How Kolkata, India will transform through 2035 through increasing population density and climate change, and how to plan for it

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Abstract

Cities are diverse multicultural hubs that significantly contribute to the economic development of a country. They provide better job opportunities, better services and overall, a better quality of life as compared to rural setups. However, recent records point out that Kolkata – the capital of the Indian state of West Bengal, located on the eastern bank of the Hooghly River – is facing a huge problem of unplanned urban density increase. Yet despite various welfare schemes initiated by the government, Kolkata has yet to put together a comprehensive plan to deal with that as well as increasingly serious issues posed for this important metropolitan area as a direct consequence of climate change.

As a model for a new integrated approach to urban planning in such a complex human system, this paper begins by providing an overview of many of the challenges the city will face over the next 15 years. It considers a vast array of topics ranging from ecological, socio-cultural, economical as well as governmental issues that will require serious reform to ensure the sustainability of the city's resources. Major issues Kolkata needs to deal with include rapid urbanization, pollution, the increasing lack of potable water, poor solid waste management, inefficient energy consumption, sea level rise, and extreme weather events/disasters caused by global warming.

The analysis that follows provides a focus on the growing complexities observed in the city due to rapid urban expansion. These have further intensified pollution and mobility challenges in the city. These issues, coupled with threats from climate change, pose a great risk to residents of the city, especially vulnerable communities from underprivileged backgrounds.

The resulting proposals outlined in the paper point to examine loopholes in existing long-term policies which will limit the ability of the city to evolve in the presence of urban changes from all sources. It also proposes focusing on solutions which are integrative rather than targeted fixes for single issues at a time, by considering simultaneously environmental, communal, governance, economic, and climate-related transformations that will demand the most creative and systemic solutions to maintain Kolkata as a vibrant and thriving urban community for the future.

Keywords: Urban Planning, Sustainable Development, Disaster Resilience, Climate Resilience, Inclusive Cities, Smart Cities, Sustainable Cities, Urban Design.

Introduction

Cities are often linked to increased job opportunities, a centralised market, better civic amenities, and better pay. They are dynamic multicultural hubs that significantly contribute to the economic development of a country.

Urbanisation is a direct result of these pull factors, and this is what causes cities to grow rapidly. Cities have constantly been experimented upon when it comes to new policy interventions. Innovative concepts and strategies of land-use planning, economic and infrastructure development, provision of civic amenities and housing have often been implemented by town planners in metropolitan cities.[1] However, recent records show that unplanned expansion and demographic growth of cities are posing a great threat to their sustainability and sustenance. Other impacts, such as anthropogenic-driven climate change, are adding to the range of unplanned issues cities like Kolkata do not consider in typical planning scenarios.

To provide an alternative perspective on what could be done in planning for a city as significant as Kolkata, this paper first sets a model for how the urban hub in this metropolis is likely to change over the next 15 years. Then it recommends strategies and timeline for what urban planners should do to mitigate for and adapt to what will be happening.

The model which follows considers a variety of environmental changes, including considerations related to how global heating and the climate crisis will begin to impact daily

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[1] Mahato, B. (2020). *Social Class and Public Space: An Empirical Study of Class Relations in New Market Square, Kolkata, India* (Doctoral dissertation, University of Cincinnati).

life. As just a few examples, the city of Kolkata has in recent years faced powerful tropical cyclones tied to superheating of the waters of the Bay of Bengal, and the early signs of sea level rise as the cryosphere melts in the Arctic, Antarctica, Greenland, and the Himalayas, due to temperature rise. Other environmental and sustainability issues, such as dealing with growing waste management and pollution concerns, is also projected.

In addition to the environment, the paper also considers pressures on societal issues such as education, jobs, access to clean water, food, transportation, medical care, and affordable housing. This paper models for how much increased population the urban region will need to support, and how it will affect daily life.

Kolkata is likely to see significant increases in population density, as it mirrors what the rest of the world has already been dealing with as more people than ever are drawn from the rural areas to cities, as part of a long-term trend. As farms begin to collapse in the face of declining health of local aquifers, even more people may seek what they see as the shelter of cities, to live and thrive. The paper concludes with various recommendations for efficient policy interventions to build sustainable urban communities.

Methodology

The methodology used for this research paper is based on secondary data that was collected by making use of various other research work conducted by past authors on relatable topics, through its literature review, published journals and articles. Various government websites were also used to retrieve creative commons and demographic data.

Overview of Main Focus Points of the Study

Kolkata, the world's 14th largest megacity by population, in some ways is a microcosm of what is happening in many other major urban centers. On the positive, it offers improved higher education services, ease of public transport, increasing job opportunities and better quality of life. In these ways, this city is providing better prospects to improve lives for the better.

On the other hand, several things are impacting negatively upon the wellbeing of this city.

One of the most concerning issues is rapid population growth and density, both representing factors which are continuously becoming harder to manage. While the obvious solution might be for local authorities and policymakers to delocalize the vast population in the city's central hub throughout the many suburban aeras of Kolkata, this would require societal shifts and infrastructure which are difficult to implement.

Other issues to be addressed include items such as:

- Escalating sold waste production without anticipation and investment in infrastructure to be prepared for it.

- Building on the city's existing strong reputation as a good place to work for educators, by taking steps to ensure their long-term job security.

- Easy accessibility to mass transit options for the population.

- Increasing shortages of clean water for drinking, cooking, and bathing.

Dealing with the reality of being one of the country's leading polluted cities, through a combination of policy actions, providing support to change the root causes of pollution, and implementing city-managed services. Recently, the city corporation made a good start in dealing with part of this problem by introducing electric buses for safe and ecologically sound transport throughout the city. It must also find a way to push these changes onto the private sector, through the reduction of consumption of fossil fuels throughout. It must also invest in and encourage industrial users to install renewable energy sources tailored to the region. These would include wind, solar, and potentially tidal energy gathering sources.

The city must build on its reputation for having some of the best governmental medical treatment centers by adding more. It must also provide guidance and incentives to attract and transform the private health sector offerings in the area as well.

As extreme weather conditions grow worse, such as when 2020's Super Typhoon Amphan came across the Bay of Bengal, the city must build on its growing capacity to mitigate the disastrous impacts such storms have created. It must move from a reactive to proactive approach, with a combination of easily deployed resources to repair and replace what gets damaged, establishment of changes in construction standards to anticipate what will soon become more common, creation of protective centers that can be opened as emergencies become more common, and a way of working with private sector institutions and the general public to determine optimum solutions for all.

Population Trends and Urban Density

Kolkata, the administrative head of the Indian state of West Bengal, was India's first ever metropolitan governmental entity.

The megacity of Kolkata is immense, covering a total of 205,000 square kilometers (79,150 square miles).

At present, the central city hub has an estimated population of 4.6 million, with 15.1 million for the entire metropolitan area, including surrounding suburbs. That puts it as the third largest metropolitan area in India.

By 2035, the population will have expanded to an estimated 20.1 million. That is an over 30 percent growth rate 13 years from now, assuming nothing else contributes to an even higher growth of the urban center, such as further collapse of agricultural lands due to high temperatures and drought. In that case, cities like Kolkata will draw even larger numbers of people to it, for jobs, education, health care, and more.

Within the urban center of this metropolis, the city has one of the world's highest population densities, with 24,000 people per square kilometer or 63,000 per square mile.[2]

Population Demographics

The mix of women to men in the city is lower than in India as a whole, with 899 females for every 1000 males. This happens because a sizeable percentage of workers in the city are travelers from outside the area, who have moved and settled to find jobs. Most of those are men, many of which have moved to Kolkata to find jobs.

Part of the attraction to coming to Kolkata, as well as a reason for its unplanned and irregular demographic growth, is it is the only major urban hub which brings together such a diverse and advanced mix of economic, political, trade, cultural, and educational activities within India. These are major draws of people to the area, which have together been responsible for driving some of the highest population of all urban centers in the 20th century.

This draw is also why Kolkata has an 87 percent literacy rate. That is considerably higher than the overall Indian literacy average of 74 percent.

The interesting part of this reckless growth trend is the population in **the KUA (Kolkata Urban Area) specifically in its peripheral area currently rises at a much higher rate than in the KMC**, which has in recent times had a negative population growth rate of -0.18 percent. There may be multiple reasons for this kind of **urban concentration**, such as the city heart being saturated in terms of ability to absorb additional inhabitants, severe shortage of essential infrastructure, and the relative ill-health of the economy.

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[2] https://worldpopulationreview.com/world-cities/kolkata-population

The high living cost and strict regulations on land use has lessened the capacity of the KMC to sustain a growing population. On the other hand, better transport systems and easy availability of low-cost living has facilitated and tempted individuals to move into the city peripheries and thus it fuels the rapid growth of urban areas. This reckless peripheral growth has created a huge stress on the existing land, economy, employment and basic infrastructures of the city. Simultaneously, the monotonous rise in urban-life poverty has become more visible in terms of lodging services available, clean water, sanitation, and sewage. The quality of the lifestyle of the occupiers and the economic status are falling as well.

This huge flow of people from rural areas to suburbs of the Kolkata metropolitan region has brought an acute crisis in the sector of employment security.

The high population density has also created problems with disease management such as during the peak periods of the coronavirus pandemic in 2020 and into mid-2021. In a densely populated metropolitan region like Kolkata, social-distancing has become a difficult task which made Kolkata a leading hotspot of covid-19 cases in West Bengal.
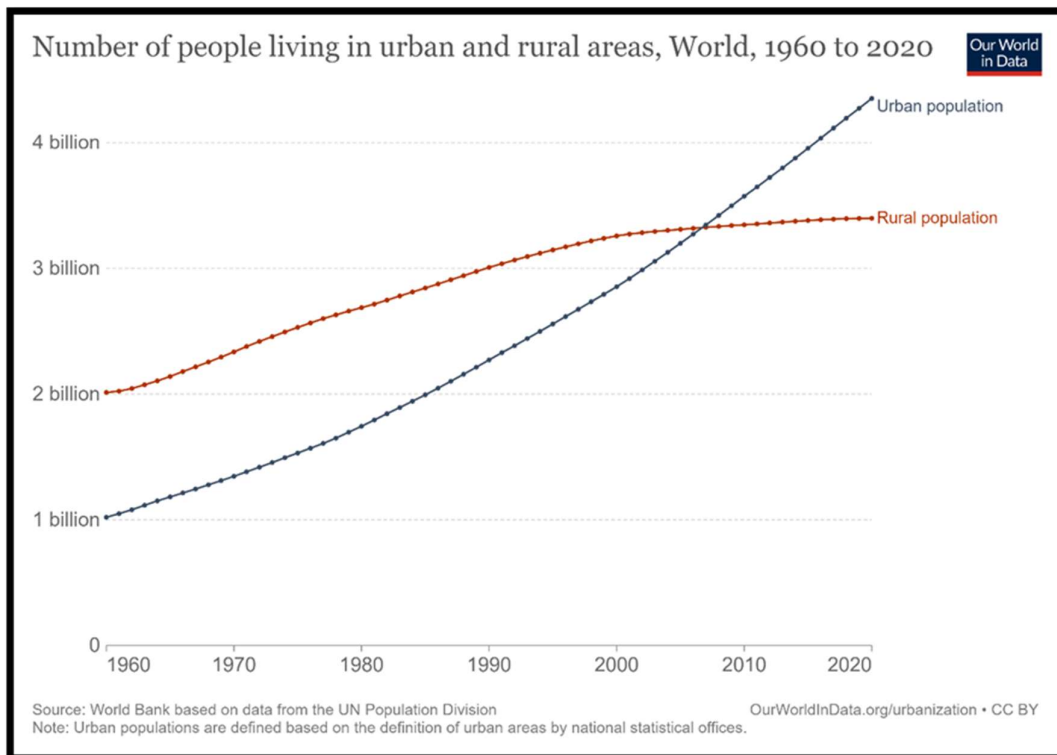

Image: Number of people living in urban and rural areas, World, 1960 to 2020
(Source: https://ourworldindata.org/grapher/urban-and-rural-population)
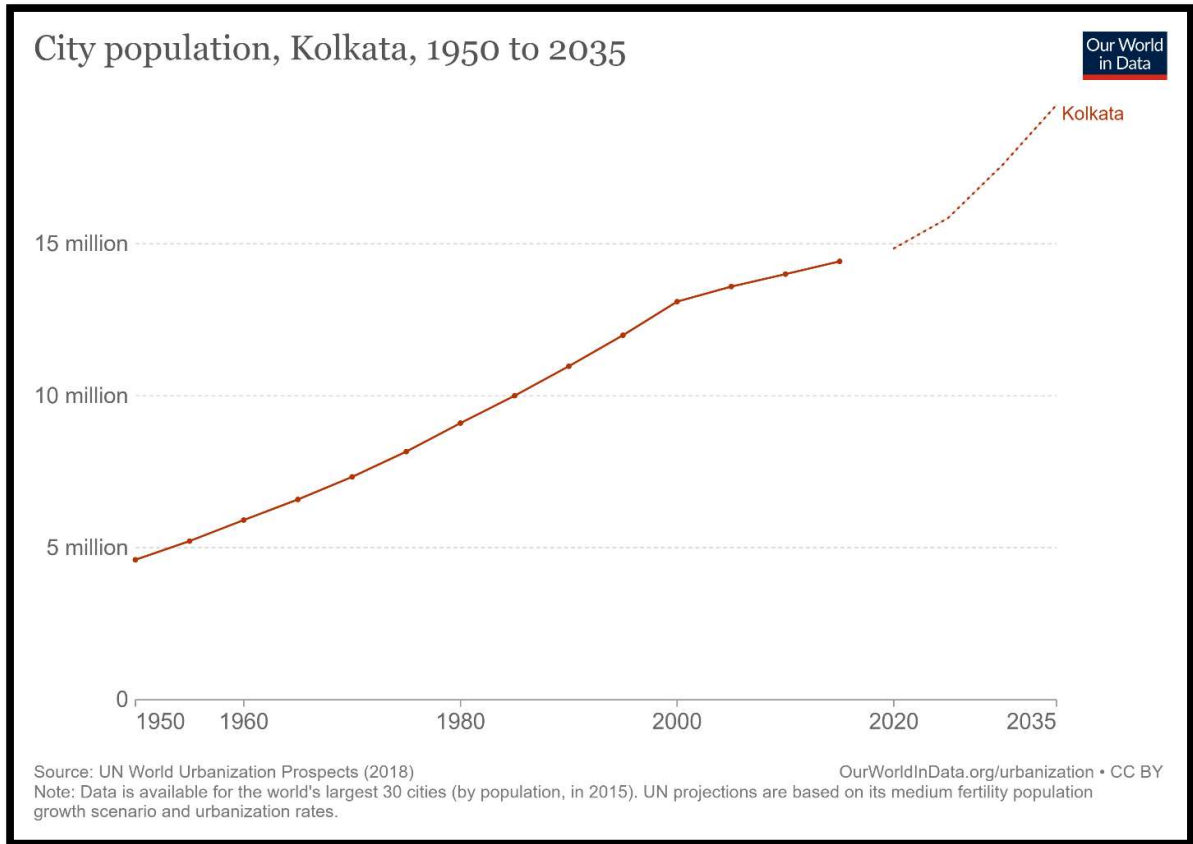
Image: Projected city population of Kolkata, 1950 to 2035
(Source: https://ourworldindata.org/grapher/city-populations-to-2035?tab=chart&country=~Kolkata)
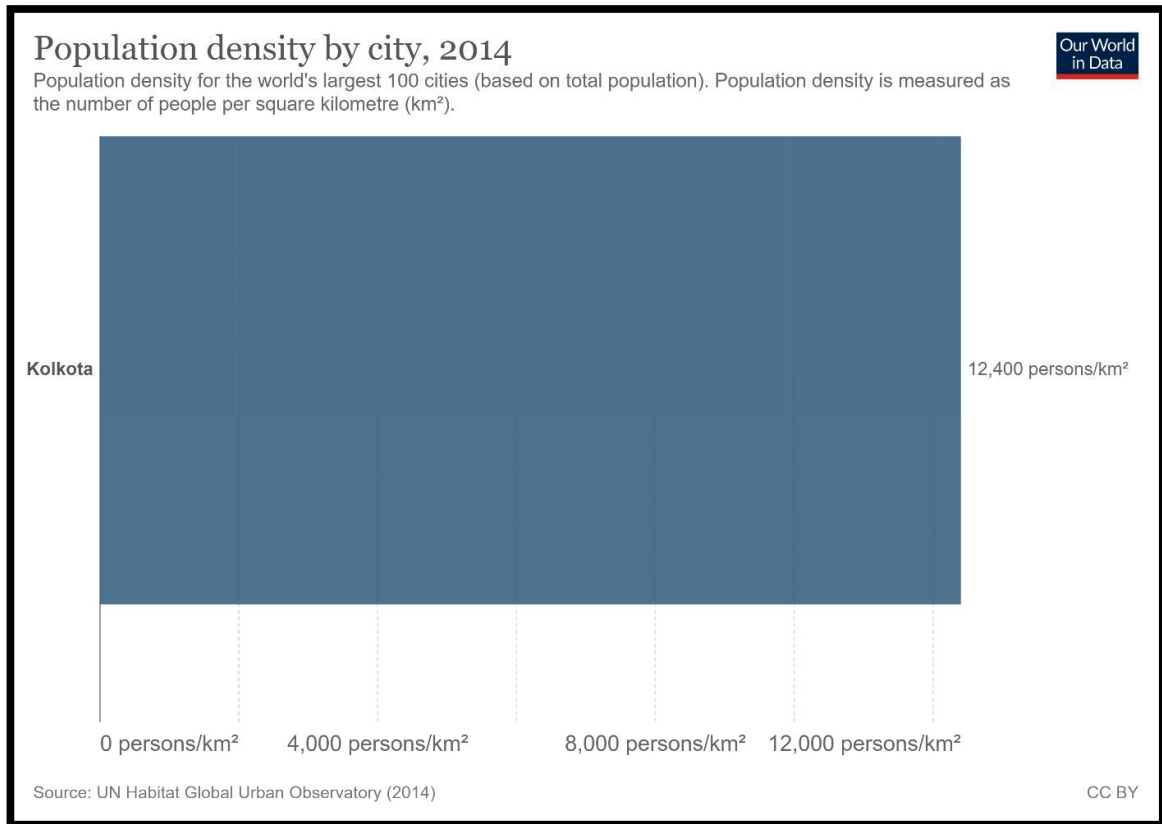
Population density by city, 2014
Population density for the world's largest 100 cities (based on total population). Population density is measured as the number of people per square kilometre (km²).

Kolkota — 12,400 persons/km²

0 persons/km² 4,000 persons/km² 8,000 persons/km² 12,000 persons/km²

Source: UN Habitat Global Urban Observatory (2014) CC BY

Image: Population density of Kolkata, 2014
(Source: https://ourworldindata.org/grapher/population-density-by-city?tab=chart&country=~Kolkota)

Solid Waste Management

As urban congestion grows, health and hygiene related issues have become a major threat in people's lives throughout the country, and waste management – especially the proper handling of solid waste – is considered one of the most important services provided by government and city institutions. Kolkata, being one of the most important urban hubs, has incurred multiple waste disposal related problems over the past few years.

The major problems in MSW management at Kolkata are due to lack of garbage segregation at source, low percentage of door-to-door collections, huge number of open vats and heaps of rotten garbage, a weakened operational efficiency of waste transport system with old unscientific vehicles, negligence of the garbage collectors in newly added areas and the most important but neglected the informal waste recycling system. These open vats and growing heaps of garbage are creating health hazards all over the urban areas and city core as well. Gradually these heaps are becoming the breeding ground for mosquitoes; the foul smell of

the rotten wastes – with harmful airborne toxins and bacteria -- has made the lives of the residents unbearable here.

With the city generating over 4500 tonnes of waste daily, unavailability of adequate land for its disposal, and a lack of advanced scientific means of waste disposal, the solid waste disposal problem has raised sufficient concern that now even the state pollution control board is involved.
With the lack of any alternative waste management system present, the waste management buildup has worsened the Kolkata urban scenario, as 4000 tonnes of waste continues to be thrown into the sole landfill of Dhapa. Though that landfill and its associated waste management processing plant exceeded its lifespan over 30 years ago, there is still to date no alternative scientific landfill solution which can share Dhapa's burden. As a result, it continues to receive additional waste. This is why it remains high on the list of India's endangered landfills.

Without any other alternatives and due to the lack of land for disposal of waste, KMC disposes of garbage in empty land, even compromising the health of the residents. If the situation cannot be handled within the next 15 years, this reckless growth of solid wastes like plastic bottles, packets, glass, disposal bags etc. will contribute to leaching of plastic contamination and other pollutants into the region, endangering water and sewer systems, and eventually contributing to and then other serious environmental issues like biodiversity loss and spread of disease.

At least two more waste management treatment plants are required in Kolkata to treat the wastes produced in the city properly. Unfortunately for the city's residents, the state pollution control board is also unenthusiastic to build any other garbage disposing dump sites within the city premises. The most the city can do is to, as KMC have urged, to actively encourage people to simply segregate garbage in return for receiving tax benefits.

Besides that, more important changes must be implemented including transformation of an informal to a formal recycling system; constructing newly engineered landfill sites with liner, leachate collection and treatment facilities; and major improvements of the city composting system; a CH4 recovery system; and launch of vermi-composting in a decentralized manner.

In the near future, an online management program should also be implemented to make the best use of the operating resource allotment and to see the Kolkata solid waste management system in an efficiently developed and sustainable position (Mahato, 2020).[3]

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[3] Mahato, B. (2020). *Social Class and Public Space: An Empirical Study of Class Relations in New Market Square, Kolkata, India* (Doctoral dissertation, University of Cincinnati).

Education

Kolkata, usually acknowledged as the "cultural capital of India", had previous prepared the way for development of what was at the time the most modern education system in India. The city became known as a center of education all over the country long before independence from the United Kingdom.

Being the third most popular metropolitan city of India, it attracts a huge number of students from several parts of the country, even from abroad. In fact, in the time of post-independence, the city consistently was recognized as being in the forefront of the educational scene.

According to the last census in 2011 Kolkata has a literacy rate of 86.31% where female literacy is 84.06%. Many prestigious institutions, like Jadavpur University, Bengal Engineering, IACS, ISI and others have added luster to the city's education sector. One of those institutions, the Calcutta Medical College, was in fact the first institute of European medicine established in India; that happened in 1935, with the school providing the most progressive forms of medical training practiced in Europe – on Indian soil.

Both the secondary and higher secondary governmental bodies of education manage and control most learning and examination activities in West Bengal. Besides the state govt board of education, the ICSE, ISCE, CBSE, the Islamic Madrasha and NIOS also operate in Kolkata. The state government has taken actions to improve the quality of teaching for and provisions of monetary support to poor children.

Through these institutions' interventions, the prakalpa or scheme like "Kanyashree" for girls has decreased the rate of school dropout girls and saved them from early marriage. Further, thanks to the joint efforts of the state and central government, the "Sarva Shiksha Abhiyan" program has made primary education mandatory for 6- to 14-year-old children.

With the help of these programs and schemes the students of Kolkata, despite being in a major urban center, are also benefiting like those in rural Bengal. Schools like the Don Bosco school, South Point high school, La Martiniere, St Xavier's school and others are among the top class institutions below the college level situated in the heart of Kolkata.

For higher learning, the University of Calcutta, established in the year 1857, today has a total of 204 colleges affiliated under it. It was the first multidisciplinary higher education institute to be built in South Asia. UGC has identified this 'five-star University' and the Jadavpur University as "centers with potential for excellence". In Kolkata, there are also many technological institutes, medical colleges, law colleges and also vocational education training institutes.

Despite that history, over the last few years the scenario has become a bit worse with the more highly esteemed institutions, especially at the primary and higher secondary levels, demanding an increasingly hefty amount of money as tuition fees. Guardians have considered this sudden fee hike as irrational and unjustified, and they have protested against it.

Another important issue which has drawn attention in recent times, especially in a progressive metropolitan like Kolkata, is that the social economic status of people is now the primary measure to secure admission in the top reputed institutions in some cases. In recent years, many incidents have gone viral where eligible candidates with good marks and brilliance are deprived due to their "status" but at the same time the seat despite their academic achievements have found themselves frozen out by someone simply able to pay the price to take their place.

The only solution to this is a more rigorous approach to making the whole education system corruption free where the available "seats" in a college class are provided based on skill rather than economic affluence.

Transport

Kolkata, also known as the "city of joy", is one of the most culturally enriched and historically most important cities in India. It is also home to multiple Heritage sites.

The city stretches north and south along the eastern bank of river Hooghly (Ganga) in the famous deltaic basin of Bengal. It also located just 75km west away from Bangladesh international border.

Kolkata is also strongly connected to various parts of India as well as South Asian countries, both as a matter of history from the time of English colonial rule. As such, efficient transport has been a priority for centuries.

The transport services of the metropolitan area are a combination of modern mass rapid transport in the form of trains and buses, and old transport like rickshaws. The holy river Ganga, with ease of movement by boat, has also made trade activities and transport easier.

Kolkata is connected with the rest of the country by National highways 2, 6, 34 and 117; the two divisions of the extensive Indian railways: the Eastern and South Eastern railways; and by air.

The Netaji Subhash Chandra Bose international terminal at Dum Dum is the only airport in Kolkata metropolitan area which operates both domestic and international flights.

Howrah bridge and Vidyasagar Setu are the two famous bridges in the city; they connect Kolkata with Howrah over the river Ganga. Vivekananda Setu and Nivedita Setu are two more bridges of note. Many flyovers and bypass roads are also there to help Kolkata and its people minimize avoid traffic congestion.

Regionally, the Kolkata - Delhi and Kolkata - Chennai golden quadrilateral roads are two of the most important routes through which Kolkata is in touch with the country. The signature yellow taxis of Kolkata also add a special value in its transport networks.

Kolkata has had many firsts in transportation, including the first sub terrene railway system ever built in South Asia. Established in 1984, over the past 15 years the metro network of Kolkata has been extended to cover most of the city.

The city also has a large-scale network of government and privately run regular and minibuses. It is the one and only city in India with a running tram network. It is ecofriendly and has an age-old charm which attracts people.

Besides these, rickshaws, auto rickshaws, private cars, bikes, and booked cabs are an integral part of Kolkata's transport services and people's daily lives.

Being a multi-functional and polycentric city, with only six percent road space and a narrow street layout, Kolkata has been suffering from a gridlock situation due to rapidly increasing vehicular population. While the city provides a wide range of affordable options for public transport, the increasing tendency of those wealthier to own personal vehicles has made the traffic situation increasingly slow and hazardous for all, which also contributes to challenges for normal business to operate effectively. Further, due to a lack of holistic planning on transport, the city is of late seeing increasingly frequent vehicular accidents. Recent studies show that 51% of road casualties occurred at signalized intersections, using phones while driving and violation of traffic rules and signals.

What this all points to is the need for smart, integrated, adequate, and affordable means of transport facilities; fulfilling the demand for parking spaces; and promoting safe and secure urban mobility for all. Urban mobility impacts the city's overall economic health, education, environment, employment and internal security thus it holds the overall social economic livability, consistent improvement and vibrancy (Paul, Chatterjee, & Roy, 2020).[4]

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[4] Paul, S. K., Chatterjee, A., & Roy, S. (2020). Issues and Challenges for Transit-Oriented Development in the Scenario of a Developing Country: The Case of Kolkata Metropolitan Area, India. In *Perception, Design and Ecology of the Built Environment* (pp. 65-89). Springer, Cham.

Availability of Clean Water

Access to harmless drinking water is a main public health concern around the globe, and Kolkata is no stranger to the issue. Safe drinking water is scarce in Kolkata, despite the importance of the city to the region and the nation. That scarcity is a problem in itself, but the lack of scientific knowledge about how to keep water safe, including the sharing, storing, and cleaning of drinking water can cause acute health hazards among the population.

A report of 2015 shows that less than half the households in Kolkata have improved sanitation facilities. UNICEF and WHO both report that 67% of Indian households do not treat their drinking water in any way, even if it is chemically or bacterially contaminated. As a result, in India pneumonia and diarrhea, illnesses made worse in areas of poor sanitation, for 50% of deaths of children 5 years old or younger.

In July 2014 a cross-sectional study was conducted on five urban slums in Kolkata to understand how people handle water used for dinking and cooking. The study revealed that about all most do to treat water is to boil it. As a result, many suffer from stomach illness or diarrhea 1 to 5 times a year.

Based on other data from various secondary sources where they are published from West Bengal Pollution Control board and KMC, the reality is that in Kolkata even now good quality water supplies are below adequate levels, and what is available is inadequately distributed.

Underground water sources are also a problem, with much of it found to be contaminated with heavy harmful metals and toxins like arsenic and lead.

The water problem is made even worse as many are selling unhygienic, contaminated water but labeling it as clean, packaged water that is safe to drink.

Further, today, thanks to excessive extraction of groundwater for already depleted wells and aquifers, unregulated expansion, and high-rise construction, subsurface water levels have been depleted, causing structural scarcity of water resources.

According to Professor Pradip Sikdar of the Indian Institute of Social Welfare and Business Management in Kolkata, the city's groundwater demand may rise about 25% by 2025 from the present demand of around 310 million liters every day.

While there are many measures the city could use to improve the availability and safety of drinking water, those steps are -- so far -- well outside the capability of the city's management and facilities to handle.

Air Quality

One of the downsides of Kolkata being ranked as the 61st most populated city worldwide and the 28th most populated of all cities in India is the air quality is poor.

With high numbers of motorcycles and other small high-emissions internal combustion engines, Kolkata is plagued by high quantities of PM2.5 particles, ones with fine particulate – but highly toxic – outputs from those engines, with particles just 2.5 or smaller microns in diameter. Such small particles embed deep in the lungs and contribute to lung disease, cancer, asthma, bronchitis, COPD, and emphysema for many.

In January 2019, the readings sampled in Kolkata showed PM2.5 concentrations at 176.1 µg/m³, putting the air squarely into the 'very unhealthy' bracket. This puts the population at a high risk of adverse health effects, with young children, the elderly and those with a predisposition to being sick at the highest risk. Air pollution is a major giver to global warming and climate change (Bera, et al, 2021).

Air pollution also has a major impact on how living plants evolve, by blocking photosynthesis in many cases with serious outcomes for the purification of the air we breathe.

Besides the high concentration of people and the presence of many high-emissions fossil fuel engines, Kolkata is also home to many other dangerous sources of atmospheric pollution.

Burning of plastic bags, unfortunately one of the more common means of eliminating solid waste of this kind in Kolkata, emits harmful gases and needs to be minimized.

With the raising populations, construction dust and emissions from the use of cement are also an increasing problem.

Pollution is also brought in by breezes from adjacent agricultural lands, as they use "slash-and-burn" practices to clear land after crops are harvested.

Coal is also a major source of power in factories and industries located throughout the metropolitan area.

High levels of nitrogen dioxide in Kolkata's industrial regions are also a constant threat, with little currently being done to curtail it. Methane generation in landfills is another source of high pollutants, much of which adds to the greenhouse gas concentrations regionally.

Kolkata has enforced some incentives over the last few years to solve the growing concern of air pollution. The best answer to deal with the regional air pollution problem is to move away

from fossil fuels, substituting them with alternative sources like solar, wind and geothermal energy, and electrical alternatives for the vehicles involved.

Besides using clean energy, adopting responsible habits and using more efficient devices are also crucial.

Much money has been poured into the public transport sector to sustainably reduce air pollution. Using newer public transport infrastructure, noxious smoke and fumes released from diesel fuels have been lessened, though just slowly over time. The government should consider introducing regular pollution checks on all vehicles in the city with strict measures and penalties.

Thermal power plants also need to be regularly monitored.

Thanks to institution of some of these practice, present air pollution levels are now moderate in Kolkata with a reading of 79 AQI and a PM2.5 concentration of 25.5 µg/m³.

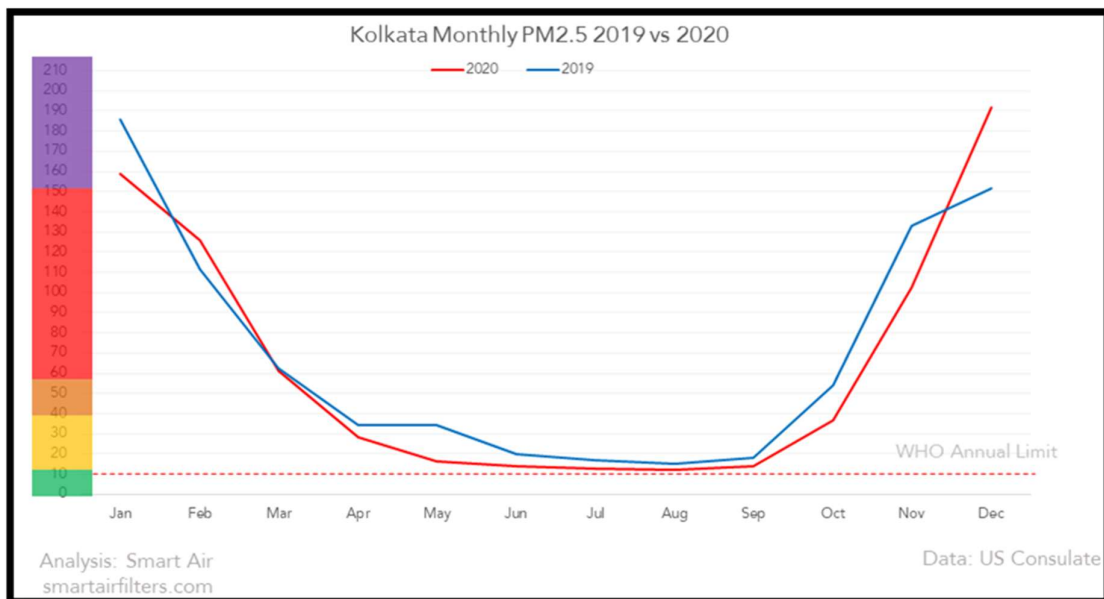*Image: Air Quality of Kolkata – Comparison of 2019 and 2020*
(Source: https://smartairfilters.com/en/blog/did-kolkatas-air-quality-improve-in-2020/)

That said, after analysing Kolkata's air quality data from the US Embassy, Smart Air found that air pollution did not improve in 2020 compared to 2019. With an annual PM2.5 level of 67 micrograms, the citizens of Kolkata are still breathing an average of over 6 times the WHO annual limit.

Pollution

Kolkata, one of the most water-abundant cities in India naturally, is becoming water stressed due to bad planning, criminal abuse of the water supply, and accumulated plastic waste in the environment.

Plastic pollution can be categorized as primary plastics, such as cigarette butts and bottle caps, or secondary plastics created as a result of the degradation of the first ones. It can also be categorized based on sizes from micro plastics, small particles of size less than 5 mm, to macro plastics.

Since the significant commercial development of plastic in the 1950s, its production has increased exponentially. But due to public negligence and a publicity program claiming plastic was easily recycled when just a few percent of it actually is captured and converted for reuse, plastic has now become a major source of water pollution.

This pollution comes from household waste dumped in landfills or abandoned in nature. This waste is carried by wind, and pushed by rains into sewers, streams, and rivers. These non-bio-degradable plastic bags clog gully pits, choke drains and trigger water logging in the city. Certain plastic debris contains potentially toxic molecules which can accumulate in the bodies through ingestion.

If that were not bad enough, it has also been observed that nearly 55% of the city's groundwater has high levels of arsenic compared to existing World Health Organization standards.

Industrial pollutants including heavy metals also leak into groundwater pipes.

Further, according to a report by FCA, 87% of reservoirs supplying water to residential buildings were contaminated with human excrement. Over 7 billion liters of raw sewage are dumped into the Ganga every day. At its worst the river contains 160,000 faucal coliform bacteria per 100ml.

Every day, other garbage, such as paper, aluminum, food, glass, rubber etc. are deposited into riverbeds. Tanker mafias also own septic tanks which illegally sell water from lakes, wells and groundwater.

Exposure to toxic chemicals coming from plastics can result in cancers, birth defects, impaired immunity, and other health problems. Water pollution can cause several diseases like diarrhea, typhoid, dysentery, or skin infections. Reducing the use of plastics to when it is necessary is the first thing to be addressed.

Numerous plastic items can be reused for diverse purposes, but recycling must be enforced and funded to continue to reduce the growing potential mountain of wasted plastic.

Increasing awareness and behavioral change is another crucial solution.

Wastewater treatment should also be introduced to remove pollutants through physical, chemical, or biological processes.

Stormwater management systems must also be introduced.

Finally, implementing advanced systems for reusing industrial water provides another significant step to decrease water pollution (Das, & Bhattacharyya, 2014).[5]

Energy Sourcing and Utilization

India is the world's third-largest energy-consuming country.

Kolkata is a major part of that problem, with an average power demand of 2,100 MW.

The use of fossil fuels as a source of energy produces significant amounts of damage to the air by creating Sulphur dioxide, nitrogen oxides, carbon monoxide, fly ash and different types of volatile organic compounds, in addition to the release of carbon dioxide into the atmosphere.

Sulphur dioxide emissions contribute to acid rain.

Acidic precipitation increases the acidity of water bodies which can be harmful to fish and other aquatic organisms. It also damages trees.

Coal-fired energy plants are the largest source of mercury pollution in the country as well. These mercury emissions settle onto the ground and are washed into water bodies where they are ingested by and accumulate in fish. That accumulation deepens when passed through the food chain into plants and animals.

As an added problem, consumption of mercury-laden fish by pregnant women also contributes to several neurological and neurobehavioral effects in infants.

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[5] Das, S., & Bhattacharyya, B. K. (2014). Estimation of municipal solid waste generation and future trends in greater metropolitan regions of Kolkata, India. *Journal of Industrial Engineering and Management Innovation*, *1*(1), 31-38.

Nitrogen oxides that contribute to ground-level ozone can also burn lung tissue and can cause asthma, bronchitis, and other chronic respiratory diseases.

The National Academy of Sciences estimated the costs of SO2, NOx and particulate matter in air pollution from coal and published an annual cost of $62 billion for 2005 or 3.2 cents per kWh.

The combustion of fossil fuels also causes increased levels of carbon dioxide in the atmosphere thus increasing the risk of global warming. In 2014 approximately 78% of US global warming emissions were energy-related emissions of carbon dioxide.

Use of low-grade coal, production of oil from shales or tar sands, burning of undried wood etc. particularly increase carbon dioxide pollution. These emissions contribute to a wide variety of public health and environmental costs.

Fossil fuel transportation emissions also represent the largest single source of toxic air pollution.

The demand for electricity is also colliding with the need for healthy fresh water. Fossil fuel plants are found to withdraw as much water as all farms and a lot more than all residences, just to keep them cool.

That power plant cooling water, usually taken from lakes and rivers, contributes to thermal pollution when it is returned to the original freshwater sources. This increases the heart rate of fish, destroys ecosystems, and decreases fish fertility.

Coal ash wastes also contain arsenic, mercury, chromium, cadmium, and are among the most highly toxic wastes produced in modern civilization. The presence of these toxic heavy materials in drinking water can cause cancer, birth defects, reproductive disorders, neurological damage, learning disabilities and kidney damage.

Oil and gas wastewater also impact aquatic life. Alternative sources such as wind energy and solar power carry very limited negative impacts at less prices and should be promoted instead.

Healthcare

Unpredictable costs, lack of proper infrastructure, and mismanagement are some ways to describe the healthcare capabilities in Kolkata.

The city has also been at the forefront of some very recent medical controversies. General medical negligence, expired medicine scams, and fake doctors' rackets are all unfortunately very common locally.

The system of health care in Kolkata consists of 48 Government hospitals under the Department of Health and Family Welfare and comprises 366 private medical institutions as of 2010. For every 10,000 persons in the city, there are only 61 hospital beds but that is at least greater than the national average, which is 9.

Ten colleges which specialize in medical services -- a feeder for new medical practitioners -- are located in the Kolkata metropolitan area.

For numerous reasons probably tied to poor water quality, health, and pollution, the fertility rate in Kolkata is 1.4, a very low number.

According to a survey in 2005 by the National Family Health Survey, a very small proportion of households in Kolkata are under any health insurance.

The infant mortality rate is around 41 per 1000 live births and the mortality rate for children below the age of five years is 49 per 1000 live births.

Obesity, anemia, diabetes, asthma, goiter and thyroid disorders are very common amongst the public. Diseases like malaria, dengue and chikungunya are also particularly common in Kolkata.

Medical facilities of all kinds are woefully inadequate to fulfil the healthcare demands of the city.

At least 78% of people of Kolkata prefer to go to the private medical sector rather than the public medical sector to address their concerns. This is because of the poor quality of care, excessive waiting time, poor hygienic conditions, and lack of facilities close to their home. Rural health centers also refer a huge number of patients to hospitals in Kolkata, leading to an excessive inflow of patients. While 25% of the best nurses in the US are Indian, Kolkata still experiences an acute shortage of nurses. People from Kolkata are now flocking away to hospitals in other parts of the country for better medical attention.

Chennai and Vellore over the last few decades have positioned themselves as inexpensive and reliable places for the treatment of the Kolkata citizens, and so the public has begun moving there for treatment more often.

To address some of the issues with the cost of private healthcare, the state government in West Bengal has recently proposed an alternative approach which could make private healthcare institutions more affordable to ordinary people. This law will review costs related to ICU, ventilation, implants, surgeries, and bed charges. Issues of overbilling, refusing to admit accident victims and holding on to dead bodies over no payment will be treated as a crime.

Extreme Weather Events

Kolkata is a city immersed in a tropical climate which is alternating wet and dry, with a wide range of differing weather conditions each year.

During summer temperatures can rise to 44° C and during winter it can fall to 5°C.

Thanks to ocean warming, thee ae now more cyclones – weather systems formed around a strong center of low atmospheric pressure, which causes winds to rotate inwards in a clockwise direction – encroaching on Kolkata via the hotter waters of the Bay of Bengal.

During summers, Kolkata is increasingly impacted by dangerous cyclonic thunderstorms. The 1970 Bhola cyclone, 1991 Bangladesh cyclone, 1999 Odisha cyclone were some very destructive cyclones. Super cyclonic storms were recorded to hit Kolkata in 1532, 1737, 1833, 1942 and 2020., with more storms of similar power happening each year.

Super cyclonic storm Amphan was the latest catastrophic tropical cyclone that caused massive damage. On 18 May 2020, Amphan reached its peak wind intensities of 260 km/hour and a very low central barometric pressure of 920 mbar.

Such cyclones or super cyclones usually bring with them many deaths. Electrocution and collapse of homes is a common scenario for such deaths. Overturning of vehicles, snapping of electric poles and breaking trees are also major causes of people being killed during cyclone impacts. Such storms can also trigger widespread flooding around the city.

Stagnant water associated with the storms, often present long after they have passed, can cause the spread of diseases.

Telephone towers and water pipes are also disrupted. In Amphan alone, over 4,000 electric poles were toppled over and much of the city lived without power for over 14 hours.
The final and usually most damaging problem with cyclones are storm surges; they typically acount for around 90% of tropical cyclone deaths.

Alipore is the major international weather monitoring station. During such cyclone forecasts, ports are cleared and marine operations are suspended for safety. Shelter homes are established in schools and community centers and residents of the low-lying areas are evacuated. Once the cyclones are over, brigades from the Indian army are usually deployed to deal with the damages, but with increasing numbers of storms and storm intensity it is becoming more difficult for them to staff appropriately to deal with them. Such cyclonic and super cyclonic storms are also extremely expensive for the Government as hefty amounts of immediate relief packages need to be provided to support recovery.

Loss of human lives can be decreased significantly with improved forecasting systems. The interruption of economic and civil activities, accommodation of displaced persons, the provisions of emergency relief and restoration as quickly as possible are the major challenges in terms of cost and social impact.

Sea Level Rise

In addition to extreme weather events, another by-product of the climate crisis is the continuing rapid melting of the Arctic, Antarctica, Greenland, and Himalayan glaciers and deep snow areas. That has contributed to sea level rises which are already afflicting many coastal areas around the world.

In Kolkata, which has built much of its city just barely above sea level, forecasts show that by 2050, much of Kolkata and its suburbs will either already be under water from sea level rise or at a high risk of annual flooding. When that happens, as many as half the population of Kolkata might face a need to migrate away from the region. To do so, however, would require planning to address what would amount to the biggest reverse urban migration in India history.
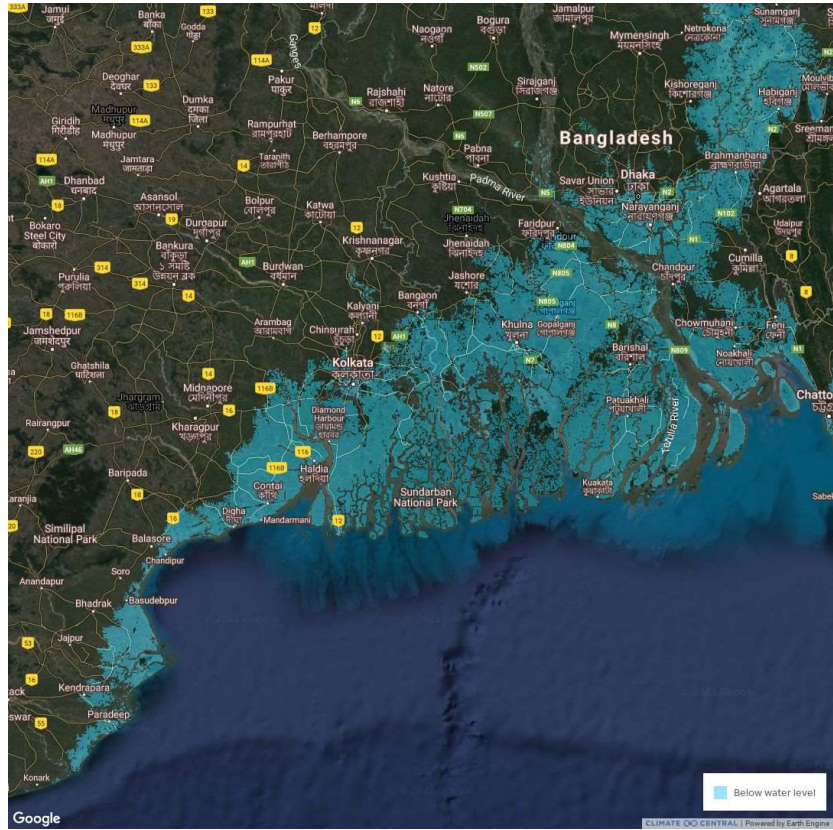
Land projected to be below annual flood level in 2050

(Source:
https://coastal.climatecentral.org/map/8/88.8533/22.3585/?theme=sea_level_rise&map_type=year&basemap=hybrid&contiguous=true&elevation_model=best_available&forecast_year=2050&pathway=rcp45&percentile=p50&refresh=true&return_level=return_level_1&slr_model=kopp_2014)

The Solution: An integrated development approach to building sustainable urban communities

In the sections above, some of the major challenges to be faced by the city of Kolkata between now and 2035 have been briefly described.

With the ever-increasing complexities visible in the environment and in planning for the increasing needs of a rapidly growing urban population, Kolkata presents a strong case in need of an integrated development approach to building sustainable urban communities. Improvements in the present governance framework cannot be achieved without thinking about the solutions from a grassroots perspective as well as through an integrated approach by looking at all the challenges as one big challenge instead of tackling them individually.

Thus, the framework to build sustainable urban communities keeping all the parameters in mind should be looked at from the following 4 dimensions:

Environmental Perspective

The pre-requisite to building sustainable urban communities requires scientists, civil society as well as governments to look at the challenge from an environmental perspective. This framework includes taking into consideration concepts and data from climate, ecology, energy, resource, and pollution.

The sustainability of the city's resources has become highly threatened by excessive exploitation of resources in recent times. Besides the severe damage to the air quality of Kolkata, unplanned and unregulated expansion of homes, industries, and some infrastructure also contributes to the widespread degradation of ecosystems throughout the city. Policy interventions should be reinforced by local authorities to preserve natural ecosystems within cities as well as other public spaces and heritage sites.

Furthermore, with the ever-increasing frequency of natural disasters and extreme weather events, disaster preparedness and disaster risk-reduction strategies must also be kept in mind while planning sustainable cities. According to Goal 13 of the United Nations' Sustainable Development Goals (SDG's), "*climate change presents the single biggest threat to development, and its widespread, unprecedented effects disproportionately burden the poorest and the most vulnerable.*"

Although the average temperature rise in India is roughly the same as the global average, Kolkata has seen the highest rise in temperature among the largest megacities of the Indian

subcontinent. What makes heat waves in Kolkata far more dangerous is the city's high humidity, averaging 75 percent in May and higher during the monsoon.

Temperature rise in India
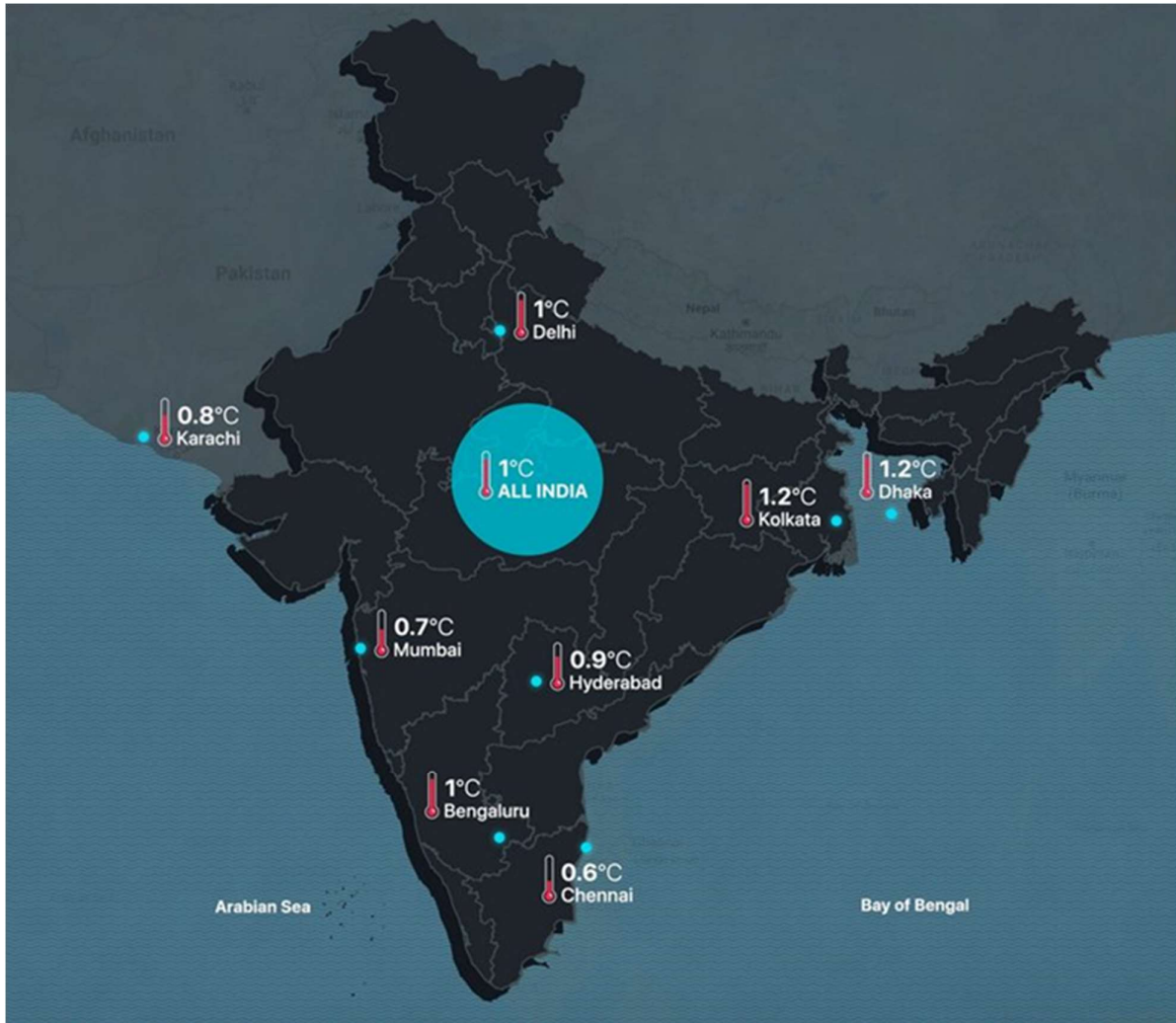
Communal Perspective

Though it should be the other way, in modern society it is often detrimental for stakeholders from diverse communities and sectors to collaborate with one another. That must be addressed by multiple means.

More public-private partnerships are also encouraged to ensure the efficiency of policy interventions.

An inspiration for such policy intervention can be drawn through Ahmedabad's Heat Action Plan. "It uses a simple, colour-coded early-warning system that alerts residents and city offices of predicted extreme temperatures and recommends precautions. The heat alerts then trigger a range of protective measures on the part of local authorities, such as increasing shade access by keeping all gardens and parks open throughout the day."

When looked at through the social perspective, any policy intervention should consist of four key strategies: forecasting extreme weather events and enabling an early warning system; building capacity of healthcare professionals to deal with emergencies; community outreach through various media; and integration of civil society, governing bodies, and scientists.

Governance Perspective

Kolkata was once a very compact, organised, and clean city. Walking to school and office was never a big deal. Residents often walked to parks and heritage sites in their leisure time. Today, however, it is impossible to walk in the city footpaths without tripping over at least ten people.

Despite the obvious need for it, public transportation has not been able to satisfy the growing needs of the residents, which in turn has contributed to large increases in the number of private vehicles in the city. This in turn has led to increased pollution levels, congestion, and traffic.

Acute housing shortages and lower levels of income has also led to infiltration of the roads by pavement dwellers. This has made governance difficult in the regions which need infrastructural development like the widening of roads. The Kolkata Municipal Corporation is popularly known to take up beautification projects in the city. However, people often fail to realise that these projects are one of the major factors contributing to Kolkata's extremely high air pollution levels as well as high carbon footprint.

Being a riverine and old city, Kolkata has plenty of bridges and heritage buildings, many of which were built years ago, including some dating back to colonial times. Because of that and for lack of funds and personnel, it is impossible to track the agency responsible for their maintenance as most of these infrastructures were built before independence.

Integrated thoughtful planning is also lacking in government. A few years ago, despite there being concrete evidence of the increasing vulnerability of Kolkata to climate change from emissions from internal combustion engines in individual vehicles, the government chose to

ban bicycles and eliminate many of the city's low-emissions trams. What should have happened would have been to secure investment in the modernisation of tramways by changing the old coaches, making them fast moving and restoring the original network of tram lines.

The lack of clarity in policy has made it detrimental for governing bodies to come up with policy interventions of just about any kind, despite the presence of models such the Smart Cities Mission.

Inclusive governance should be given priority in order to ensure the provision of basic infrastructure and civic amenities to all residents in the city, with that as a first goal but in consideration of the integrated approach recommended at the beginning of this paper. According to Ismail Haque et al., "holistic version of "inclusion" requires the dismissal of discriminatory exclusions; generation of equitable markets, services, and spaces; and the protection of human rights of the deprived groups."

Economic Perspective

Kolkata, the capital of West Bengal is home to many public and private sector industries.

The major industries cover a wide range of sectors including steel, heavy engineering, agriculture, jute, textiles, pharmaceuticals, and tourism to name a few.

The newer part of the city in the suburbs have also become home to many special economic zones and IT parks, with the IT industry having added many job opportunities and higher income for those in the software, electronics hardware, IT real estate, IT-enabled services, and IT securities industries. This has attracted companies IBM, Tata Consultancy Services, Samsung, and Genpact, to name a few.

The city is also the biggest tea handling port and tea auction market in the country.

Further in contrast to the older parts of the city, there is a new planned area situated on the northeastern periphery of the city called 'Newtown'. That area has been ranked 8th out of the 100 smart cities in the country by the ministry of housing and urban affairs.

All major civic related services for residents of Newtown have already come online.

Newtown has also received 2 out of 5 stars in the Climate Smart Cities Assessment Framework 2.0. The Climate Smart Cities Assessment Framework (CSCAF) is a first of its kind city assessment framework on climate relevant parameters. The framework serves as a tool for cities to assess their present climate situation and provides a roadmap for cities to adopt

and implement climate actions to help mainstream resilience. CSCAF consists of 28 indicators across five thematic areas, namely:

1. Energy and Green Buildings
2. Urban Planning, Green Cover and Biodiversity
3. Mobility and Air Quality
4. Water Management
5. Waste Management

The Newtown Kolkata Development Authority (NKDA) of West Bengal has also recently announced they are promoting the use of renewable energy and pollution free environment by making use of canal-top solar plants, using more solar panels, deploying electric buses, and using more battery run vehicles.

The authority is also responsible for the switching on of 25 EV charging stations last year, in a joint effort to set up India's largest public charging station and make the city more energy efficient.

New Town also bagged the Platinum Green City certificate issued by the Indian Green Building Council for developing cycle friendly roads, integrating land use with green and open spaces, e-mobility, wastewater treatment etc.

Although New Town has shown commendable results through their innovative plans and strategies and could be a good model to monitor in the future, there is still a long way to go before Kolkata can transition into a fully green and smart city.

Conclusion

With a combination of the old glory of Calcutta in its midst and under pressures from climate change and the urban density crush of a city with limited resources, Kolkata is challenged like few other cities to transform itself into a thriving city for the future.

While the city government has responded to these needs by focusing on the betterment of the economic health of Kolkata, that is proving to be far less effective than it needs to be.

A city such as Kolkata must be safe and resilient in the time of hazards, natural or man-made, problems of law and regulations and also socio - political disbalances.

Effective participation of citizens in the governance process, identifying and correcting the loopholes in the existing multiheaded authorizing structure should be ensured to allow the city government to deal with the problems of vulnerable populations.

The processes of urban planning must be reframed through the addition of more realistic approaches and integrated solutions for each category of problems being addressed. In the case of ensuring good health, it is necessary to have everything from proper shelter, nutrition, employment (to provide economic stability), housing/shelter, education, and access to clean energy.

Simultaneously inexpensive and rapid transport must be accessible for the working class to address the issue of increased geographical distance between housing and jobs. Public places must be safe for women, children, and senior citizens. For that, vulnerable areas must be well lit, monitored using CCTV without any negligence, and frequent police patrolling.

The framework of integrated approaches suggested in this paper aims at promoting a socially and spatially integrated city that wisely combines heritage with modernity, culture with effectiveness and quality of life with productivity.

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