslands and Gardens
Bengaluru lies in the centre of the Southern Deccan Plateau at an average altitude of 920 metres above sea level[21]. The Deccan Plateau is a large triangular shaped plateau. The landmass is formed by igneous rocks from massive volcanic eruptions. Because of its location on the plateau, the region that became Bengaluru was a mix of hills, valleys and relatively flat grasslands in the rain-shadow region of the hills.

Harini Nagendra, Ecologist and Professor of Sustainability at the Azim Premji University, notes in her book Nature in the City: Bengaluru in the Past, Present and Future, that the earliest settlements in the region of present day Bengaluru existed at least 6000 years, while the earliest evidence of human presence dates even further back to 600 BCE[22].

This region was a semi-arid area with rocky hills and thick thorny scrub forests in the west. Two high ridges ran North to South along the western edge, which were difficult to occupy. The present day High Grounds and Golf Course were around these ridges. To the east however were relatively gentle slopes and flat lands amenable to agriculture. In the South, was yet more dense forest, covering parts of Kengeri, Bannerghatta and Kanakapura. These forests were filled with large mammals including wild boar, leopards and tigers. This area was settled by pastoralists who grazed livestock in jungles.

Many of the early settlements began in the relatively easy terrain, east of the city in the plains and the valleys. Nagendra writes of settlements

Bengaluru was historically a semi-arid area with rocky hills and thorn forests.

Settlements were initially made in plains and grasslands towards the East of Bengaluru

Kempe Gowda, the city's founder established the old fort city or pete in 1537.

The old Bangalore Fort in 1860.

under the Ganga Dynasty, between sixth and ninth century in the east in areas which correspond to Begur region (near current day Hosur road) Agara, Varthur and KR Puram. By the 12th Century under the Chola Empire, settlements spread to more parts of the plains of the east into areas in present day such as Domlur. By the 13th and 14th Century under the Hoysala Empire, settlements spread across the region, to include areas like Halasuru (or Ulsoor), Jakkur, and Hebbal, though the rocky hill terrain of the west was still avoided. But these settlements were unified into the city of Bengaluru only in the 16th Century under Kempe Gowda.

The common origin story of the city is of course that Bengaluru was a tiny hamlet with a handful of people and forests until Kempe Gowda a local chieftain and a vassal of the Vijayanagara Empire arrived in the area, enjoyed a humble meal of *benda kalu* or boiled beans and named the city *Bendakaluru* or boiled beans town. But this freely repeated story is today accepted by historians to be apocryphal.

Kempe Gowda was one of the Yelahanka Nadu

Prabhus, meaning lord of Yelahanka, located in present day North Bengaluru, near the international airport. It was from here that he began a campaign of conquest across the region, for the Vijayanagar Empire. He captured the Shivaganga region 60 kilometres away from Bengaluru, today a tourist attraction popular with trekkers. He moved south across the landscape and captured the Domlur area and eventually central parts of the city. Here in the city centre, he built the fort of Bengaluru in Doddapete, today known as Avenue Road and Chikkapete the commercial centre that still goes by the same name.

In his book Bangalore through the Centuries, published in 1970, historian M. Fazlul Hasan documents Kempe Gowda's journey from his small Kingdom of Yelahanka, capturing the region around the Shivagange peak today and then engaging small battles with local chieftains from around regions like Domlur for years. Hasan writes that the name Bengaluru likely came from an existing small settlement by the same name dating back to the 9th century found near the Kodigehalli village, which is located on the way to the International Airport in in the present

The old city or pete in contrast with the British settlement in Cantonment in the 1890s. The British planted large-canopied trees for shade. Much of the greening was focused on British settlements

day North Bengaluru[23]. Even as Kempe Gowda planned and built his walled city, the region between Yelahanka and Domlur lay covered in dense thorn forests.

After a series of wars and conquests Bengaluru came under Hyder Ali s rule in 1758. Hyder Ali and later his son and successor Tipu Sultan were fond of ornate Mughal style gardens and created a well-planned garden of Cypress trees and roses, today known as the Lal Bagh Botanical Garden. Lal Bagh was not only seen as leisure grounds but also a space for horticultural experiments, a tradition that is carried out to this day[22]. Through most of its history, pre and post Kempe Gowda, Bengaluru was an open, semi-arid landscape with hot days and cool nights. The transformation of the city into a Garden city with large treelined streets and parks is often credited to the British, but Nagendra says this was not so. In her book, she notes that almost all rulers of the city were anxious about planting trees for shade and fruit.

Hyder Ali, Tipu Sultan and the Wodeyar Dynasty paid close attention to planning parks and dense groves of trees around the city. Villages around the fort city also planted large native fruit bearing trees such as Mango and Tamarind and sacred trees like Pipal. But these were only patches of greenery and by the time British took over in the 19th century, decades of war and famine had left the city barren in parts.

The British expanded into the hitherto impenetrable western ridges of the city, establishing settlements around Malleshwaram and the High Grounds. They continued Hyder Ali s experiments, adding dense plantations of large shade giving trees, wherever they built new institutions like the Victoria Hospital or the St John s School. They also set up Cubbon Park, another huge green space in the city s commercial centre and planted tree lined streets and gardens. The British aesthetic favoured large canopy trees mixed with well-manicured lawns and flowering plants, often bringing in exotic species from other tropical countries like the African Tulip Tree and Rain Tree. They also brought in exotic plants like Lantana, a native of South America, which spread across the open lands in the city. Lantana invasions in empty plots across the city continue to

this day. This focus on planting large fruit bearing and shade giving trees, continued through much of Post-independent Bengaluru.
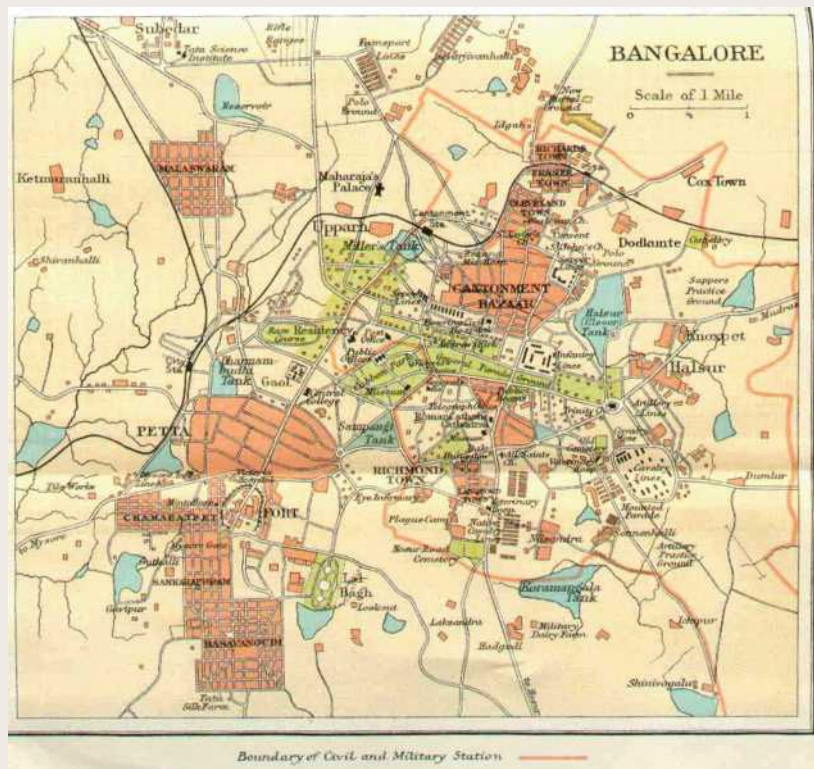
This period of urbanisation saw Bengaluru jostling for space with considerable wildlife. In her book, Nagendra highlights records of dense thickets of vegetation in the newly built area of Sheshadripuram in 1910 where residents had to be on guard from wild animals. Jalahalli in the northwest of the city, was filled with snakes, hares, partridges and quails and even one man-eating leopard according to hunter Kenneth Anderson, before it was cleared to make prisons for Italian prisoners during the second world war and later became an Indian Air Force Base.

While the history of scrub and deciduous forests of Bengaluru are somewhat well documented, there is very little written about the grasslands of the city and its fringes. Ameen Ahmed notes that grasslands were present throughout the flat lands of the eastern part of Bengaluru right into the city centre. Colonial British hunters wrote that grassland specialist wildlife such as Blackbucks and Wolves were common in these part of the city, particularly around the Sarjapur area. Grasslands were also present in the Subedar Chattram area, today known as SC Road, a place for cheap electronic goods. Here British hunters found good populations of the Lesser Florican, the smallest bird in the Bustard family and an endangered species today[24].

City of Lakes

The thorny scrub forest and grasslands thrived in the low rainfall region of Bengaluru. Most of the water came from small rainfed streams flow-

Map of Bengaluru showing the old city or Pete and the Cantonment in 1924

ing from the hills into the valleys. This led to much anxiety for the agrarian city of the time. The undulating terrain of the city gives way to three major valleys, the Vrishabhavati valley to the west, the Koramangala Challaghatta Valley to the east and the Hebbal Valley in the north[25]. Over the centuries, Bengaluru s rulers paid close attention to improving water security and irrigation in the city, by creating lakes that would capture rainwater flowing from the higher reaches into the valleys and wells that were recharged by aquifers. Some of these lakes survived well into the 19th Century during the British rule. The Ganga dynasty for instance built the Agara Lake in the ninth Century, the oldest lake surviving to this day. The Cholas built the Bellandur lake and the Hoysala empire built the Dharmambudi lake and several smaller tanks called *kere*. They called the larger lakes *sandra* or *samudra* , as in the sea, names which continue to be associated with areas in the city today. Examples are Mallasandra in present day Jalahalli West and Hongasandra, an upcoming residential layout in

South Bengaluru. These lakes not only provided drinking water but were vital for other livelihoods such as agriculture, livestock management and fisheries.

Kempe Gowda expanded the Dharmambudhi lake and also built the Kempambudhi lake, today a sewage outlet near the Bull Temple in his time. His successor added five more rain-fed lakes including the Sampangi lake which is today the Kanteerava Stadium. Hyder Ali and his successor Tipu Sultan also carried forward this tradition of building lakes or tanks for capturing rainwater flowing from the high elevations of the city towards the valleys. Many of these lakes went through a constant cycle of disuse with wars for the city and revival by the subsequent victors.

By the 1800s Bengaluru s population had grown substantially under the British Rule, with a mix of workers for the city s textile industries and the British Army troops established in the Canton-

The Agara Lake was built in the 9th Century during the reign of the Ganga Dynasty

ment Area. To add to the water supply, a series of interconnected lakes called the Miller s Lakes were created from 1873. These included the original Dharamambudhi Lake, connected to Miller s Lake in today s Miller s Road and several minor *Kalyanis* or temple ponds and wells. In 1882 the Sankey Tank, which was then over 1000 acres was built and connected to this network. They also built the Halasuru lake. But even these were unable to quench the city s thirst.

Under the Wodeyar Dynasty and British rule, two major reservoirs were created to divert water from the tributaries of the Cauvery skirting the city. The Arkhavathy river, a tributary of the Cauvery originates in the Nandi Hills, northwest of the city, flows through the Ramanagara district and joins the Cauvery at Sangama in Kanakapura. Arkhavathy was dammed and water diverted to create the Hessarghatta reservoir in 1896. The Kumudavathi river a minor tributary of Arkhavathy, originating in the Shivagange hill, Kempe Gowda's first conquest, flows into the TG Halli Reservoir in South Bengaluru which was created in 1933[26]. Both reservoirs are operational to this day. The construction of these reservoirs under the British rules led to many lakes, falling into disuse or disrepair. The British also drained several lakes fearing that the standing water would cause malaria[22].
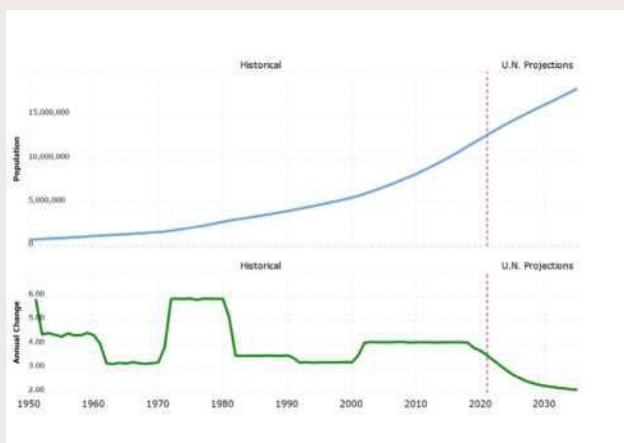
Nature in the Silicon Valley

Post-independence, Bengaluru grew rapidly as agriculture and textile industry were replaced by public sector industries like the Hindustan Aeronautics Limited, Bharath Electricals and Hindustan Machine Tools in the 1950s. Private small scale factories soon followed in areas like the Peenya Industrial Layout. Between 1970s and 1980s, electronic industries had established themselves firmly in the city creating a foundation for the arrival of the IT industries. But it was in the early 2000s, with the IT sector boom, that the city grew massively in both area and population, driving real estate values. The decades when these industries arrived in Bengaluru, in the 1950s, 1970s and then 2000s, saw the greatest population growth rates in the city[22].
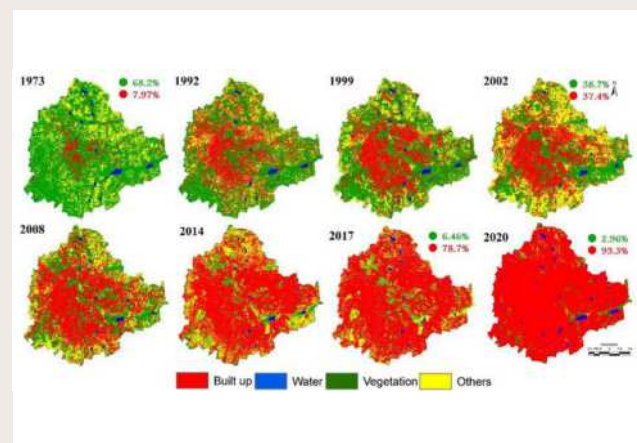
During the last census in 2011, Bengaluru was India's fifth most populous city, behind Chennai with a population of 8,443,675 people[27]. By 2021, the city will have overtaken Chennai to become India s fourth most populated city according to various bodies. The UN Department of Economic and Social Affairs estimates that the current population will be around 12.7 million[28] while according to the Karnataka Government s Directorate of Economics and Statistics the city s population will be over 14 million in 2021, which is a whopping 48 percent increase in a decade[29]. Bengaluru s growth trajectory both in terms of population and area, makes for an excellent case study in how biodiversity and urbanisation interact.

Despite its massive growth, Bengaluru still has substantial wildlife. Forty one species of mammals including slender loris, leopards, jungle cats, common mongoose, several species of bats and rodents have been recorded in the city[30]. Citizen scientists have documented over 300 species of birds are found in the city, including long-distance migratory birds from the Himalayas, Central Asia and Siberia[31]. Seventeen species of amphibians, 52 species of reptiles, 1707 species of insects and arachnids and thousands of species of plants are also present in the city[32].

Population trends in Bengaluru from 1950 to 2030 (projections)

Built up area has steadily increased while vegetation and lakes have decreased

Urban forest and tree cover

This biodiversity is spread across the city s parks, institutional grounds, home gardens, lakes urban forests and peri-urban areas, but is threatened by rapid urbanisation and unrestricted real estate growth and associated infrastructure development such as roads. A study by the Centre for Ecological Sciences (CES) at the Indian Institute of Sciences (IISc) reported that built-up area in Bengaluru increased from 7.97 percent in 1973 to 73.72 percent in 2013, a nearly 65 percent increase[33]. Another study from 2017 found that built-up area has increased from 2.53 percent in 1973 to 48.61 percent in 2016[34].

Simultaneously, vegetation, green cover and wetlands in the city have declined affecting the city s biodiversity. Dense vegetation which once covered 68.27 percent of the city had declined to less than 15 percent of the city in 2013 and covered only approximately 8 percent of the city in 2016. This dense network of old growth trees planted by Bengaluru s erstwhile rulers including the British, are vital for carbon capture, minimising air pollution and for maintaining optimal temperatures and shade. They are also important habitats for a variety of wildlife.

Public parks, sacred groves, tree-lined streets, home gardens and even empty plots of land are all reservoirs of plants, insects, birds, reptiles, and mammals. Harini Nagendra and her team found that parks in the city, on an average support at least 55 species of trees, 45 species of birds, 41 species of butterflies and 68 types of insects. Birds in particular depended on large

IISc Bengaluru and its adjacent areas

Satellite views show the Indian Institute of Sciences Campus, a patch of green surrounded by built up area

Bird watchers have documented over 200 species of birds in the GKVK campus including clockwise L-R Coppersmith Barbet, Asian Paradise Flycatcher, White-eyed Buzzard and Indian Pitta

canopy trees, while several long distance migratory birds like Greenish Warblers and Blyth s Reed Warblers that breed in Central Asia and the Arctic and winter in India, depended on unmanaged wild vegetation in vacant sites. While larger parks were more biodiverse, in dense neighbourhoods it was crucial to have a network of small parks for butterflies[35].

India has a long tradition of sacred groves, where patches of wild or planted forests are protected and often places of worship amongst different religions. Nagendra and her team also recorded over 5000 individual trees belonging to 98 different species across in temples, churches and cemeteries across the city. Unlike the managed parks in the city, these sacred groves also favoured native species and keystone species like

fig trees that are vital habitats for other wildlife[36].

A landscape connected with trees, is vital for preserving biodiversity, particularly insects, reptiles, birds and mammals. The loss of these trees is likely to have ripple effects on the city s biodiversity. An example of this is the Slender Loris, an elusive shy primate endemic to the tropical forests of the Western Ghats, Eastern Ghats and Sri Lanka. The Slender Loris is an arboreal primate, meaning it lives its entire life on trees and uses a canopy of interconnected trees to move across a landscape. Considering their need for dense tree cover, it is a mystery how this critically endangered species survives in Bengaluru. But populations of the slender loris survive in Bengaluru, especially in campuses of the Indian Institute of Sciences (IISc) and the Gandhi Krishi Vignana Kendra (GKVK) where there is dense tree cover. But journalist Mohit Rao reported that in other parts Bangalore, such as Hennur, slender loris populations are trapped in a small patch of trees surrounded by a sea of concrete[37].

With tree cover declining in the city, campuses like Bangalore University, IISc and GKVK and landscaped spaces like the Lalbagh and Cubbon Park Botanical Garden are crucial reservoirs of biodiversity in an increasingly concretised city. The GKVK campus spread over 800 acres is a Biodiversity Heritage Site[38]. The campus home to well-known academic institutions like the University of Agricultural Sciences and the National Centre for Biological Sciences, comprises 40 acres of old growth scrub forest as well as numerous agricultural fields, orchards and plantations and a botanical garden. The campus has 530 species of plants, at least 13 species of mammals including common mongooses, jungle cats and of course slender lorises. Both the

GKVK and IISc campus is a paradise for bird-watchers. The IISc campus hosts at least 190 species of birds[39]. The larger GKVK campus is home to over 200 species of birds[40], while the Botanical Garden within the campus has around 160 species of birds[41]. Migratory birds, including Himalayan and Central Asian breeders like the Kashmir Flycatcher, Red-Throated Flycatcher and Taiga Flycatcher are common visitors to IISc and GKVK campuses. The IISc campus was even visited by an otter in recent years[42]. But real estate expansion and infrastructure threats looms large over these biodiversity hotspots[43,44].
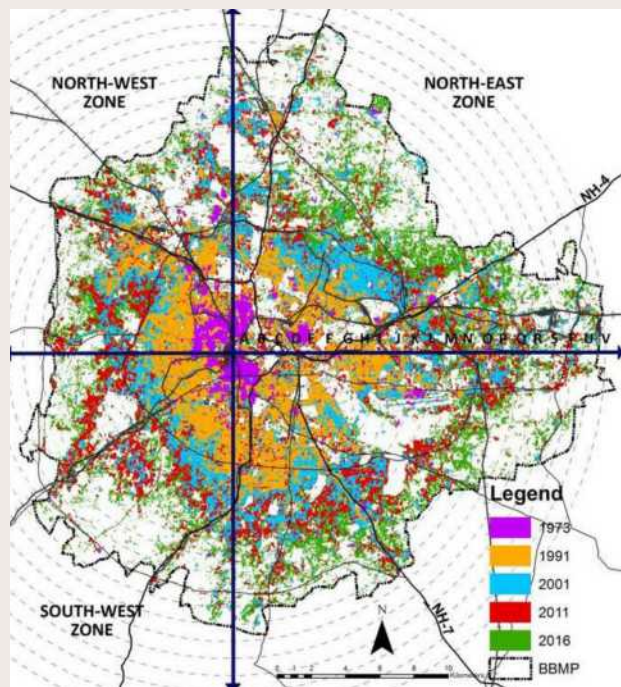
Apart from loss of habitat, increase in concrete structures and decrease in green cover, also impacts biodiversity by causing what is known as the Urban Heat Island effect, where built up areas within cities are on average hotter than surrounding areas with more vegetation and open spaces. Concrete surfaces trap more heat than trees, water bodies and even open soil, creating pockets of hotter surfaces. The Urban Heat Island effect has been well documented in Bengaluru. Average surface temperatures in the city have risen by 2-2.5 degrees Celsius and are likely to increase further[45]. The central areas of the city, such as Shanthinagar, Kalasipalya and Commercial Street are warmer than well developed and typically wealthier neighbourhoods like Jayanagar and Basavanagudi. Areas with green cover such as IISc are on an average 2.4 degrees Celsius cooler than surrounding areas[46,47]. Street trees also have been found to reduce air temperature by as much as 5.6 degrees Celsius and road surface temperatures by around 27.5 °C[48]. Increase in surface temperatures have been covered periodically by the media, particularly from the point of view of impacts on people (such as greater exposure to heat waves), increase in en-

ergy consumption (because of increased use of fans and air conditioners) and the loss of Bengaluru s year round pleasant weather. But the city s rising temperatures also impact biodiversity. Studies have shown that plants, birds and most reptiles and amphibians are impacted by increased surface temperatures[49].

For instance, a study by the Institute of Wood Science Technology, found that Sandalwood trees, the state trees of Karnataka, and Pongamia trees, a popular native avenue tree in Bengaluru have become more susceptible to disease by pests that thrive in warmer temperatures and under drought or bad rainfall years[50]. Researchers from the Centre for Ecological Sciences, IISc have found that lizards like Rock Agamas and the Common Garden Lizard, are able to tolerate the city s current recorded temperatures, but caution that a further increase could affect the populations of these reptiles in the city[51].

Peri-Urban Areas

Bengaluru s growing population has meant that the city has expanded greatly since the Kempe Gowda years. The city that was around two square kilometres in area during the Hyder Ali-Tipu Sultan years, had grown to around 741 square kilometres in 2011[52]. Much of this growth is happening in the peri-urban areas of the city. Land is scarce in the centre of the city; much of it is already built up or occupied by various government institutions or prohibitively expensive. So, to accommodate the city s growing population, the Bengaluru Development Authority has been opening up land in villages surrounding Bengaluru for residential and commercial buildings. As the city spreads its web, agricultural lands, waterbodies and dense vegetation have declined drastically in these areas while barren lands ready for real estate development and built up area have increased[53]. It s a phenome-

Map shows spread of built up area in Bengaluru between 1973-2016

The rocky outcrops in the lower reaches of Nandi Hills are habitats for the Yellow-throated Bulbul endemic to Peninsular India

non that researchers call urban sprawl.

Many of these habitats lie in peri-urban areas of the city, rather than the centre. Peri-urban areas are the transition zones between rural and urban areas. Areas like Hessarghatta, Doddaballapura, Sarjapura, Kankapura and Hoskote are some peri-urban areas surrounding Bengaluru. Peri-urban areas are important reservoirs of urban biodiversity. These areas can have a mix of agricultural fields, grazing lands, village ponds and lakes, rocky hills and patches of scrub forest which can support a range of forest loving as well as grassland or other open area species. A recent study found that peri-urban areas around Doddaballapura in North Bengaluru held more species of plants than purely rural areas[54].

Peri-urban areas are some of the last strongholds of rare and endangered fauna around the city but are fast being taken over by the expanding city. The iconic Nandi Hills range located in the Chikkaballapur District just 60 kilometres from Bengaluru hosts both wildlife typical of dry scrub forests of Peninsular India and the Western Ghats. While media reports largely focus on the tourist attractions of the region, Nandi Hills is also identified as an Important Bird Area by Birdlife International. Rocky outcrops and deciduous scrub forests in its lower slopes are habitats for several birds such as the Red Spurfowl, Painted Spurfowl, Grey Junglefowl and the Yellow Throated Bulbul endemic to Southern Peninsular India and made famous by Salim Ali s book the Fall of the Sparrow.

The hill tops at 900-1000 metres, are a mix of evergreen forests and exotic trees and attract birds endemic to the Western Ghats including the Malabar Whistling Thrush, Crimson Sunbird, Nilgiri Wood Pigeon. Nandi Hills is also an important wintering habitat for migrant birds from the Himalayas such as the Blue Rock Thrush, Pied Thrush and the Indian Blue Robin. Birdwatchers have spotted rare and globally threatened birds of prey including Steppe Eagles and Bonnelli s Eagles which breed in Central Asia and winter in the Indian Sub-continent[55]. The hills surrounding Nandi hills are rich in mammalian diversity and home to at least 16 leopards. Researchers have recommended the surrounding hills be converted into a wildlife sanctuary[56].

The planted evergreen forests on top of Nandi Hills is home to several Western Ghats species such as Nilgiri Wood Pigeon (right) and Tickell s Blue Flycatcher (left)

In South Bengaluru, the city s fringes end at two Protected Areas. The Bannerghatta National Park (BNP) in the south is the city s link to the scrub forests of the Eastern Ghats as well as the Nilgiris in the Western Ghats. In the Southwest Bengaluru, Bannerghatta merges into the Kanakapura Forest Range, which in turn adjoins the Cauvery Tiger Reserve which in turn abuts the Nilgiri Biosphere Reserve. Bannerghatta is approximately 260.51 square kilometres in area and is part of Asia s largest elephant reserve with a population of about 200 elephants moving through the area[57]. BNP is also home to several other endangered species like Leopards, Sloth Bears, Pangolins and Asian Dholes[58] and over 200 species of birds[59]. Reports suggest the presence of a lone male tiger in the park[60]. There are

at least 123 species of trees documented from these forests[61].

Peri urban areas of Northwest Bengaluru are also home to the last remaining patch of grassland, Hesarghatta, in Northwest Bengaluru. The Hesarghatta reservoirs and grasslands are an important habitat for several open area specialists such as Jackals, Common Mongoose and Black-naped Hares[62]. At least 39 species of grassland flora, 11 species of trees, 13 species of mammals, five species of reptiles and numerous insects and arthropods have also been recorded in the grassland complex. Birdwatchers have documented 264 bird species in the area, including rare globally threatened birds like the grassland specialist Lesser Florican, birds of prey

Hesarghatta grasslands are the last remaining grassland patch in Bengaluru

like Common Kestrels and Montagu s Harriers and Arctic migrants like Black-tailed Godwits[63].

Such peri-urban areas are under immense threat from the expansion of the city. Bannerghatta is being rapidly hemmed in by city. Residential and commercial real estate projects have come up within the 10 km buffer zone of the park. Subsistence agriculture in the villages on the periphery of the park have given way to commercial farming and horticulture to cater to the city. The granite hills and rocks of the national park are increasingly being illegally quarried for stone for construction projects in Bengaluru[64]. Studies by researchers from the Centre for Ecological Sciences shows that between 1973 and 2015 there was nearly 20 percent decline in vegetation cover in Bannerghatta. The study predicts that by 2027 forest cover in the park and the buffer zone would be an approximately five percent decline in forest cover with a simultaneous increase in urban areas[65]. The spread of real estate projects and roads in the buffer zones of BNP and the Cauvery and Kanakapura forests has often shrunk habitats for animals like leopards leading to the big cats straying into schools and residential complexes in the city[66].

The Hesarghatta grasslands were mooted by the Government of Karnataka as a site for a proposed Film City showcasing the Karnataka Film Industry[67], until massive public outrage put the plan on a back burner[68]. An upcoming IT hub in the area around Nandi hills has shot up land prices in the region[69] with large, gated communities and holiday villas coming up in the region.

Hesarghatta is vital habitat for grassland specialist raptors like Common Kestrels (left) and Montagu s Harriers (right) both declining in India

The real-estate website 99 acres lists at least 39 properties[70] for sale around the base of Nandi Hills while Magic Bricks lists around 55 plots for sale most properties set within gated communities[71].

There were over 1000 waterbodies within the borders of what is the current city of Bengaluru[72]. Rapid urbanisation under the British[73] and Indian rule, has reduced this network. By the 1970s Bengaluru had grown to 161 square kilometres and had 285 lakes. By 2006, Bengaluru had grown to nearly seven times the size. But only 194 lakes remained in an area of 741 square kilometres. The historic Dharmambudhi lake built by the Hoysalas and expanded by Kempe Gowda, is today the Majestic Bus Terminal, while the Sampangi lake is the Kanteerava Indoor Stadium.

Land around the Nandi Hills and other peri-urban areas are rapidly being converted into real-estate projects

Maps show the three major drainage valleys in Bengaluru and lakes they feed (left). Lost lakes in red have been built up (right)

Others like the Miller's Lake, Domlur Lake, Oaklipuram Lake and Richmond Town Lake have become residential areas. Many of the remaining lakes in Bengaluru are near suburbs or peri-urban areas. But even these are not in good shape. Of 105 lakes surveyed in 2013, 98 percent were found to be encroached to various degrees and 90 percent were found to be sewage fed[74]. Encroachments continue. The BBMP's own survey

The Majestic Bus Terminal stands on the ancient Dharmambudhi Lake built by the Hoysala empire and expanded by Kempe Gowda

of lakes found this year that nearly 4500 acres of lakes were being encroached upon[75].

Despite this dire state, the wetlands of Bengaluru are important biodiversity hotspots. The lakes are occupied by resident and migratory birds including ducks, waders, and terrestrial birds. Birdwatchers have recorded well over 150 to 200 species of birds in lakes under intense real estate pressure such as the Jakkur Lake, Yelahanka lake, Hennagara lake and the Kaikondrahalli lake[76].

People and Biodiversity

People are an integral part of any biodiversity landscape. Public lands or commons are spaces that are freely accessible to all citizens in an area for livelihood, spiritual and recreational reasons and not owned by any single individual or institution tradionally. Commons are used differently by residents depending on their socio-economic backgrounds.

Bengaluru historically was city of multiple villages, and its native residents were largely farm-

Lakes in Bengaluru are important habitats for over 100 species of birds including (clockwise L-R) spot-billed ducks, Northern Shovelers, Brahminy Kites and Spot-billed Pelicans

ers, fishers, pastoralists and farm labourers. Each village in the city maintained a series of commons that provided different services. For instance, *Gunda thopes* or wooded groves provided shade for livestock and pastoralists during the day, timber for the village needs, fruits and honey and were often places of worship with shrines. *Gunda thopes* were located near lakes that provided water for agriculture and livestock as well as fish for fishers. The immediate area surrounding the lake was a *gomala* or grazing land. Lake beds were surrounded by grasses and reeds that were collected for fibre and fodder[77].

But urbanisation can often lead to city planners favouring infrastructure and development for richer residents while ignoring the needs of the poor, thereby reducing common lands and encouraging private ownership. Tracing the co-

lonial history of Bengaluru s lakes as public commons, researchers found that several lakes that the British allowed to fall into disrepair or filled up fearing malaria, or built up for recreational needs, were vital to native residents livelihood and spiritual needs.

Several commons have today been built up but residents continue using the existing spaces like lakes for fishing, fodder collection, livestock and collecting edible greens for food. But with management of these commons passing over to local governments like the BBMP, researchers found that many urban commons are today developed to cater exclusively to the recreational needs of richer residents[78]. *Gunda thopes* have been built up, grazing lands converted into parks with jogging tracks and open air gyms with restricted entry as are lakes. Lake periphery is

Lakes and surrounding areas are vital to livelihoods of Bengaluru s most marginalised residents. The periphery of the Hoskote Lake (left) is used for livestock grazing and reed collection by local residents. Building up lake peripheries such as in Ulsoor Lake (right) excludes these communities from accessing their traditional resources

often developed with concrete boundaries and walking tracks that prevent grazers and reed collectors from accessing these waterbodies. The Lake Development Authority also issues fishing licenses that restrict fishing to few people, while lakes are seeded with exotic fish species that destroy native fauna. Traditional occupations like farming, fishing and livestock herding are seen as illegal in these public spaces.

Researchers also found that residents from marginalised castes and economic backgrounds, often forage for edible wild plants for food and medicinal needs. A majority of these foragers were women who looked for plants in unused plots of land, parks, farms and nearby forests. Unsurprisingly this ability to forage diminishes in the more urban, built up parts of city. The researchers noted that many people would have liked to forage for wild plants but lacked access to lands and parks[79].

The city s richer residents rely on public parks and lakes for exercise and recreation. With greater access to cameras, social media and the internet, these richer residents are also increasingly becoming naturalists and birdwatchers, documenting the city s wildlife[80]. This interest in the city s biodiversity has only increased with the rise of citizen social media and internet. An important by product of the digital era, is the rise of citizen science in the city, where general public documents the city s biodiversity creating a large pool of data that enables researchers to study urban ecology.

Indeed, according to the global citizen science platform eBird, Bengaluru is one of the most birded cities in India, with birdwatchers having documented over 300 species of birds from 463 birding hotspots[81]. Birdwatchers using the eBird platform have helped identify Important Bird Areas like Hoskote lake in Bengaluru[82]. Other platforms like iNaturalist have also been gaining popularity in the city, allowing naturalists to document smaller fauna like reptiles, insects and arthropods.

Residents of the city are increasingly participating greening the city, restoring lakes and creating patches of nature. Resident Welfare Associations around lakes in Bengaluru are increasingly working with the BBMP to restore lakes and develop the areas around these water bodies[83]. RWAs have in fact joined hands to form a larger federation to advocate for lake restoration and development in the city[84]. The NGO Say Trees has been pioneering forest patches within commercial-residential complexes like the Manyata Tech Park[85] near the Outer Ring Road and public sector institutions like the Indian Railway Institute of Disaster Management on Mysore Road[86]. Organisations in the city are also helping residents learn more about urban wildlife. Some animals like snakes and bees are feared and reviled. Resident Welfare Associations like Whitefield Rising and the BBMP are conducting awareness programmes for city dwellers to coexist with snakes[87]. Similarly, researchers studying honeybees at the National Centre for Biological Sciences, in Bengaluru have started a project that helps apartment residents co-exist with rock bee colonies, educating them about the important pollination services that these insects provide[88]. The Education and Public Engagement Programme at the Nature Conservation Foundation, an NGO based in North Bengaluru conducts regular bird and tree watching sessions for children, school teachers and parents in Bengaluru and other cities in India[89].

Reporting on Urban Biodiversity

Urban ecology and natural history

Despite increasing urbanisation in the city, there are many stories of biodiversity that the media can tell. New species are constantly being discovered in and around Bengaluru. For instance, scientists discovered a rare species of ant, called *Dilobocondyla bangalorica*, nesting in Frangipani plants in the Indian Institute of Sciences campus in 2006[90]. A new species of burrowing frog, *Sphaerotheca bengaluru*, was described from the outskirts of Bengaluru in 2020.

Such discoveries are quickly picked up by print and digital media[91] highlighting the diversity of life that the city is still able to support. But it is important to provide context to these discoveries. This can be done by 1) explaining the ecology of the species and local ecosystems that allow for these rare fauna to survive in the city and 2) identifying the current threats to these local ecosystems in the city and 3) connecting these discoveries to large biodiversity and ecology patterns.

For instance, the IISc ant *Dilobocondyla bangalorica* was only found in Bengaluru, in the IISc campus and Cubbon Park. The researcher Thereseamma Varghese who made the discovery, surveyed multiple sites in biodiverse Western Ghats to no avail. Interestingly, the ant nests were only found in different species of *Plumeria* or Frangipani plants, a popular ornamental plant across Bengaluru. Is this a mutualism? Why do the ants prefer *Plumeria*, a group of exotic plants native to Mexico and Caribbean? Why were the ants only discovered in Bengaluru? While no scientific studies have been done on these questions, a story focussing on these questions and nature of this discovery could highlight the complex relationship between biodiversity and the city.

The discovery of the burrowing frog *Sphaerotheca bengaluru* in 2020 from the outskirts of Ben-

Researchers continue to discover new species like this burrowing frog *Sphaerotheca bengaluru* from the city

galuru was similarly reported by multiple print and digital outlets in the city. But few mainstream newspapers went beyond reporting on the discovery and the naming of the frog after the city. Details such as where in Bengaluru the frog was found, the habitat it was found in, and the larger ecosystem were missing. An exception to this was the online science communication outlet *Research Matters* an initiative of the research collective Gubbi Labs. Science writer and PhD scholar Baheerathan M., published a feature truly contextualising this discovery and its place in the biodiversity of the Deccan Plateau in which Bengaluru lies, for *Research Matters*[92]. While print media has the disadvantage of being limited in space, online digital media can certainly explore the possibility of such detailed features. But this requires journalists taking the time to understand the nuances of scientific research, and developing skills such as reading scientific manuscripts rather than relying on brief press releases.

Species discoveries in Bengaluru can have global importance. For instance, in 1957 entomologists from the University of Agricultural Sciences, Bengaluru discovered a species of parasitic wasp called *Neodusmetia sangwanies* in the Hesarghatta grasslands. The larvae of the wasp species are parasites that usually feed on aphids and mealy worms. Around the time of this discovery, livestock owners in Texas were battling a species of mealy bug from Asia called Rhodegrass scale. Rhodegrass scale had invaded Texan grasslands causing huge damage to grazing lands. *Neodusmetia sangwanies* was then used as a natural bio-control to eradicate this pest, boosting cattle production by 177 million dollars[93].

Hesarghatta is a reservoir of biological diversity that has allowed scientists from Bengaluru's many institutions to make exciting biological discoveries. Krushnamegh Kunte, a professor at the National Centre for Biological Sciences, highlights the journey of an exciting study his group conducted from Hesarghatta that lead to the discovery that caterpillars of the Lilac Silverline moth depended exclusively on a species of ant called cocktail ant to feed them. This relationship was so close and tight knit that the caterpillars were found to have specific organs similar to the ants, in order to be able to eat the food the ants provided. This discovery was only possible because naturalists found a healthy breeding population of the Lilac Silverline moths in Hesarghatta. Such stories of scientific discovery are exciting to readers in and of itself but are made more relevant by the fact that Hesarghatta has been under threat of development recently[94]. Yet these stories have not made it to the mainstream media.

Tracking the city's urban ecology research as well as observations of the city's numerous naturalists, can help journalists cover more natural history focussed stories of the city. Journalists must also keep an eye out for new discoveries highlighted on websites of Bengaluru's research organisations as well as follow their social media platforms.

Urbanisation and biodiversity

The main way in which urbanisation affects biodiversity in Bengaluru is habitat loss. This is predominantly driven by unrestricted real estate growth and associated infrastructure development such as roads. To accommodate the city's growing population, the Bengaluru Development Authority has been opening up land in villages surrounding Bengaluru for residential and commercial buildings. To improve connectivity

Reporting on impacts of urbanisation on wildlife with maps and satellite imagery

across the growing city and ease traffic congestion, the government also brings in large scale infrastructure projects like the Metro rail and new flyovers can also impact biodiversity.

The media coverage of these projects is often focused on tree felling and loss of green cover. But journalists can cover biodiversity impacts more deeply by identifying the habitats that are lost to these projects and the wildlife that depends on these habitats.

An excellent example of this is Mohit Rao s reporting on the impacts of urbanisation, loss of tree cover and habitat connectivity on populations of Slender Lorises in the city. While many journalists have covered the presence of Slender Lorises in IISc and made passing mention to the threats to these species, Rao instead turned to a population in a small park in Hennur surround-ed by buildings and the extremely busy Outer Ring Road. Using historic satellite imagery freely available on Google Earth, Rao highlighted how the Hennur Park once connected by a dense network of trees leading all the way to IISc campus eight kilometres away, had now become a tiny island of trees where the lorises were trapped. Using such maps is an excellent way to illustrate how Bengaluru has changed and connecting it to slender loris populations highlights the city s biodiversity[95]. Journalists can also ask research-ers working on urban ecology in the city to help prepare such maps when required.

Journalists must also identify specific species of plants and animals that are affected by urban-isation projects. Loss of avenue trees for road widening would impact different sorts of wild-life, compared to the loss of a century old gar-den such as the All Saints Church for the Metro

Project or the loss of an agricultural field for an apartment building. Most large scale projects require Environmental Clearance from the State Environment Impact Assessment Authority or SEIAA. Such projects have to submit an EIA report to the SEIAA. The documents submitted can be an important source of information on the type of land-use change occurring in a region and the biodiversity that will be affected by the change. These documents can also be corroborated independently by used Google Earth imagery as well as village maps to detect change in the landscape.

Journalists can also seek expert opinion on biodiversity information in these EIA reports by asking appropriate specialists. For instance, agricultural scientists who specialise in the study of plants, insects, soil microbes and birds, may be good sources to understand what sort of agro-biodiversity may be affected by a project coming up in agricultural land.

Not all biodiversity suffers from urbanisation. Some animals are able to adapt to city living, by changing their behaviour, occupying new habitats or learning to eat a range of foods including foods sourced from humans. Ecologists have increasingly turned their attention to these adaptations. The Rock Agama research from CES is an excellent example of the type changes urban lizards are making in their behaviour and habitat to survive in Bengaluru, including learning to use human landscapes such as construction debris and concrete walls as habitats, and learning to be more alert to threats. But the lizards still need some open space, open soil and unpainted unvarnished walls to substitute their rocks[96]. Journalists need to look out for more such studies and examine why they are not incorporated

by city planners and builders in their designs. Finally, it is important for journalists to question and investigate how large scale city planning activities takes urban biodiversity into consideration. The BDA Masterplan for the city created once every ten years, decides the land-use policy for the city. Under the now shelved Masterplan 2031, land area for residential and commercial purposes increased substantially while the land area under agriculture, public lands and open areas in the city reduced compared to the previous 2015 Masterplan inviting criticism from environmental activists and other residents.

Several real estate projects trying to obtain Environmental Clearance, cite the BDA Masterplan s land-use classification as justification for Environmental Clearance. The BDA has been asked to revise the 2031 Masterplan. But the planning process does not involve any sort of Environmental Audit and there is no mention of biodiversity impacts of converting parks, agricultural fields, and open spaces to residential and commercial lands. Reporters can examine the new plan, which lists ward wise land-use change in the city to identify areas or habitats that might be lost to real estate activities and then determine what biodiversity may be impacted by these plans[97].

Citizen science and reporting
Because urban ecology is still an emerging field in India, there is a dearth of studies that are specific to Bengaluru. Journalists will need to be imaginative in how they use urban ecology literature in their reporting. For instance, studies are showing that generalist bird species, that do not depend on a narrow set of foods and habitats, are better at surviving in urban spaces[98]. So, when investigating the impact of a project, journalists

need to look into whether that habitat supports any specialist species and whether environment management plans account for that. A project coming up in a grassland or pastoral land could impact specialist grassland birds like larks and pipits that cannot adapt to a residential complex with landscaped gardens and extensive tree planting.

An excellent resource for biodiversity are the citizen science platforms making inroads into India. Platforms like eBird provide and iNaturalist provide both broad data at city level as well as location specific data on wildlife around the city. eBird which is global database where hobby birdwatchers upload their sightings of birds has a list of 400 hotspots around the city. These hotspots can sometime provide more updated information on bird species composition and frequency of sighting than researchers. For example, IISc researchers preparing a report on the Kaikondrahalli Lake, noted that the lake had 34 species of birds. But birdwatchers from the city have documented the presence of 165 species of birds, nearly five times number. This information collected by hobby birdwatchers in a systematic way can be used for detailed data journalism stories as well as visualisations.

In a detailed feature on how eBird data is used in India for the digital outlet Factor Daily, journalist Shamsheer Yousaf created a detailed map of Bengaluru, showing how many bird species are found in different parts of the city[99]. This is a good example of how citizen science data can be used to tell interactive stories. Such data can also be used to corroborate information in official government documents or EIAs by project proponents. Indeed, journalists can become citizen scientists themselves and participate in documenting birds and other lifeforms on these platforms. In the absence of any information, it is possible for journalists to collaborate with hobby naturalists and birdwatchers in the city, and conduct a real time rapid survey of a project site as part of the reporting. Some useful resources have been provided in the final section.

Biodiversity and stories of People
We have highlighted at length how different people in the city depend on biodiversity. Studies show that this time spent in nature and interacting with wildlife improves mental health and wellbeing of people. But this access is deeply unequal. Ecologists have noted that biodiversity in cities is often restricted to affluent neighbourhoods, while poorer neighbourhoods have little access to green spaces, parks or street trees. Biodiversity as a result becomes a luxury feature available to few[100]. Researchers have noted the luxury effect and unequal access to biodiversity within Bengaluru. But journalists rarely investigate these stories.

For instance, the now rejected BDA Masterplan 2031[101] attempted to allocate more land towards real estate projects while reducing open lands and public lands. With the loss of public lands and vacant sites, the city s pastoralists have few grazing areas for their livestock. As lakes are encroached or lie in dire straits residents relying on fishing and reed grass collection from lake fringes are also losing a source of livelihood. What happens to the livelihoods of these residents?

Large scale tree felling for road widening and other infrastructural projects, impact poorer residents such as hawkers, sanitation workers and migrant construction workers, who rely on large shade giving trees for respite and protection. How are their needs and views taken into account by the city s planning authorities? Access to food plants, particularly herbs and fruit trees in public areas help supplement nutrition of poorer residents. Does the BBMP s afforestation and planting schemes take this into account?

Centring people in biodiversity stories

A study by researchers from IIM Bangalore has shown caste, religious and economic segregation in Bengaluru s wards[102]. IISc researchers have documented an unequal distribution of trees and vegetation in Bengaluru s wards[103]. Is there equitable distribution of parks, playgrounds and tree planting activities in all wards in the city? Such questions can be answered with the help of caste, socio-economic maps of city combined with publicly available data on BBMP managed parks and tree planting drives.

Even richer residents, who can afford to watch wildlife as a hobby, find that access to several parks and lakes are restricted for them. For instance, Cubbon Park one of the oldest botanical gardens in the city prevents birdwatchers from carrying cameras or binoculars. Public university campuses like the GKVK campus and the IISc campus also don t allow for free movement of birdwatchers, despite these hobbyists documenting several rare birds from the campuses.

When citizens do engage with civic authorities and governments to revive and restore natural spaces such as lakes in the city, it often makes news. But the lake committees and Residential Welfare Associations that take up these issues are disproportionately upper caste and upper class. Marginal-

ised communities who have traditionally relied on these resources are not often included in citizen groups and often have little say in these[104] and little representation in media.

Two stories in 2020 highlighted and gave voice to traditional stakeholders of Bengaluru s commons. Prachi Pinglay-Plumber highlighted the role of the fishing community in North Bengaluru in reviving the now famous Jakkur Lake[105]. The reporter places the story of Jockim a fisherman from Jakkur village at the heart of this piece in Mongabay India. Mohit Rao in a joint project by Mongabay India and Citizen Matters, writes about the local communities benefiting from the vegetation surrounding the recently restored Varthur Lake in East Bengaluru and provides a blueprint for how improving biodiversity can benefit all sections of the society[106].

The interactions between the human residents and biodiversity in Bengaluru, throws up many important stories. It is important for journalists to identify the many ways in which the city s residents rely on biodiversity and in turn help maintain and protect it. Ultimately for journalists to do justice to these stories, they need to go beyond superficial reports and engage deeply in the ecological and sociological literature of Bengaluru as well actively learn about nature from the city s people.

Useful Resources

In this section we have documented some important sources of information that can help journalists tell more stories about biodiversity in Bengaluru. Apart from the IT industry, the city is known for several research organisations that have studied different environmental aspects of the city. Some important research groups and organisations are listed below:

Urban ecology, Access to Nature, Bengaluru Ecological History
Harini Nagendra, Professor for Sustainability, Azim Premji University
Seema Mundoli, Researcher, Lecturer, Azim Premji University
Hita Unnikrishnan, Urban Institute Group, Sheffield University

Climate Change, Environmental Change, Lakes and Urban Sprawl
T.V. Ramachandra, Centre for Ecological Sciences, Indian Institute of Sciences

Urban Animal Behaviour
Maria Thaker, Centre for Ecological Sciences, Indian Institute of Sciences
Axel Brockmann, National Centre for Biological Sciences

Citizen Science
Bird Count India
Early Bird

Other Organisations
List of Lake Organisations (Resident Groups)
Environment Support Group
Say Trees
Bangalore Environment Trust
Rainwater Harvesting
www.rainwaterharvesting.org
Ashoka Trust for Research in Ecology and Environment
University of Agricultural Sciences
National Centre for Biological Sciences

Data Sources
Google Scholar for more research papers on Bengaluru s ecology
Mapping lakes in Bangalore
eBird India a global citizen science platform for bird monitoring
iNaturalist a photo based global citizen science platform for all living organisms
Open City is open source data repository with documents ranging from BBMP s tree planting campaigns to BDA Masterplans.
Google Earth provides visually striking satellite imagery of land use change such increased built up area or reduced tree cover

Government Sources
State Environment Impact Assessment Authority Environmental Clearance and Environment Impact Assessment Documents for various projects
Bengaluru Bruhat Mahanagara Palike
Bengaluru Development Authority
Lake Development Authority (LDA)
Karnataka Forest Department
Minor Irrigation Department

Karnataka Lake Conservation and Development Authority (KLCDA)

Media Resources
This is not a comprehensive list of all media outlets, but a selection of outlets with reporting on Bengaluru, urban biodiversity or both.

Digital Media Outlets
Citizen Matters: Focused on cities and citizens, covering key civic and urban issues
The News Minute: South India focussed
Mongabay India: Environmental News
The Wire Science: Science Journalism Focussed
Residents Watch: Bengaluru Neighbourhoods focussed writing

Print Media
Bangalore Mirror: Bengaluru focussed English Newspaper
Deccan Herald: Karnataka Focussed English Newspaper
Deccan Chronicle https://www.deccanchronicle.com/: South India Focussed English Newspaper

Science Journalism Sources
The Open Notebook information for journalists interested in science journalism, including resources on how to read scientific journals, data journalism and understanding statistics.
Sci-Dev Net

Image Credits

Abstract

Why does biodiversity matter?

Biodiversity has intrinsic and utilitarian value Graphic from The Economics of Biodiversity: The Dasgupta Review commissioned by the UK Government. Published February 2021. Accessed on Flickr https://www.flickr.com/people/191878461@N05/ [CC BY 2.0]

The Age of the Anthropocene

Graphs show cumulative vertebrate species recorded as extinct or extinct in the wild by the IUCN since 14th Century. Dashed black curve represents the number of extinctions expected at current rate. (A) Highly conservative estimate. (B) Conservative estimate. (Ceballos et. al. 2015)
Graphic from Accelerated modern human induced species losses: Entering the sixth mass extinction. By Gerardo Ceballos, Paul R. Ehrlich, Anthony D. Barnosky, Andrés García, Robert M. Pringle, Todd M. Palmer. Science Advances19 Jun 2015. DOI: 10.1126/sciadv.1400253 [CC BY-NC 4.0]

Terrestrial vertebrate species on the brink of extinction globally. (Ceballos et. al. 2020)
Graphic from Vertebrates on the brink as indicators of biological annihilation and the sixth mass extinction. Gerardo Ceballos, Paul R. Ehrlich, Pe-

ter H. Raven. Proceedings of the National Academy of Sciences Jun 2020, 117 (24) 13596-13602. DOI: 10.1073/pnas.1922686117 [CC BY 4.0]

Distribution of terrestrial vertebrate species on the brink of extinction. (Ceballos et. al. 2020)
Graphic from Vertebrates on the brink as indicators of biological annihilation and the sixth mass extinction. Gerardo Ceballos, Paul R. Ehrlich, Peter H. Raven. Proceedings of the National Academy of Sciences Jun 2020, 117 (24) 13596-13602; DOI: 10.1073/pnas.1922686117 [CC BY 4.0]

A Planet of Cities

Number of people living in urban areas globally from 1960-2017
Graphic from https://ourworldindata.org/urbanization based on http://data.worldbank.org/data-catalog/world-development-indicators

Percentage of populations living in urban areas globally in 2017
Map from https://ourworldindata.org/urbanization based on http://data.worldbank.org/data-catalog/world-development-indicators

Urbanisation trends globally between 1900-2016
Graphic from https://ourworldindata.org/urbanization based on http://data.worldbank.org/data-catalog/world-development-indicators

Urban vs Rural population projections for India
Graphic from https://ourworldindata.org/urbanization based on http://data.worldbank.org/data-catalog/world-development-indicators

Population densities of Indian cities as of 2014
Graphic from https://ourworldindata.org/urban-

ization based on http://data.worldbank.org/data-catalog/world-development-indicators
Urban population centres (red circles) will increase in and around biodiversity hotspots like the Western Ghats (in blue) by 2025 in India, (yellow circles refer to population centres outside India)
Graphic from Cities and Biodiversity Outlook. Secretariat of the Convention on Biological Diversity. 2012. (CC-NC By 3.0)

The City of Many Names

Bengaluru was historically a semi-arid area with rocky hills and thorn forests. Representational image of Savandurga
Photo by Shyamal via Wikimedia Commons. (CC BY-SA 3.0)
Settlements were initially made in plains and grasslands towards the East of Bengaluru
Photo by Andreas Metz via https://elevation.maplogs.com/poi/savandurga_hill_karnataka_india.532106.html. (CC-A-NC-SA)
Kempe Gowda, the city s founder established the old fort city or pete in 1537
Photo by Nvvchar via Wikimedia Commons. (CC BY-SA 3.0)
The old Bangalore Fort in 1860
Photo by Nicholas Bros via British Library, UK
The old city or *pete* in contrast with the British settlement in Cantonment in the 1890s. The British planted large-canopied trees for shade. Much of the greening was focused on British settlements
Photo of the old city taken in the 1890s by an unknown photographer, from the Curzon Collection s Souvenir of Mysore Album via the British Library Photo of Cantonment by J. H. Furneaux in Glimpses of India. A grand photographic his-

tory of the Land of Antiquity, the vast Empire of the East. Historical Publishing Company. Philadelphia 1895.Via Wikimedia Commons
Map of Bengaluru showing the old city or *Pete* and the Cantonment in 1924
Image of a 1924 city map from Murray s 1924 Handbook via Wikimedia Commons
The Agara Lake was built in the 9th Century during the reign of the Ganga Dynasty
Photo by Ashwin Kumar via Flickr (CC BY-SA-2.0)

Nature in the Silicon Valley

Population trends in Bengaluru from 1950 to 2030 (projections)
Bangalore, India Metro Area Population 1950-2021. Graphic from macrotrends.net based on UN-World Population Prospects. https://www.macrotrends.net/cities/21176/bangalore/population
Built up area has steadily increased while vegetation and lakes have decreased
Image from Water Situation in Bengaluru, ENVIS Technical Report 114, Environmental Information System. Ramachandra T V, Vinay S, Durga Madhab Mahapatra, Sincy Varghese and Bharath H. Aithal. 2016. CES, Indian Institute of Science, Bangalore 560012. Printed with permission
Satellite views show the Indian Institute of Sciences Campus, a patch of green surrounded by built up area. Google Earth image from The slender loris struggles to find canopy in Bengaluru. Mohit Rao. Mongabay India. Citizen Matters. 2020. https://india.mongabay.com/2020/09/the-slender-loris-struggles-to-find-canopy-in-bengaluru
Bird watchers have documented over 200 species of birds in the GKVK campus including (clockwise L-R) Coppersmith Barbet, Asian Paradise Flycatcher, Indian Pitta and White-eyed Buzzard

Coppersmith Barbet, Asian Paradise Flycatcher, Indian Pitta photographs by Sivaguru Noopuran White-eyed Buzzard photograph by Albin Jacob

Map shows spread of built up area in Bengaluru between 1973-2016

The rocky outcrops in the lower reaches of Nandi Hills (left) are habitats for the Yellow-throated Bulbul (right) endemic to Peninsular India.

Nandi hills photo by RSHETTY93, via Wikimedia Commons (CC BY-SA 4.0)

Yellow-throated Bulbul photo by Selvaganesh17 via Wikimedia Commons (CC BY-SA 4.0)

The planted evergreen forest on top of Nandi Hills is home to several Western Ghats species such as Nilgiri Wood Pigeon (right) and Tickell s Blue Flycatcher (bottom left).

Nandi hills photo by Nikhil Verma via Flickr (CC BY-SA 2.0)

Nilgiri Wood Pigeon photo by Koshy Koshy via Flickr (CC BY 2.0)

Tickell s Blue Flycatcher photo by Anandaraman Sivakumar via Wikimedia Commons (CC BY-SA 2.0)

Hesarghatta grasslands are the last remaining grassland patch in Bengaluru

Photo by Mahesh Bhat

Hesarghatta is vital habitat for grassland specialist raptors like Common Kestrels (left) and Montagu s Harriers (right) both declining in India.

Common Kestrel photo by Sumeet Moghe via Wikimedia Commons (CC BY-SA 3.0)

Montagu s Harrier photo by Subramanya C.K. via Wikimedia Commons (CC BY-SA 3.0)

Land around the Nandi Hills and other peri-urban areas are rapidly being converted into real-estate projects

Photo by Natesh Ramaswamy via Flickr (CC BY-NC 2.0)

Maps show the three major drainage valleys in Bengaluru (left) and lakes they feed (right). Lost lakes in red (right) have been built up

Image from Water Situation in Bengaluru, ENVIS Technical Report 114, Environmental Information System. Ramachandra T V, Vinay S, Durga Madhab Mahapatra, Sincy Varghese and Bharath H. Aithal. 2016. CES, Indian Institute of Science, Bangalore 560012. Printed with permission.

The Majestic Bus Terminal stands on the ancient Dharmambudhi Lake built by the Hoysala empire and expanded by Kempe Gowda.

Photo by Hayath Khan, via Wikimedia Commons (CC BY-SA 3.0)

Lakes in Bengaluru are important habitats for over 100 species of birds including (clockwise L-R) spot-billed ducks, Northern Shovelers, Brahminy Kites, and Spot-billed Pelicans

Spot-billed ducks and Northern Shovelers photos by Kandukuru Nagarjun via Flickr (CC BY 2.0)

Spot-billed Pelicans photo by Sankarshan Sen via Wikimedia Commons (CC BY-SA 4.0)

Brahminy Kite photo by C.L. Pramod via Wikimedia Commons (CC BY-SA 4.0)

Lakes and surrounding areas are vital to livelihoods of Bengaluru s most marginalised residents. The periphery of the Hoskote Lake (left) is used for livestock grazing and reed collection by local residents. Building up lake peripheries such as in Ulsoor (right) excludes these communities from accessing their traditional resources

Hoskote Lake photo by Prashanth NS via Wikimedia Commons (CC BY-SA 2.0)

Ulsoor Lake photo by Ramesh NG via Wikimedia Commons (CC BY-SA 2.0)

Reporting on Urban Biodiversity

Researchers continue to discover new species like this burrowing frog *Sphaerotheca bengaluru* from the city
Photo by Ashwin Viswanathan

Reporting on impacts of urbanisation on wildlife with maps and satellite imagery
Screenshot from Citizen Matters: https://bengaluru.citizenmatters.in/slender-loris-bengaluru-habitat-canopy-loss-survival-iisc-52478

Centring people in biodiversity stories
(Left) Screenshots from Mongabay India story by Prachi Pinglay-Plumber: https://india.mongabay.com/2021/04/the-story-of-jakkur-lake-sets-an-example-for-inclusive-rejuvenation-projects/
(Right) Screenshots from Citizen Matters by Mohit Rao: https://bengaluru.citizenmatters.in/bengaluru-lakes-livelihoods-greens-fish-varthur-kelkere-lake-pollution-rejuvenation-53981

References

1 https://www.therightsofnature.org/
2 Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases https://www.sciencedirect.com/science/article/pii/B9781455748013003222
3 Phylogeography of Kyasanur Forest Disease virus in India (1957 2017) reveals evolution and spread in the Western Ghats region. Yadav et. al. 2020. Scientific Reports. https://www.nature.com/articles/s41598-020-58242-w
4 https://www.who.int/southeastasia/outbreaks-and-emergencies/health-emergency-information-risk-assessment/surveillance-and-risk-assessment/nipah-virus-outbreak-in-kerala
5 Global hotspots and correlates of emerging zoonotic diseases.
https://www.nature.com/articles/s41467-017-00923-8
6 Does urbanization make emergence of zoonosis more likely? Evidence, myths and gaps. https://journals.sagepub.com/doi/full/10.1177/0956247819866124
7 Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy. https://www.weforum.org/reports/new-nature-economy-report-series
8 Global Assessment Report on Biodiversity and Ecosystem Services https://www.ipbes.net/news/Media-Release-Global-Assessment
9 Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs https://openknowledge.worldbank.org/handle/10986/23775
10 Natural climate solutions https://www.pnas.org/content/114/44/11645
11 Biodiversity in sacred urban spaces of Bengaluru, India https://www.sciencedirect.com/science/article/abs/pii/S1618866717307264
12 Biodiversity, cultural pathways, and human health: a framework https://www.sciencedirect.com/science/article/pii/S0169534714000238
13 Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://doi.org/10.5281/zenodo.3831673
14   Urbanization". Published online at OurWorldInData.org. https://ourworldindata.org/urbanization
15 Cities and Biodiversity Outlook. Secretariat of the Convention on Biological Diversity 2012.
16 World City Populations 2021. https://worldpopulationreview.com/world-cities
17 Decoding Urban Climate Change Resilience, The Energy and Resources Institute https://www.teriin.org/resilient-cities/urbanisation.php
18 https://smartcities.gov.in/cities-profiles
19 https://www.financialexpress.com/economy/three-fourth-of-indias-gdp-to-come-from-urban-population-if-these-reforms-are-made/1668629/
20 Nature in the Urban Century, The Nature Conservancy https://www.nature.org/en-us/what-we-do/our-insights/perspectives/nature-in-the-urban-century/?vu=r.d_urbannature100
21 https://www.karnataka.com/profile/physiography/
22 Nature in the City: Bengaluru in the Past, Present, and Future. Harini Nagendra. Published by Oxford University Press. 2016
23 Bangalore through the Centuries. M. Fazlul Hasan. Published by Historical Publications. 1970
24 When the city was a jungle. Ameen Ahmed. 2014. https://www.deccanherald.com/content/442183/when-city-jungle.html
25 Water Situation in Bengaluru. T.V. Ramachandra et al. http://wgbis.ces.iisc.ac.in/energy/water/paper/ETR114/section4.html
26 Urban Industrial Rivers. Bangalore Environment Trust. http://bngenvtrust.org/work/introduction-river-map/
27 Population Census 2011. https://www.census2011.co.in/census/city/448-bangalore.html
28 World Population Prospects, 2019, UN Department of Economic and Social Affairs Accessed online at https://www.macrotrends.net/cities/21176/bangalore/population
29 Bengaluru's story: 96.21L. in 2011, 1.42 Cr. by 2021 https://www.deccanherald.com/city/top-bengaluru-stories/bengalurus-story-9621l-in-2011-142-cr-by-2021-802313.html
30 Fauna of Bangalore. Karnataka ENVIS. http://karenvis.nic.in/Content/FaunaofBangalore_7012.aspx
31 eBird: a citizen-based bird observation network in the biological sciences. https://ebird.org/region/IN-KA-BN
32 iNaturalist. https://www.inaturalist.org/observations?nelat=13.17370600858147&nelng=77.88268086666527&place_id=any&swlat=12.73428884772176&swlng=77.37919807560223&view=species
33 Green Spaces in Bengaluru: Quantification through geospatial techniques. Ramachandra et. al. 2017. Accessed online: https://www.researchgate.net/publication/315670439_GREEN_SPACES_IN_BENGALURU_QUANTIFICATION_THROUGH_GEOSPATIAL_TECHNIQUES
34 Analysing Urban Sprawl and Shifting of Urban Growth Centre of Bengaluru City, India Using Shannon s Entropy Method. Verma et. al. 2017. Journal of Settlement and Planning. Accessed online: https://www.researchgate.net/publication/322012550_Analysing_Urban_Sprawl_and_Shifting_of_Urban_Growth_Centre_of_Bengaluru_City_India_Using_Shannon%27s_Entropy_Method
35   Building biodiversity in neighbourhood parks in Bangalore city, India: Ordinary yet essential. Swamy et al. 2019. Plos One. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0215525
36 Biodiversity in sacred urban spaces of Bengaluru, India. Jaganmohan et. al. 2018. Urban Forestry & Urban Greening. https://www.sciencedirect.com/science/article/abs/pii/S1618866717307264
37 The slender loris struggles to find canopy in Bengaluru. Mohit Rao. Mongabay India. Citizen Matters. 2020. https://india.mongabay.com/2020/09/the-slender-loris-struggles-to-find-canopy-in-bengaluru/
38 Biodiversity Heritage Sites. ENVIS Centre on Wildlife and Protected Areas. http://wiienvis.nic.in/Database/bhs_8650.aspx

39 eBird: a citizen-based bird observation network in the biological sciences https://ebird.org/hotspot/L2609314
40 eBird: a citizen-based bird observation network in the biological sciences https://ebird.org/hotspot/L2525709
41 eBird: a citizen-based bird observation network in the biological sciences. https://ebird.org/hotspot/L2676130
42 https://jlrexplore.com/gallery/iconic-images/otter-in-the-city
43 https://bengaluru.citizenmatters.in/1435-gkvk-high-court-road-link-issue-1435
44 https://www.deccanherald.com/content/121848/heritage-tag-may-save-gkvk.html
45 Heat, dust and floods: What's up with Bengaluru? https://bengaluru.citizenmatters.in/bengaluru-vegetation-loss-high-temperature-dust-pollution-25591
46 Greater Bangalore: Emerging Urban Heat Island. T. V. Ramachandra et. al. 2010. The Geospatial Resource Portal. https://www.researchgate.net/publication/256848028_Greater_Bangalore_Emerging_Urban_Heat_Island
47 Minimizing Urban Heat Island Effect and Imperviousness Factor in Bangalore. Kiran Kumar. The Energy and Resources Institute of India. 2014 https://www.researchgate.net/publication/335774580_Reducing_Urban_Heat_Island_Imperviousness_in_Bangalore
48 Effect of street trees on microclimate and air pollution in a tropical city. Vailshery, Jaganmohan and Nagendra. 2013. Urban Forestry and Urban Greening. https://www.sciencedirect.com/science/article/abs/pii/S1618866713000289?via%3Dihub
49 Thermal spikes from the urban heat island increase mortality and alter physiology of lizard embryos. Hall and Warner. 2018. Journal of Experimental Biology. https://journals.biologists.com/jeb/article/221/14/jeb181552/19675/Thermal-spikes-from-the-urban-heat-island-increase
50 Climate Change Alters the Intensity and Population Dynamics of Insect Pests: A Case Study with Ferrisia virgata (Cockerell) Infesting Sandalwood and Pongam in Karnataka. R. Sundararaj and Rashmi R. Shanbhag   In: Climate Change: Challenges and Solutions. Eds: Ritu Kakkar, Vinaya Kumar K.H., Remadevi O.K., Hema N. and Cruz Antony J. (Eds.) 2018. Allied Publishers Pvt. Ltd., New Delhi, 318
51 Urbanisation and its effects on lizards: A study from a climate change perspective. Thaker and Amdekar. In: Climate Change: Challenges and Solutions. Eds: Ritu Kakkar, Vinaya Kumar K.H., Remadevi O.K., Hema N. and Cruz Antony J. (Eds.) 2018. Allied Publishers Pvt. Ltd., New Delhi, 318
52 Water Situation in Bengaluru, ENVIS Technical Report 114, Environmental Information System, CES, Indian Institute of Science T.V. Ramachandra et. al. 2016. http://wgbis.ces.iisc.ac.in/energy/water/paper/ETR114/section4.html
53 Analysing Urban Sprawl and Shifting of Urban Growth Centre of Bengaluru City, India Using Shannon s Entropy Method. Verma et. al. 2017. Journal of Settlement and Planning. Accessed online: https://www.researchgate.net/publication/322012550_Analysing_Urban_Sprawl_and_Shifting_of_Urban_Growth_Centre_of_Bengaluru_City_India_Using_Shannon%27s_Entropy_Method
54 Structure and composition of field margin vegetation in the rural-urban interface of Bengaluru, India: a case study on an unexplored dimension of agroecosystems. Nautiyal et. al. 2020. Environmental Monitoring and Assessment. https://link.springer.com/article/10.1007%2Fs10661-020-08428-6
55 eBird: a citizen-based bird observation network in the biological sciences https://ebird.org/hotspot/L3150186
56 Rosettes in Chikkaballapura: Estimating leopard densities and abundance through camera trapping, Gubbi, S., Suthar, S., Girish, M. N. & Menon, A.M. 2020. Nature Conservation Foundation, Mysore, India. https://www.ncf-india.org/western-ghats/rosettes-in-chikkaballapur-estimating-leopard-densities-and-abundance-through-camera-trapping
57 Ecology, Conservation and Management of the Asian Elephant in Bannerghatta National Park, southern India. Surendra Varma, Vijay D Anand and Avinash KG. 2009. A Rocha India and Asian Nature Conservation Foundation. Accessed online: https://www.researchgate.net/publication/234550739_Ecology_Conservation_and_Management_of_the_Asian_Elephant_in_Bannerghatta_National_Park_southern_India_A_Rocha_IndiaANCF_Asian_Elephant_Ecology_and_Conservation
58 Wildlife management plan for Bannerghatta National Park 2008 2013. edited by Forest Department Bangalore. Bangalore, India: Forest Department, Government of Karnataka. Singh, V. V. 2008.
59 eBird: a citizen-based bird observation network in the biological sciences https://ebird.org/hotspot/L2525578
60 https://www.newindianexpress.com/cities/bengaluru/2019/aug/11/lone-tiger-in-bannerghatta-national-park-searches-high-and-low-for-a-mate--2017250.html
61 Tree diversity in the tropical dry forest of Bannerghatta National Park in Eastern Ghats, Southern India. Gopalakrishna, S. P. et. al. 2015. European Journal of Ecology. https://doi.org/10.1515/eje-2015-0013
62 Recommendation for a Greater Hesaraghatta (GHCR) Conservation Reserve in Bangalore. Submitted by Mahesh Bhat, Seshadri KS, Ramki Sreenivasan to Karnataka Forest Department. 2013. https://images.citizenmatters.in/wp-content/uploads/sites/14/2021/01/Hesaraghatta-Conservation-Reserve.pdf
63 eBird: a citizen-based bird observation network in the biological sciences. https://ebird.org/hotspot/L2525708
64 Mistaking the Map for the Territory: What Does the History of Bannerghatta National Park, India, Tell us about the Study of Institutions? 2019. Jayaprakash and Hickey. Society and Natural Resources.
65 Sustainable Management of Bannerghatta National Park, India, with the Insights in Land Cover Dynamics. T.V. Ramachandra and Bharath Setturu. 2019. FIIB Business Review. https://journals.sagepub.com/doi/abs/10.1177/2319714519828462
66 Excerpt from Leopard Diaries: The Rosette in India. Sanjay Gubbi. Westland. 2021. https://scroll.in/article/989282/leopards-of-silicon-city-what-is-the-future-of-the-species-around-bengaluru-and-in-india
67 Bengaluru's yes to Hesaraghatta film-city means a no to the Lesser Florican. Citizen Matters. 2021. https://bengaluru.citizenmatters.in/hesaraghatta-grasslands-film-city-project-biodiversity-protection-55815
68 https://www.deccanherald.com/metrolife/metrolife-your-bond-with-bengaluru/no-film-city-in-hesaraghatta-are-grasslands-safe-then-966556.html
69 Upcoming IT zone hots up Nandi realty.
http://timesofindia.indiatimes.com/articleshow/45093320.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst
70 https://www.99acres.com/new-projects-in-nandi-hills-bangalore-north-ffid
71 https://www.magicbricks.com/residential-plots-land-for-sale-in-nandi-hills-bangalore-pppfs
72 Water situation in Bengaluru. T.V. Ramachandra et. al. 2016. ENVIS Technical Report 114, Environmental Information System, CES, Indian Institute of Science.

73 Traditional water bodies and urban resilience: a historical perspective from Bengaluru, India. Unnikrishnan et. al. 2017. Water History. https://link.springer.com/article/10.1007/s12685-017-0199-9

74 Wetlands: Treasure of Bangalore. T.V. Ramachandra et. al. 2015. https://www.researchgate.net/publication/289531068_Wetlands_Treasure_of_Bangalore

75 https://www.deccanherald.com/city/top-bengaluru-stories/4500-acres-of-lake-land-grabbed-in-bengaluru-urban-and-its-an-underestimate-1001209.html

76 eBird: a citizen-based bird observation network in the biological sciences

77 Down the drain: the tragedy of the disappearing urban commons of Bengaluru. Unnikrishnan et. al. 2016. South Asian Water Studies. Accessed online: https://www.researchgate.net/publication/301754513

78 Urban commons in a globalizing city. Unnikrishnan, H., Manjunatha, B. and Nagendra, H. 2017. India Seminar. https://www.india-seminar.com/2017/690/690_hita_unnikrishnan_et_al.htm

79 Patterns of urban foraging in Bengaluru city. Somesh D, Rao R, Murali R, Nagendra H. 2020 Urban Forestry and Urban Greening. doi: https://doi.org/10.1016/j.ufug.2020.126940

80 https://lifestyle.livemint.com/news/big-story/how-citizen-scientists-are-shaping-the-future-of-indian-research-111601435093020.html

81 eBird: a citizen-based bird observation network in the biological sciences. https://ebird.org/region/IN-KA-BN

82 http://datazone.birdlife.org/site/factsheet/hoskote-kere-iba-india

83 https://www.deccanherald.com/content/347698/with-toil-residents-yelahanka-lake.html

84 https://www.thehindu.com/news/cities/bangalore/lake-groups-joins-hands-to-form-federation/article24187135.ece

85 https://bengaluru.citizenmatters.in/8000-sqm-forests-manyata-tech-park-15-residents-saytrees-miyawaki-afforestation-43042

86 https://www.newindianexpress.com/cities/bengaluru/2021/jun/27/bengaluru-gets-largest-miyawaki-forest-2322051.html

87 https://bangaloremirror.indiatimes.com/bangalore/others/communities-are-learning-to-coexist-with-fanged-friends/articleshow/52856815.cms

88 https://honeybeelab.weebly.com/urban-bees.html

89 https://www.ncf-india.org/education-and-public-engagement

90 https://www.antwiki.org/wiki/Dilobocondyla_bangalorica

91 https://indianexpress.com/article/cities/bangalore/newly-discovered-frog-species-named-after-bengaluru-city-7072539/

92 https://researchmatters.in/news/new-burrowing-frog-discovered-bengaluru-could-tell-lot-about-unexplored-cityscapes

93 Complete biological control of Antonina graminis in Texas with Neodusmetia sangwani (a classic example). Dean et. al. 1979. Bull. Ent. Soc. Amer. doi:10.1093/besa/25.4.262.

94 https://news.ncbs.res.in/research/strange-bedfellows-how-butterfly-caterpillars-sustain-their-association-cocktail-ants

95 The slender loris struggles to find canopy in Bengaluru. Mohit Rao. Mongabay India. Citizen Matters. 2020. https://india.mongabay.com/2020/09/the-slender-loris-struggles-to-find-canopy-in-bengaluru/

96 https://india.mongabay.com/2019/02/how-lizards-in-bengaluru-are-faring-when-compared-to-their-country-cousins/

97 https://opencity.in/pages/bda-revised-master-plan-2031-land-use-maps

98 Which Traits Influence Bird Survival in the City? A Review. Patankar et. al. 2021. Land. https://www.mdpi.com/2073-445X/10/2/92

99 Birds in data: Counting cuckoos and other stories. Shamsheer Yousaf. 2019. Factor Daily. https://archive.factordaily.com/birds-in-data-counting-cuckoos-and-other-stories/

100 Biodiversity and socioeconomics in the city: a review of the luxury effect. Leong M, Dunn RR, Trautwein MD. 2018. Biology Letters. http://dx.doi.org/10.1098/rsbl.2018.0082

101 https://opencity.in/pages/bda-revised-master-plan-2031-land-use-maps

102 Isolated by Caste: Neighbourhood-Scale Residential Segregation in Indian Metros. Bharathi et. al. 2018. IIM Bangalore Research Paper No. 572. Accessed online: SSRN: https://ssrn.com/abstract=3195672

103 Trees of Bengaluru, ENVIS Technical Report 75. Ramachandra T.V. et. al. 2014. ENVIS, Centre for Ecological Sciences, IISc.

104 Applying the social-ecological system framework to the diagnosis of urban lake commons in Bangalore, India. Nagendra and Ostrom. 2014. Ecology and Society. http://www.ecologyandsociety.org/vol19/iss2/art67/

105 https://india.mongabay.com/2021/04/the-story-of-jakkur-lake-sets-an-example-for-inclusive-rejuvenation-projects/

106 https://india.mongabay.com/2020/11/the-link-between-bengalurus-lakes-livelihoods-and-local-memories/