

# Human Face of Climate Change

## From Risk to Resilience in Indian Cities



A Tale of Three Cities: Agra, Delhi, and Panaji



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This research paper is part of Tandem Research's 'Future Cities' initiative.

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Please cite the work as follows:

Tandem Research. 2019. Human Face of  
Climate Change. From Risk to Resilience in  
Indian Cities. A Tale of Three Cities: Agra,  
Delhi, and Panaji.

# **Human Face of Climate Change**

## **From Risk to Resilience in Indian Cities**

**A Tale of Three Cities**



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# Changing Climate, Changing Rivers

## AGRA, KATRA WAZIR KHAN, YAMUNA RIVER BED



Vulnerable communities living in informal settlements along the Yamuna riverbed face many challenges (*see Section 1*). Agra is rapidly urbanizing due to growth in tourism and settlements along the riverbed have been swelling (*see Section 2*). Climate change related impacts faced by the communities living in these settlements include increasing heat, dwindling water flows and the possibility of flood related risks and displacement (*see Section 3*). The ability of households to cope with these changes is shaped by their social conditions; caste for example can strongly influence their resilience to climatic changes (*see Section 4*). To seek a better quality of life, manage scarce resources like water, and deal with multiple stresses including climate impacts, individuals need to navigate the social structures that reinforce vulnerability (*see Section 5*).

# 1 Introduction



“I have grown up hearing that this entire place next to the Yamuna where we live will be taken from us by the government someday,” says 23-year-old Sunny.

Sunny lives with his family of eight in Katra Wazir Khan — an informal settlement at the edge of the Yamuna river basin within the municipal city limits of Agra. Informal settlements have grown along the entire southern and eastern bank of the Yamuna over the last couple of decades. The flow of the river these days is a trickle — the stream occupying only a tenth of the entire riverbed. The last rows of houses in Katra Wazir Khan are just thirty paces away from the stream, separated from the river by mounds of garbage.

In his lifetime, Sunny has seen the river water rise only once; almost touching their houses before receding. However, in 1978, the Yamuna had overflowed its banks and flooded nearly the entire old city of Agra, with water levels reaching 2.5-3 meter. As climate changes and glaciers melt, the seasonal variations in the intensity of flow of the Yamuna could become more pronounced. In the long term, upstream water management of the river will have consequences for Agra. As precipitation patterns change, upstream dams might need to release water, which would increase the likelihood of flooding in areas close to the river bed. In the absence of a river basin development controls regime, a large population that chose the riverbank for habitation is likely to be subjected to displacement, relocation or progressive deterioration of environmental services.

Water pollution is already a major challenge. Drainage channels carry untreated wastewater from the city toward informal settlements, leading to stagnation of untreated wastewater. Sunny’s uncle, 50 year old auto-driver Noor Mohammad, has moved to Mahua Khera in eastern Agra, roughly 8 km from the city center to get cleaner water. It takes him a while to get to work in the Taj Mahal precinct every morning, but he is happy to have moved. “The river was right there but water was always a problem.” he says, “There was always shortage of water for all of us. The water was so toxic that I was beginning to lose my hair bathing in it. I didn’t want that to happen to my children. I face a fair share of problems living in my new house, but water is cleaner and ground water level is higher because it isn’t overused like there. I am much happier.”

Climatic change impacts like increasing heat and infrequent precipitations, coupled with rampant urbanization and the pollution of Yamuna, have taken a toll on the local groundwater table. For residents of the informal settlements, these changes are more severe. A global tourist destination, Agra is undergoing rapid urbanization; but, marginal communities living in informal settlements are not part of the development story: Sunny and Noor Mohammad struggle to cope with a range of challenges in their everyday life, only aggravated by climate change.

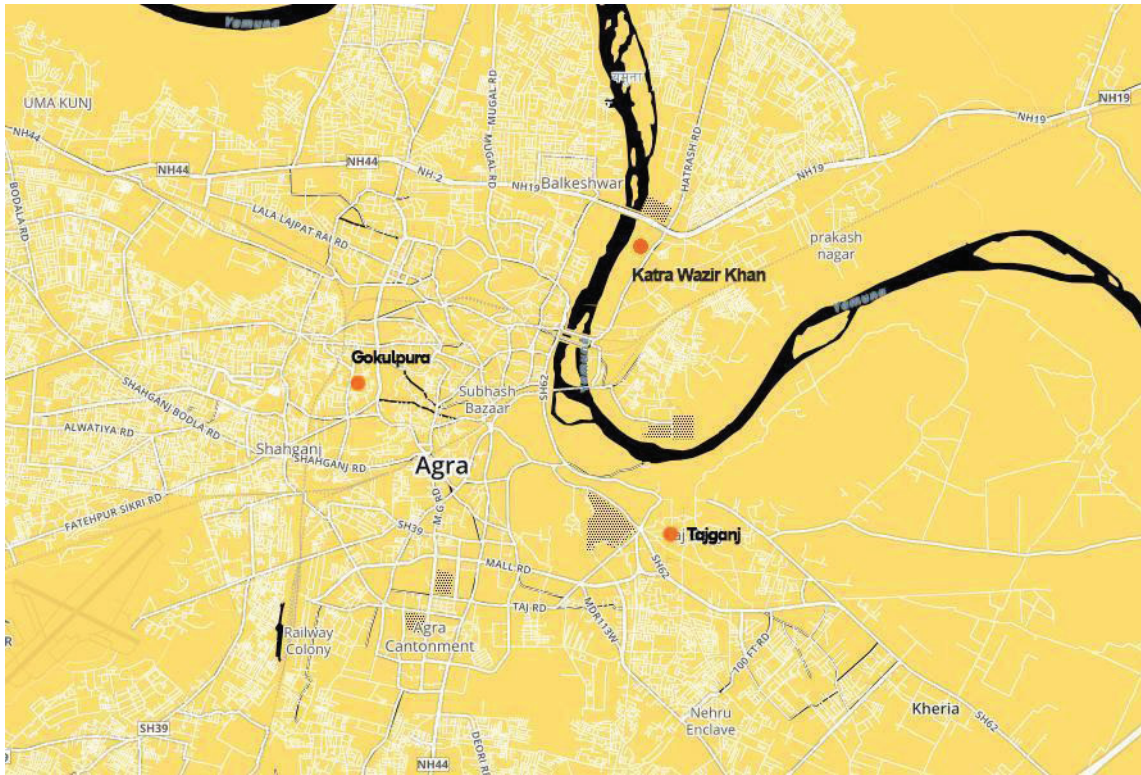
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## 2 Katra Wazir Khan





Agra has 417 informal settlements with 123,846 households making up for about 56% of the urban population.<sup>1</sup> Areas where these settlements are concentrated in Agra are Lohamandi, Rakabganj, Bundu Katra-Gwalior & Deori Road, Tajganj, Shahganj and Trans-Yamuna area. (See Map)

As per Census 2011, Agra's population increased from 1,275,134 to 1,686,976 at a decadal growth rate of 32.2%.<sup>2</sup> Growing local populations along with migrants from nearby towns and villages constitute the urban poor living in informal settlements. Katra Wazir Khan and Tajganj have a concentration of small-scale and household industries that, along with the large-scale industries west of Yamuna, form the industrial base of the city. Most residents are employed as informal laborers in manufacturing units for electric and mechanical goods, textile mills, foundries and transportation and logistics services. Many residents also pursue livelihoods dependent on traditional skills in making local handicrafts i.e. marble carving and

inlay work and leather goods. Like Noor Mohammad, a significant section of the urban poor also work in the thriving tourism industry in the city, working in restaurants and guesthouses or driving auto rickshaws.

The challenges faced by Noor Mohammad are not unique; access to clean water and sanitation is, by far, the most critical challenge faced by the residents in Katra Wazir Khan. A major source of water for the city is surface water from the Yamuna river. However, the water is contaminated and unfit for drinking. Most households in informal settlements throughout Agra do not have access to individual water supply connections and acute water shortage is a major issue. Further, informal settlements in Agra are also not connected to basic sanitation and municipal services. The absence of individual or public toilet facilities in settlements leads to the unsanitary practice of open defecation. Sewer lines are choked and untreated sewage from settlements along the river basin like Katra Wazir Khan flows directly into the river.

## 3 Climate Impacts



On May 2nd 2018 there was a severe dust storm followed by heavy rains throughout western Uttar Pradesh. “It started at 7 in the evening and just kept getting severe. Trees had fallen all along the road. I had to park the auto at a friend’s house and walk back. My phone was damaged by the rain and it took me two months to get a new one”, said a distraught Noor Mohammad. Agra’s better-off residents welcomed the rains and respite from the heat, but many houses in informal settlements were reduced to rubble, flooded, and left without any electricity. That night 43 people died in Agra.<sup>3</sup> The storm was said to be caused by a confluence of conditions — abnormally warm temperatures, high levels of humidity and dust storms.<sup>4</sup> All of these are factors which are increasingly attributed to climate change and could get further exacerbated as global temperatures rise.

Direct impacts of climate change on Agra include rising mean temperatures, extreme heat waves, and flooding. Agra shows a stronger trend of warming than surrounding cities of Delhi, Jhansi, Jaipur and Ajmer at 0.18°C/decade annually.<sup>5</sup> Average surface temperature has increased, creating urban heat islands within dense informal settlements. Inadequate shading, and long term exposure causes heat stress— well-described physiological cumulative impacts of heat stroke, heat exhaustion, heat syncope and cramps.<sup>6</sup>

Groundwater level is steadily declining throughout Agra.<sup>7</sup> As water supply does not reach all informal settlements, the government has provided hand pumps and public taps, shared by a large number of residents. These often dry up in summers. Communities in informal settlements are hence left to the mercy of

private water tankers and informal water markets. Water quality in the settlements is poor, affected by high pollution levels, improper drainage and waste disposal and contamination from landfills.<sup>8</sup> Poor water and unsanitary conditions leads to adverse effects on the health of households living in informal settlements. With adverse topography, erratic rainfall, rapid urbanization and overused groundwater, drought is a very real concern in Agra.

Streets often become dumping grounds for household garbage, easily prone to infestation from vector borne-diseases. Waste water is similarly disposed in the Yamuna River. In the absence of a functioning sewage system, the gray water and waste water from houses is directly dumped into the open drains along with solid waste leading to a choking of drains. As a result, water logging is prevalent in the informal settlements and this in turn has direct consequences on the health conditions. This situation is aggravated during heavy rainfall or events of flooding, especially for settlements along the Yamuna riverbed.

Water control barrages operated by neighboring states and extreme precipitation in upper catchment areas leave informal settlements along the Yamuna basin at risk of flooding. Unplanned urbanization is impacting natural drainage patterns and growing population contribute to increasing waste water outflow into the river. A large number of settlements in low-lying areas along the river bank (like the Trans-Yamuna informal settlements), who chose to live there for the locational advantage of being closer to the city, are at risk of displacement due to the changing course of the river.

## 4 Social Vulnerabilities

In a tight, poorly-ventilated room in Kans Gate, Gokulpura, 34-year-old Sanjay sits with five other men ploughing away with a hand drill for 14 hours every day. They sit on the floor, sweaty faces masked by rags to avoid breathing in the white dust floating through the room. He carves hundreds of the miniature Taj Mahals from marble blocks to sell to shops in bulk. “I moved because Agra is where the big factories in this work are, where we get our orders from.” Sanjay is a migrant from Benares, like others in the room. They acknowledge that working conditions are hazardous. “This is not something I want to do all my life; many like me come here work for some time, then go back and do other things.” Depending on their skill and pace they make anywhere from 300-500 INR a day. He has been doing this for over 8 years now.

Climate plays an important role in worsening their conditions. He recalls when two years ago their

local bore well dried up. Water is crucial in the carving process. They had to travel a kilometer to get water from the closest public tap, and started buying additional bottle water for drinking. “We are doing work that is killing us, if we drink that [groundwater], it will definitely kill us. After 45 [years], this work is hard to carry on; ‘til the body has the energy to do this, we do it.” Contamination of water and outlet of effluents into the river has exposed residents in Agra informal settlements to skin irritation, respiratory problems and other diseases. 0.3% of the city population is suffering from Tuberculosis and 0.5% from respiratory problems.<sup>9</sup>

A large group of such laborers work on low wages to meet the needs of small shops and export houses in marble inlay and shoemaking. Small industries which used to work intimately with craftsmen are quickly shutting down. Those that have lost business to big



**Table 3-5 : Distribution of Slum population w.r.to different social groups**

Particulars	SC	ST	OBC	Others	Total
Total slum population	428116	10314	344850	102521	885801
Total Households	57338	1488	55111	9909	123846
Total BPL population	5371	50	2813	83	8317
Total BPL Households	895	6	467	17	1385
No. of women headed households	4005	86	3775	335	8201
No. of persons > 65 years	15091	201	14161	2167	31620
No of child labors	19253	360	17580	1654	38847
No. of physical handicapped persons	1195	20	897	111	2223
No of mentally challenged persons	358	8	305	14	685
No. of Persons with HIV-AIDs	10	3	9	1	23
No. of persons with tuberculosis	1511	17	866	52	2446
No. of persons with Respiratory diseases	2248	20	1610	127	4005
No. of Persons with Other Chronic Diseases	556	7	380	21	970

*Source: Primary survey, 2011*

Source: RAY: SLUM FREE CITY PLAN OF ACTION, RCUES Hyderabad

factories employ hundreds of men like Sanjay.

Their situations are shaped by complex social vulnerabilities. The general composition of the majority of informal settlements comprises of scheduled tribes (ST), scheduled castes (SC), and other backward classes (OBC), forming the weaker sections of society. Among the informal population in Agra, it is important to note that 87% belong to the OBC and SC divisions of social groups.<sup>10</sup> While caste plays less of a role in the daily lives of the upper and middle classes, there is evidence that it still plays a major role in the employment, education and living conditions of the lower caste groups.<sup>11</sup> Livelihoods of people in informal settlements are based on unskilled or semi-skilled work. Inhabitants work on low, irregular wages and on informal terms, creating economic vulnerabilities which subsequently make them more vulnerable to climate change impacts than others.

Children in many households have to work to

supplement household incomes. While many children are enrolled into schools, they don't stay in school for long. Children from lower income groups drop out. Their reasons range from a lack of interest on the part of these children or their parents, compulsion to work, or the need to look after younger siblings.<sup>12</sup> Unmonitored small industries in households are where many children end up working as laborers without fixed timings. Missing out on timely education opportunities, children in the informal settlements of Agra become trapped in a future of low wage unskilled jobs.

## 5 Coping and Resilience

Households in Katra Wazir Khan are engaged in informal and insecure labor with limited livelihood security. They face a range of direct and indirect climate impacts that cumulatively create very poor living conditions. These impacts are felt and acknowledged; however, the lack of resources makes adaptation a lesson in perseverance. Katra Wazir Khan is also prone to flooding. Houses here are built on plinths that are raised one or two feet off the ground. In front and alongside the roads are open drains that have to be kept clean to avoid waterlogging. During hot summer afternoons, residents use the plinths as platforms to sit on outdoors in order to escape high indoor temperatures, as well as to socialize with their neighbors.

Many households, especially in Tajganj — part of the old city informal settlements — have lived together for decades, resulting in strong social bonds among communities that come from same caste groups. Solid waste and sanitation management are big issues here: residents pool efforts to maintain some cleanliness and hygiene in their immediate surroundings, but the fringes of the settlements, along the riverbed, are used to openly defecate and dispose garbage. Many households living in the informal clusters do not have the means to provide for their family on a regular basis. Traditional craftsmen during interviews spoke about their unemployment and struggle every year during the hotter months when tourism-based livelihoods were impacted. Many restaurants and other tourism-run businesses, including export houses, lay off staff in these months. For the unskilled and uneducated urban poor, these livelihoods are unfavorable and

many cope by diversifying their livelihood strategies and pursuing various forms of trading activities.

Before renting an auto-rickshaw, Noor Mohammad used to be an inlay craftsman with his family in Tajganj. He remembers a time when it was a respected job. “There used to be time when, if a man was working in ‘Galicha’ (carpet making), they used to say get your daughter married to him before anyone else does. The same used to be the case for marble handicrafts or leather shoes. Now if you tell someone you work in shoes, then you get shoes— his work is dead. He can only work in a factory. All small businesses have shut down”. It is difficult to isolate climate-related stresses from the multiple other stresses that communities in informal settlements face on a regular basis. Effective climate response would include strategies to resolve larger issues of development within these communities. If one has a steady income and stable livelihood, then adapting to climate impacts is easier.

Macro-level initiatives introduced by the government have helped improve the conditions of urban services. Under the Pradhan Mantri Ujjwala Yojna scheme, LPG connections were provided to below poverty line (BPL) households at higher rates, but, the exceeding amount was refunded in the bank account of a female household member. The scheme helped many households open their first bank accounts. Sunny’s household has a toilet, though the family rarely uses it because the drainage beyond their walls doesn’t flow. The Individual Household Latrine (IHHL) scheme allocated funds for urban poor households to build their own toilets. However, the scheme faces many

challenges. The application process was embroiled in corruption, not transparent, and many households were denied funds even after they had completed the process.

There were several stories where the involvement of the private sector became an enabler for small businesses and individuals. Ever since the Electricity Board in Agra was privatized by Torrent Power Ltd in 2009, even the smallest households in Katra Wazir Khan received an electricity meter, curbing rampant theft and power cuts. Initial backlash at their higher surcharges has subsided and residents have now come to accept the benefits of a stable urban service. In Noor Mohammad's case, his smart phone allowed him to marginally increase profits by registering on apps. Local food and guesthouses have tapped into online spaces like Zomato, Google maps, TripAdvisor or self-made websites.

Left to rely on their own means, these communities often came together to seek solutions to better their conditions. This was widely seen in the common practice narrated by many where neighbors would pool together money to solve issues of water shortage. While individual residents were clearly economically vulnerable, together, they became resourceful.





## 6 Policy and Action



Resilience needs and efforts vary by household and location. Therefore, communities living in informal settlements, especially those lying along the river basin need tailored policies, support, and assistance to address resilience building because of a history of social inequities and systematic underinvestment in basic urban services and infrastructure. Governing institutions in Agra lack the tools, resources and capacities they need to effectively serve an increasing informal population and the people themselves have limited social mobility and access to information. In order to change that, developing adaptation strategies at multiple scales with the government, civil society, and private sector is imperative.

The first step to achieving this is creating a framework for vulnerability assessment with the assistance of civil society organizations and research institutions. Evidence-based vulnerability assessment is key to learning from the experiences of informal households, complementing policymaking and programming processes at local, state and national levels. Successful adaptation measures by individual households can be scaled up and implemented on a larger scale. Policies providing individuals living in informal settlements with economic stability, and empowering community members to engage in local politics will aid capacity building efforts. An assessment framework will also be useful for local stakeholders and community members to track progress.

Acting alone, federal, state, and local governments cannot address the extent of climate resilience

challenges. These challenges can be partially addressed through more effective public and private partnerships (PPPs). While the number of PPPs assisting communities and states with building resilience has grown in recent years, most are limited in their duration, scale, and financial resources.

A large section of the urban population in Agra depends on small and medium enterprises that need fast-track policies that standardize traditional and tourism-based livelihoods, alleviating employment conditions and providing dignity of labor. Initiatives to help poor households improve conditions of urban services and household facilities such as sanitation, drinking water, etc, are important at local levels. This would entail introducing financing mechanisms such as tax credits or easy loans to provide incentives for resilience-based retrofits for households, among other efforts.

Current housing models in these settlements have no tenability, are highly dense, and in deteriorating conditions. Due to their physical location along the riverbed, drains, or close proximities to high power lines, relocation is often the necessary solution. There is a need to introduce a strategy for supplying affordable housing to the urban poor at the same time as prevention of illegal encroachment. Often policies fail to take into account the urban fabric and the needs of these vulnerable groups, displacing them from their sites of livelihoods. From an urban planning perspective, there is a need to create ways to upgrade infrastructure and settlements responding to the needs of the community and context.

At a state level, decisions regarding public infrastructure, land-use management and public investments need to include resilience thinking into policymaking. Furthermore, state level directives aimed towards climate change need to be implemented on the ground. In the absence of accounting for future impacts associated with climate change, infrastructure investments and land-use commitments can have costly long-term ramifications (e.g. high maintenance costs, public health and safety risks, stranded assets, etc). In the context of the Yamuna, there is a need to prioritize developing relocation guidance as a resource for communities where relocation is an effective and necessary solution.

At a national level, climate resilience policies need to be mainstreamed, ensuring that long-term infrastructure investments and commitments incorporate future climate-related risks. All government-funded projects, development agencies and infrastructure planning should incorporate the best available climate data and projections. A portion of national disaster assistance should be mandatorily allocated to address the resilience needs of the poorest and most at-risk communities. This could include funding pre-disaster training for local government officials, emergency responders, and community leaders in high-risk communities.


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# Double Burden of Climate Change

## DELHI, KHIRKI AND HAUZ RANI



Climate migrants from rural areas who end up in informal settlements within megacities face a new set of climate-related vulnerabilities (*see Section 1*). In a rapidly urbanizing Delhi, residents in informal settlements of Khirki and Hauz Rani do not have access to any municipal services provided by the Government (*see Section 2*). Residents increasingly face challenges due to heat waves, water scarcity and unpredictable and changing rainfall and weather patterns (*see Section 3*). Migrant workers, who lack identity and social moorings are often most vulnerable to these changes (*see Section 4*). Their coping measures are limited to their individual agency and efforts and restricted due to lack of social networks within the communities (*see Section 5*).

# 1 Introduction



Every morning, masons and laborers from the informal settlements of Hauz Rani and Khirki in New Delhi wait with their bags of tools at a busy road intersection, hoping that they will be hired as daily wage workers on nearby construction sites in the affluent neighborhoods of South Delhi. Among them is fifty-year old Rahit, a migrant from a village near Sitapur in Uttar Pradesh. For many like him, the impact of climate change on agriculture is already being felt. “Crops don’t grow well in this heat,” he says, “they use much more water to irrigate. I moved here because my family wasn’t making enough money from farming anymore.”

Unfortunately, this narrative is typical of a many urban poor living in informal settlements, many of whom will only earn 300 to 600 INR per day. Rahit’s six roommates, whom he shares a room with since moving to the city eight years ago, work alongside each other as laborers during the day and often spend the nights working shifts as security guards.

Urban and rural areas are inexorably interlinked in the stories of climate resilience in India. Climate impact on agriculture is exacerbating migration to urban areas as well as rendering informal settlements and rural migrants within cities increasingly vulnerable. Rahit and those that share the same fate— the landless, small or marginal farmers with limited skill, capital and social networks— are perhaps the most vulnerable groups to climate change in India. Displaced from failing crop cycles, drought, extreme weather events and debt, they move into illegal, unserviced urban

settlements only to get further exposed to new urban environmental hazards and climate-related risks.

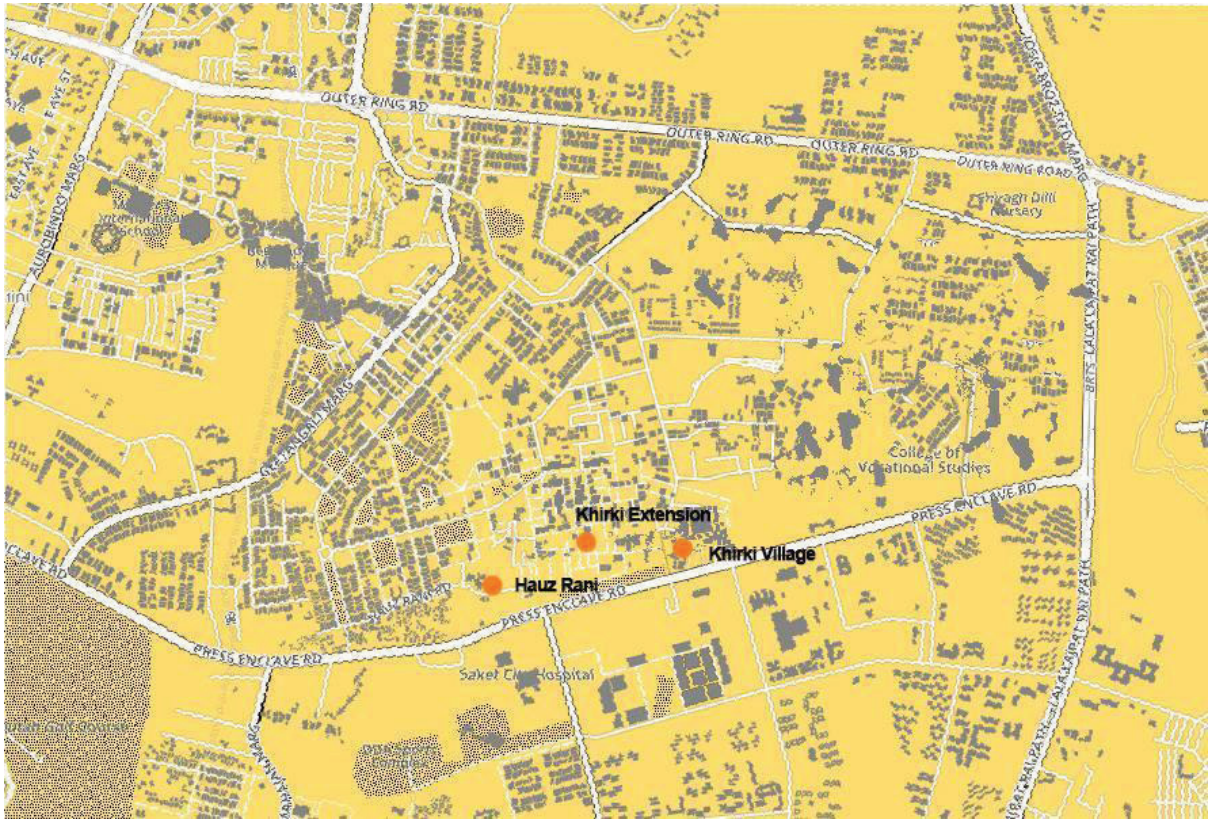
Rahit waits for work with other men every day from seven in the morning until the late afternoon, standing for hours on end in the heat of Delhi summers that reach temperatures as high as 45° C. He is often thirsty and without access to drinking water taps and affordable packaged water. Even after suffering from a heatstroke recently, he was back at the labor chowk the next day in the search for work.



## 2 Hauz Rani and Khirki







Hauz Rani and Khirki are informal residential settlements clustered around green spaces and historical monuments in Delhi's affluent South Delhi district. Both Hauz Rani and Khirki have a complex urban morphology, where different types of settlements coexist - residential neighborhoods; unauthorized colonies; urban villages; Jhuggi Jhopris; and informal settlements. While much of the population in the area shares similar socio-economic features, some areas of Khirki Village and Extension have more diverse occupants ranging from middle-class households to temporary housing. Hauz Rani, on the other hand, is a predominantly Muslim settlement, densely packed, and with limited access to urban services.

Khirki village consists of clusters of wall-to-wall houses and narrow lanes, on small plots arranged in an organic pattern attributed to Lal Dora areas (former village land for used for non-agricultural use). The Khirki precinct is home to the historic Khirki fort and Satpula Bridge, that, when juxtaposed with the residential colonies of houses rapidly being converted into flats and apartment, highlights the overflowing demand for housing in the area. Exempt from building

bylaws and strict construction guidelines— as regulated under the Delhi Municipal Act<sup>1</sup> — Khirki was host to rapid and unauthorized construction with little to no oversight.

Residents include original village households, students and white-collar professionals living on a short-term basis, and migrants from other towns and villages. Those who have chosen to live here compromise on amenities and quality of life for the area's locational advantage, lower rent and closer proximity to work. Furthermore, Khirki is also experiencing gentrification, with emerging arts practices building new studios and artists moving into the neighborhood.

Flanked by Malviya Nagar in the north and Saket in the south, Hauz Rani is a dense, intricate maze of built structures, narrow streets and a population living in deteriorating urban conditions. Hauz Rani is home to a large population involved in informal work just like Rahit. The majority Muslim settlement — with a large Afghan refugee population— retains rural characteristics with self-sustaining local businesses and coexistence of different social groups.

## 3 Climate Impacts



Across India, annual mean temperatures are projected to increase by 2–5°C by the end of the century.<sup>2</sup> Consequently, several weather conditions including sunshine hours, average temperatures, humidity, and precipitation are likely to be affected.

Delhi has a semi-arid and sub-tropical climate and is as such very vulnerable to rising temperatures and heat waves and changes in rainfall patterns. Delhi experiences micro and meso-scale heat waves, more pronounced in the city than in nearby rural areas because of urban heat island (UHI) effect. Higher temperatures due to climate change may increase the incidence of heat-related mortality, especially for the urban poor.

27-year-old Itrar lives in a household in Gupta colony, Khirki Extension, with his parents and four other brothers. He drives an auto rickshaw while his brothers work on construction sites. His father moved to the city twenty years ago and started a clothes shop in Khanpur, another informal settlement nearby. “Last month I had serious cramps and had to go to a doctor. I was out all day in the sun getting customers. The doctor said my condition was caused by dehydration. Food poisoning is possible in summer because food spoils quickly.” In many places, heat only magnifies the persistent urban problems, including a shortage of basic services like electricity and water. If temperatures continue to increase at their current pace, heat and humidity levels could become unbearable, especially for the poor like Itrar, making them more prone to dehydration or starvation.

In the case of rainfall patterns, changes could, in turn, lead to an increase in the frequency and intensity of extreme weather events. This can go both ways—unseasonal and heavy rains can cause floods, and long dry spells can induce drought-like conditions and

scarcity of water. India is experiencing a mean increase of annual precipitation by 7 to 20%.<sup>3</sup> This leaves cities like Delhi at a risk of floods during heavy rainfall. Flooding in Delhi can do more than disrupt urban systems and damage the existing infrastructure—it can also increase the spread of waterborne diseases. This is particularly dangerous for communities in informal settlements that have poor sanitation facilities and little or no access to affordable healthcare.

Further, urbanization impacts the flow and recharge of groundwater, which can no longer support families like Itrar’s. In fact, groundwater levels in several parts of Delhi have gone below the twenty to thirty-meter mark. Water supply to Khirki is only partially supplied by the Delhi Jal Board’s Water Treatment plant in Sonia Vihar—the main source of water to most of Delhi. Meanwhile, Hauz Rani almost entirely depends on groundwater which the households access through bore wells. The surface and groundwater that is accessible has high levels of salinity and beyond-permissible chemical concentrations like nitrate and fluoride.<sup>4</sup> Poor water resource management in cities, in addition to overexploitation of groundwater, causes a sharp drop in water tables throughout the Indo-Gangetic plain.<sup>5</sup> Facing these shortages, many households and individuals rely on informal water markets, buying expensive water from tankers operated by private players.

In addition to climatic changes, city residents are exposed to fog, dense haze, and winter smog.<sup>6</sup> Suspended particulate, coupled with hot and dry winds from plains of Northwest India, leads to major dust storms every year. Such extreme weather events tend to increase death and pathology rates directly through injuries or indirectly through diseases.

## 4 Social Vulnerabilities

When settlements are classified as informal or unplanned, they confer varying shades of social citizenship for communities, causing differential access to basic services, systems and opportunities. Within informal settlements, this exclusion is further amplified for the most vulnerable sections of society during a calamity i.e. rural-urban migrants, casual laborers, economically-insecure informal workers, excluded minority communities, inhabitants of ‘jhuggi-jhopri’ (JJ) clusters, and women.

Access to livelihood opportunities shapes adaptive capacities to climate change impacts. Informal employment accounts for 93% of the urban workforce. Casualization of labor is now seen as directly linked to poverty and employment status.<sup>7</sup> The highest percentage of urban poor— 53% among men and 62% among women— are casual laborers.<sup>8</sup> With low wages and no job security or regular contracts, these groups have a high incidence of poverty.

An economically vulnerable household or individual is unable to afford the means to adapt and build resilience to climate change. In cities like Delhi, the share of the already-large informal and unorganized sector has been increasing in the recent years.<sup>9</sup> People working in the unorganized sector, many of whom choose to live in low-rent informal settlements to be closer to work, are primary inhabitants of these areas.

Pradha Mantra, age 45, makes a living by selling steel utensils and wooden artifacts along the Press Enclave Road in front of Max Hospital. She has lived by the roadside in a kutch house of brick walls, under a roof of salvaged materials, for over a decade. Several small clusters of such households are encroaching roadside pavements, drains, and unoccupied plots in

and around Hauz Rani and Khirki. Living conditions for these households are alarmingly bad. With precarious shelters of semi-permanent brick walls and makeshift roofs, these structures lack any provisions for decent water, sanitation and sewerage services. “Every time there is heavy rain, our roof starts leaking and water from the adjacent drain overflows, flooding into our houses.” These houses lack formal sanitation services, giving members no option but to defecate in the open. For women and children, this presents extremely unhygienic and unsafe living conditions.

“Mosquitoes are a big problem. The sewer connection outside our house easily gets choked and overflows onto the road. We have to walk through it to go to work every day,” says Itrar. His mother is the only member in the house with medical insurance. When she contracted malaria during last year’s monsoon, she was admitted into a private hospital nearby which put the family through financial stresses. “We wear full sleeved clothes, sleep in mosquito nets and use repellants but unless this street is fixed by the government, there is only so much we can do.”

Communities that are restricted from public spaces— like in the case of Muslim-dominated Hauz Rani, where there is a limited presence of females in public spaces—are less cohesive socially.<sup>10</sup> It is spaces like this where there is already inequitable access to services and resources that the effects of climate change will be felt the most. It is during hazardous situations like those caused by climate change where these social inequalities play out more than ever.<sup>11</sup>



## 5 Coping and Resilience



Individual capacities for coping and resilience in informal settlements within a city differ across households. These distinct needs are shaped by their built environment, livelihood security, and social status. Households in both Hauz Rani and Khirki face heatwaves in the peak summer months from April to July. Dense, unplanned housing means every inch of available space is utilized, including outdoors. Poorly-ventilated inner rooms can be kept cool through desert coolers, but residents must resort to frugal solutions of makeshift canopies over shopfronts and windows to keep out direct heat. Flats within unauthorized colonies are prone to flooding during monsoon— to avoid this, residents construct raised barriers in front of their gates so rainwater and overflowing sewage does not seep into their basements.

For poorer families and individuals, and those living in informal settlements like Pradha, survival is a struggle. Pradha reasons her condition is worsened from the lack of recognition by the state. “We have no Jaati Praman Patr (caste certificate), which makes it hard for us to seek any help from the government. We are refused an address by authorities who come to check our house, so we cannot install an electricity meter, or apply for gas, or open a bank account. Some of us don’t even have ration cards.” Many people in these temporary housing clusters are trapped in a chain of inaccessibility due to lack of proper identification or address proof; they have no legitimate way to seek state support or urban services, thus restricting their adaptive capacity. Individual attempts at ‘making-do’ are limited to traditional inexpensive innovations

and precarious alternatives. For example, households use an earthen pot for cool water, jute hand fans, and sometimes portable stoves that run on gas cylinders from the black market. Though many have expressed their willingness to pay for these services, they resort to the easiest option of electricity theft to run lights and a floor fan in their house.

There is a lack of social cohesion among neighbors in Khirki Village and Khirki Extension, largely because the majority of the residents are temporary and socially stratified, with no avenues to socialize. Closed communities Afghani and African refugees live in densely concentrated districts. For migrants like Rahit living without a solid community base to rely on, is challenging. Limited social networks restrict him from seeking support. There is no job security or savings to tap into. Lack of social safety nets and community identity means that adaptive measures are based only on an individual's agency, efforts and capabilities.

Resilience depends on the strength of the community's social cohesion, for example in an old settlement where Muslim households have lived together for generations —Hauz Rani — social networks and friendships serve as a source of strength during hard times and extreme events, despite the lack of external support from the government. Residents pool together resources to confront the neighborhood's issues: sweeping of streets happens through private arrangements; neighbors collectively install private submersible pumps or issue water tankers to meet shortages; the community takes help from local labor to solve everyday infrastructure

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breakdowns of potholed roads and clogged drains. It's important to note that faith is a strong contributor to social cohesion among these residents, with the local mosque being an important community building and socializing space in the otherwise congested settlement. The presence of viable public spaces at the periphery of the settlements, where smaller buffer public parks and a well-maintained privatized park are frequented by the local public, also help shape cohesion of the community.

At a macro level, the National Action Plan on Climate Change in 2008 was a precursor to Delhi's own Climate Agenda of 2009, under which several missions were setup to support initiatives on an urban scale. These initiatives do not address the special needs of informal settlements. Small grassroots undertaken

by local organizations in the form of cleanliness and plantation drives, training and skilling for local youth, empowering local enterprises, or even street art, help instill a sense of community participation in Khirki neighborhoods. Though residents in these settlements show awareness about adverse climate impacts, they still lack means to cope with these changes.

## 6 Policy and Action



The impacts of climate change are highest on poor and marginal communities and therefore policy interventions need to reflect a bottom-up approach towards building resilience. At the same time, tackling the broader problem of climate-induced impacts requires a set of top-down guidelines and policies. Hence, policy guidelines should propose a mechanism for multilevel engagement to help develop a complete ecosystem for urban climate resilience with defined roles and responsibilities for all stakeholders.

Households within informal settlements employ a variety of low-cost solutions which can be successfully deployed on a larger scale. Small measures like free public water taps, reflective paint on roofs, and training of medical staff to identify early signs of climate-induced diseases, can help reduce mortality risks. Specific awareness campaigns and outreach programmes in collaboration with local NGOs and community leaders can sensitize communities towards resilience efforts.

Climate adaptation at the grassroots can only happen when measures are taken to provide social and economic security to vulnerable groups. Tenure security, employment, financial insecurity, and social networks also affect the sensitivity of the urban poor to climate change and disaster risk. Economic vulnerability hampers their investments in services and housing improvements. Therefore, within these informal settlements, steps need to be taken to identify and issue land and property licenses or right of occupancy to improve security of tenure, which could

be used as collateral for economic empowerment. Strong social networks are important for some communities where residents work together to build resilience at the local level, to which end, a community engagement model should be encouraged involving local organizations, incentivized companies and institutional participation. Interventions should include a special focus on issues of gender and social inclusion.

Presently, the National Disaster Management Authority (NDMA) annually prepares Guidelines for state governments to implement Heat Action plans to mitigate impacts of heat waves. The mandate to address the issue falls under different ministries and departments both at the national, state and local level. It is imperative that similar guidelines on specific climate vulnerabilities are mandated to state and city authorities to ease implementation. From an urban planning perspective, apart from allocating funds towards upgrading urban services and infrastructure within informal settlements, planning institutional bodies should observe capacity-building to assess the long-term impacts of climate change for the city.

At the national and sub-national level, climate resilience needs to be mainstreamed into policy dialogues, and adaptation measures need to be identified and implemented. These include improvements in public communication; resilient infrastructure; developing weather warnings systems; and consideration of climate impacts in planning and development policies. This needs to be a more system-driven and multi-layered approach, requiring



national and state level involvement, public private partnerships, and technical innovation to work in unison.


There are certainly areas where more research and innovation are needed, such as the development of zero emission, low energy, low-cost, cooling systems; low-cost reflective paints; green building techniques that can regulate temperature effectively; and many others. For this, public-private partnerships can be leveraged to develop innovative solutions that cater to, and are mindful of the needs of the most vulnerable groups.

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# Rising Seas and Coastal Livelihoods

PANAJI, Caranzalem



Coastal communities in low-lying areas of Panaji live under a constant risk of flooding and disruption (*see Section 1*). Panaji – on the edge of both a river and the sea, is exposed to a number of climate change impacts (*see Section 2*). These include sea level rise, beach erosion, inundation of low lying areas and extreme weather events (*see Section 3*). The vulnerability of coastal communities is driven by a slow loss of coastal commons to rapid urbanization and a loss of fishing livelihoods (*see Section 4*). In their pursuit for resilience, coastal communities collectivize to interrogate the socio-economic drivers that disrupt the natural resources on which they depend on for their life and livelihoods (*see Section 5*).

# 1 Introduction



It was a stormy monsoon evening with grey skies in Panaji and the rain had barely stopped for a moment. The month of August is off-season for tourists — there are no shacks to duck under in Caranzalem beach, no loud music, and no food stalls. Between fishing canoes perched along the shoreline, there lies scarce bamboo houses, most of them locked. Two men sit inside one of these shacks, with the man on the left passed out on top of a mound of fishing net. Next to him, 53-year-old Lucas Po sits and eyes the waves uneasily. He contemplates, “After the [2004] tsunami, a lot of things changed for us traditional fishermen. Before, we could look at the intensity of the tides, direction and speed of the winds and predict these waters— when the water will reach a certain level, when it will go down. Now the sea has completely changed. It’s unpredictable.”

Lucas has lived in Caranzalem since birth. A traditional fisherman like his father, he earns a livelihood through fishing in the shallow coastal waters. His neighbor — 54-year-old Devi Naik — goes to the Malim Jetty at 6 every morning to buy fresh fish from the fishermen. She boxes them and brings them to Panaji where women like her run the local fish market. They express concerns about the growing shortage of fish. “Rains and storms are our worst enemies; when boats don’t go out to sea, we starve.”

About 5 km from Panaji, Caranzalem beach is a 3.5km long stretch with clear sands and water. Lucas believes that it is about to change: “The government is out to destroy livelihoods of communities like ours

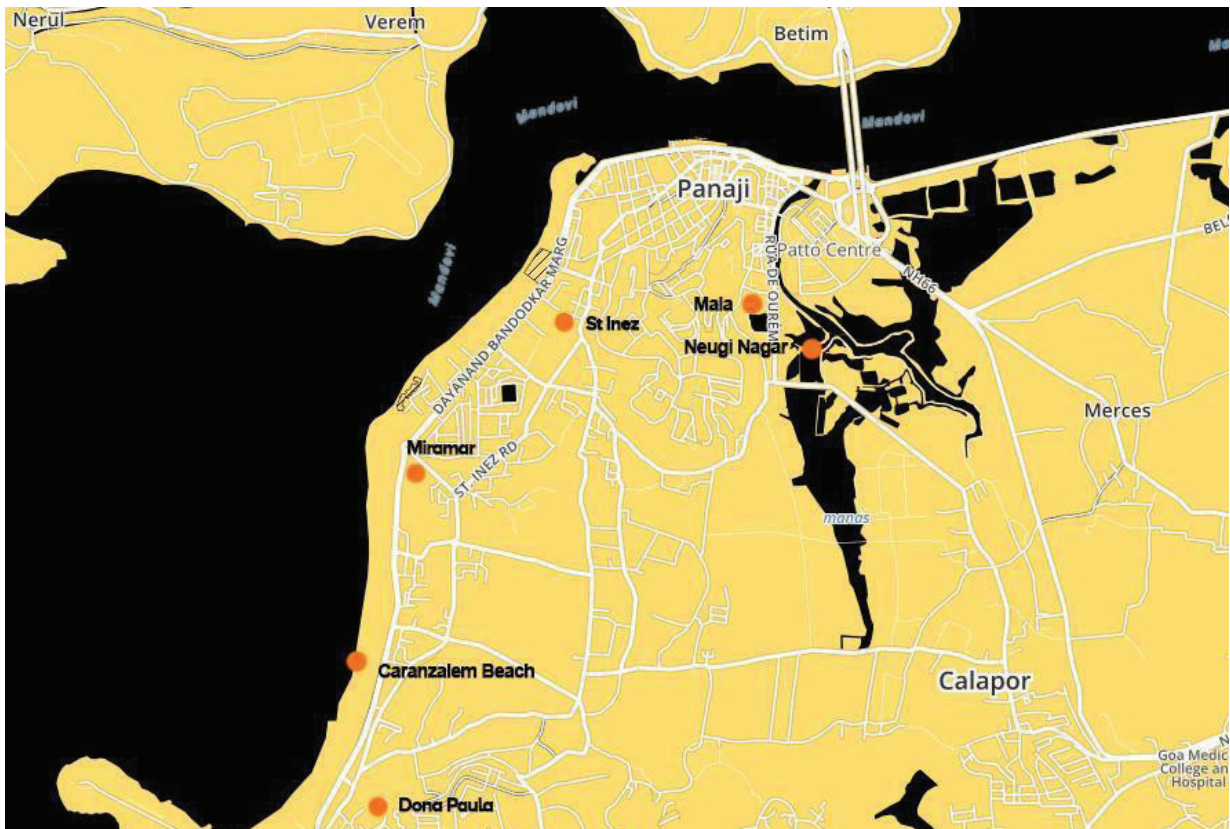
in the interest of the builder lobby. They will allow construction and development closer to the beach.<sup>1</sup> Between these areas you couldn’t build anything. Only traditional fishermen like us were allowed to have their temporary shacks this close. Now the builder lobby wants to enter the protected zone, which means our livelihoods will be completely destroyed. Moreover, the high tide is steadily rising with every passing year. If they build so close to the coast — all this area will become risky.”

India’s coasts, especially the western coastline, are expected to grow dramatically in population, infrastructure and industrial investment in the next two decades. However, much of the new development and traditional livelihoods and settlements are highly vulnerable to the impacts of climate change, especially from potential sea level rise. These are likely to be felt most by the small coastal communities with fishing-based livelihoods, who live in low-lying areas and are already suffering impacts of unplanned urbanization and displacement.



## 2 Caranzalem





The urban agglomeration of Panaji has a population of 114,405 (as per the 2011 Census data)<sup>2</sup> spread over just 812 hectares. The city is located in an undulating topography and has varying urban density. The heart of the city is densely populated with mixed land use of residential, commercial, public and semi-public purposes. Certain areas in the city have been designated as conservation and preservation areas. Given that Goa is a prime tourist destination, Panaji has an additional floating population, recorded at 639,177 tourists in 2004-2005<sup>3</sup> — almost five times the population size of the city.

Caranzalem village lies between Miramar and Dona Paula beaches, south of Panaji. (See map). Residential areas of Campal, Mala, and Caranzalem have high densities with congested and haphazard development. The more planned residential areas are confined to Taleigao, Miramar, Tonca and the St. Inez colony. While the main city is contained within embankments, Panaji

also has coastal beaches and colonies on reclaimed low-lying land such as those in Mala, Altinho, and nearby Neugi Nagar, among others. (See map).

The Goan ecosystem is sustained by 11 rivers and 42 tributaries,<sup>4</sup> which are the source of water, food and livelihoods for local communities. Panaji, just like the rest of Goa, is intimately linked with its rivers and coast. Parts of Panaji are built around the estuary of Mandovi River at the mouth of the Arabian Sea, surrounding an intricate system of wetlands, tidal marshes and cultivated paddy fields— all interconnected by canals, inland lakes, bays, lagoons and creeks governed by regular tides.

## 3 Climate Impacts





Panaji is a deltaic city surrounded by soft sedimentary coasts, estuaries, lagoons, mangroves and dunes, thus ecologically exposed and vulnerable to a wide range of climate change impacts. Among the most anticipated risks of climate change in Panaji are the effects of sea level rise and accompanying hazards on low-lying areas.<sup>5</sup> Direct impacts of rising sea levels include shoreline erosion, as well as flooding in low-lying areas. The Intergovernmental Panel on Climate Change (IPCC) estimates a rise in global mean sea level between 26 and 98 cm by the year 2100.<sup>6</sup> A study of the tidal gauge data of Panaji was found to show a sea level increase at 0.83mm/year.<sup>7</sup>

As global mean temperatures are rising, the frequency and magnitude of extreme weather events are going to increase.<sup>8</sup> Rising sea levels in conjunction with storms or other extreme weather events such as cyclones or heavy rains and can lead to flooding in low-lying areas, which are inhabited by a large segment of the urban population.<sup>9</sup> “All of this area used to be submerged underwater at some point.” says Mary Fernandes, a 46-year-old resident of Mala. Formerly low-lying areas that served as catchment basin for river and rain water are now residential settlements with a steady development of business complexes in their midst.

In addition to unplanned development, extreme weather events of heavy rainfall, especially during the monsoon, create situations of water logging in the city, where natural drainage patterns are no longer in effect. The likelihood of inundation because of river overflow discharge is higher in the low-lying areas of Mala, Nuegi Nagar, St. Inez, and Altinho, which are situated on the banks of the Mandovi River estuary. In both settlement types, storms and flooding increase the risk of water-borne diseases.

There is a risk of landslides and subsidence in Panaji,

much due to rapid urban development<sup>10</sup> which impacts the city’s soil profiles. Often a consequence of heavy rainfall, landslides affect life and property and also handicap essential urban systems. Panaji and surrounding areas have a history of landslides like the Mapusa-Panaji NH 17 landslide in 2007 and another in 2013,<sup>11</sup> both of which left the respective highways impaired for almost a month. The soil profile of soft clay and silt along the Mandovi river makes this land prone to subsidence. Thus, while new constructions in these settlements have solid foundations and support systems in place, older residential colonies like Mala are ticking time bombs. “Many older buildings have half the floor sunken below the ground. Our own building appears to be slightly tilted on one side,” says Mary. Every year, during the monsoon, many of these older structures are inundated.

## 4 Social Vulnerabilities

Within the city, communities living in low lying areas are more vulnerable to impacts of climate change, and more specifically, flooding. The TERI vulnerability assessment of Panaji in sea level rise and extreme events identified the areas of Ribandar, Patto, Fontainhas, Nuegi Nagar, St. Inez, La Campala, Miramar, Caranzalem and Dona Paula to be partially vulnerable; and the watersheds of the Mandovi river basin around Panaji to be highly vulnerable to climate impacts.<sup>12</sup> Mary's experience sheds light on climate impact among the most vulnerable: "There was a time it was not permissible to build an extra floor in this area. All this has changed. Now there are 4-5 floor complexes that have come up recently. They have high solid foundations that displace water into our houses. During high tides or rains, every year water fills up to our waist on the roads." Such accounts are not uncommon, as it is often the city's urban poor living in unplanned settlements who are most affected by these impacts.

Social vulnerabilities are even more stark within communities which depend on their ecosystem for livelihoods and resources. This is seen in the case of agricultural livelihoods supported by ecologically-dependent Khazan lands.<sup>13</sup> Rapid urbanization has affected drainage in the unique, coastal, estuarine agro-system of Khazans around Panaji, and subsequently reduced resilience of communities dependent on agricultural livelihoods.

Similarly, in coastal communities, climate change is threatening natural resources intricately linked to the coastal ecosystem. Sea level rise has and will continue to change the coastal morphology and soil characteristics. In addition to these factors, rapid urban development is accelerating the loss of beach-space, coastal commons

and the livelihoods previously supported by these areas. "When builders take over this area, we won't have a chance to buy a small plot of land by the beach for our work. Our access to the beach will be closed off by rows of bars and hotels. Traditional fishing happens in shallow water. We join our nets and hire over fifty people to help us pull the catch onto shore. The area will not be sufficient for us to do that," says Lucas, adding with caution, "Our competition is truckloads of fish that the government gets from other states for consumption in Goa. Those fish have formalin (preserving chemical used in mortuaries). While we are trying to offer fresh fish, it's a pity."

Devi Naik reiterates the point: "When I was 10, I would go with my dad to the market. Back then one full box of fish used to be 5 rupees. Now each box is anywhere from five to ten thousand. The fish are much smaller and fishermen are losing livelihoods to trawlers." Since losing her husband to the flu in 1991, Devi has been managing her family of five children and elderly parents by herself. Getting a bank account was never a priority for her, and she was quite comfortable with managing her expenses in a day-to-day manner. But now, with growing climate variability, and the resultant shortage of fish, the need for savings is felt far more strongly. She feels particularly vulnerable as a woman, particularly as she gets older and the need for a financial safety net becomes urgent.



## 5 Coping and Resilience

Squeezed between a resort and commercial showrooms is what remains of the traditional fishing village of Caranzalem—a dense cluster of households on a small stretch of land along the coast. These households are built on raised solid foundations, with *balcões* opening into common spaces, tying the community together. Many have shifted from traditional fishing to other occupations like running homestays and small shops. Small measures and a limited number of coping and make-do strategies help these households prepare to face seasonal impacts. During monsoon, roofing in old houses is prepared to brace the impacts of storms by being treated and covered with tarp to avoid leakage. Wells and water tanks are similarly cleaned after the monsoon period.

Poorer residents in Panaji find themselves seeking homes in high risk, low-lying flood-prone settlements like Mala and Neugi Nagar because they are more affordable. The most vulnerable are at a risk of displacement, both because of the impact of climate variability and land tenure issues. Migration has emerged as an important coping strategy - there is a steady flow of native Goans moving to the Gulf countries or Europe, seeking better prospects.

At a community level, people associated with traditional livelihoods are declining in numbers and moving to other occupations. Gaps in the city's urban infrastructure and services, coupled with their inability to seek support through the government whose vested interests lie in larger economic goals, makes many Goan communities form associations in order to be heard. The government's decision to reduce CRZ, enabling urban expansion closer to the coast, increases urban vulnerability of coastal communities

and has been met with objections by local associations and environmental NGOs.<sup>14</sup> Together, with residents of Caranzalem and several other villages throughout Goa, Lucas is associated to the GRE (Goenchea Raponkarancho Ekvott) — a citizens' collective that actively protests and holds the state accountable for their action and inaction.

Lucas explains his anguish, “the government is opening up the coastline for port-led development and mega projects without addressing the need to protect Goa's fragile ecosystem and protecting the livelihoods of communities staying in those areas.” Sea-level rise can increase the damage caused by storms because mean water level — the base level for storm effects — has elevated. Waves now attack higher on the shore profile and coastal erosion is thus expedited, bringing structures nearer the shoreline and potentially removing protection offered by sand dunes and other such features, which act as a beach's first line of defense.

Lucas is also member of an association of Caranzalem fishermen — 19 men and women in all this year. “All the savings from our first catch of the season in August are put together and kept for our association. That is the money we use for our security. We use it when we have financial struggles or some police work. Otherwise we have no support from outside or the government.”

In many cases, these citizen groups are left powerless, “Sand-mining is a big problem. There are powerful mafias in control of illegal sand-mining operations in parts of Goa (for construction purposes) which is eroding our beaches and affecting biodiversity at large.” Coupled with urbanization impacts, increasing

focus on tourism activities, rampant construction, encroached beaches and illegal sand mining leave coastal communities defenseless.

On a macro level, the government organizes resources to clear drainage loaded with solid waste. Local governance structures are more prominent and cater to specific needs of the local population. Informal settlements by the river Rio de Ourém, under the Mala-Patto bridge connecting Panaji, are at a risk of water-borne diseases. In response, local governance structures frequently sprays anti-mosquito insecticides and residents undergo regular blood check ups. Government intervention was again seen when a wall was placed by the river to prevent inundation in the face of seasonally-prone rising tides.

There is an urgent need to upgrade existing drainage systems and build efficient waste management among other urban services. Drainage systems are damaged or choked by solid wastes, hence many informal settlements rely on the natural gradient of the land for drainage. Yet, the existing drainage system is often uncovered and affected by unplanned construction. Only 31.3% of total households in Panaji with access to water supply have access to sewage connections<sup>15</sup> — a large population relies on private septic tanks.<sup>16</sup> An alarming number of urban households (11.72%) across North Goa reportedly resort to open defecation according to Census figures (2011).<sup>17</sup> Storm water drainage in Panaji was laid during the Portuguese period and still continues to function; however, there is a persistent problem of flooding during monsoon due to heavy rainfall with high water levels in River Mandovi. The storm water drainage system is not robust enough to mitigate such incidences.<sup>18</sup>

Most houses within informal settlements are built in stone packed mortar, and some newer constructions in brick and concrete. Across Goa, there is a significantly higher number of houses in stone without mortar, hence they are weaker, untreated and susceptible to weathering from climate forces and salinity seepage. These houses also lack a solid foundation and are thus vulnerable to landslides and subsidence due to lowering groundwater levels.

## 6 Policy and Action



In order to build resilience of vulnerable coastal communities, strategies are needed for diversifying the livelihood opportunities of coastal communities; introducing grassroots and policy measures for the conservation and management of coastal commons; curbing rampant illegal practices of sand mining and encroachment; and strengthening governance and institutional framework for climate resilient management of coastal areas. As climate change impacts are unevenly distributed among individuals and communities due to differential exposures and vulnerabilities, there is a need for an assessment of adaptive capacity at a local level, and to situate them within urban, state level and national governance frameworks.

At a community level, understanding local perceptions and experiences with climate impacts can help identify inherent characteristics that enable or constrain a community to respond, recover and adapt. Local and traditional knowledge is key to climate change research and should be included in research design and implementation. This includes efforts that involve coastal research and management institutions to conduct periodic vulnerability assessments of coastal cities. This in turn will inform planning of the ecosystem and community-based resilience interventions. Assessment can then help national and state-level governance on adaptation and management measures to address climate change. Early warning systems can significantly reduce impacts of affected communities through correct communication. For this, it is important to have a strong political commitment

and robust institutional capacities along with public understanding and trust in the system.

It is important to build capacity of local coastal communities and ensure adaptation of their livelihood activities for long-term sustainability. This involves prior business planning and access to resources; enabling the scaling up of agriculture and fishery operations; providing the community members with livelihood protection; access to finance, certification, tenable land and fishing rights; and access to markets. Tourism activities could further be built upon eco-tourism models, enabling alternative livelihood opportunities for the local communities as well.

The government should help the creation of detailed ecosystem and site-specific protocols and guidelines based on global and national best practices. For this, they will need to incorporate cutting edge technologies and traditional knowledge systems for the restoration and conservation of marine ecosystems (mangroves, khazans, dune vegetation, etc.) using an ecosystem based adaptation approach.<sup>19</sup> Building bylaws in coastal settlements should integrate ecological approaches with resilient infrastructure as a construction norm. Individuals, communities, NGOs, government and policymaking bodies can play a crucial role in combating future adverse impacts.

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# 1 Endnotes

- 1 Slum Free City Plan of Action - Agra. 2013. Hyderabad: Regional Centre for Urban and Environmental Studies. Retrieved from [[http://mohua.gov.in/upload/uploadfiles/files/23UP\\_Agra\\_sfcg-min.pdf](http://mohua.gov.in/upload/uploadfiles/files/23UP_Agra_sfcg-min.pdf)].
- 2 Taj Ganj Slum Housing Upgrading Project Phase II: DPR for funding under RAY. 2011. Cities Alliance. Retrieved from [[http://www.citiesalliance.org/sites/citiesalliance.org/files/CAFiles/Projects/Final\\_Annexure\\_20.pdf](http://www.citiesalliance.org/sites/citiesalliance.org/files/CAFiles/Projects/Final_Annexure_20.pdf)].
- 3 Hindustan Times. 2018. 64 killed after dust storm and rains lash Uttar Pradesh, Agra worst-hit. Retrieved from [<https://www.hindustantimes.com/india-news/42-killed-in-uttar-pradesh-in-dust-storm-that-hit-north-india-on-wednesday/story-a4Azrn1IFTQM8284Olm2MN.html>].
- 4 Withnall, A. 2018. Forecasters warn of more bad weather after 143 people die in 'freak' Indian storms. [online] The Independent. Retrieved from [<https://www.independent.co.uk/news/world/asia/india-dust-storms-thunder-death-toll-weather-delhi-agra-rajasthan-uttar-pradesh-latest-a8335891.html>].
- 5 Dhorde, Amit, and Anargha Wakhare. 2009. "Evidence of Long-term Climate Change at Major Cities of India during the Twentieth Century". *The International Journal of Climate Change: Impacts and Responses*. 1 (3): 15-42.
- 6 Ebi, Kristie L., Joel B. Smith, and Ian Burton. 2014. Integration of public health with adaptation to climate change: lessons learned and new directions.
- 7 Chauhan, A. 2015. Agra division ground water level depleting fast - Times of India. *The Times of India*. Retrieved from [<https://timesofindia.indiatimes.com/city/agra/Agra-division-ground-water-level-depleting-fast/articleshow/46148548.cms>].
- 8 Jha, S. 2009. Solid Waste Management - Agra City. Retrieved from [[https://www.researchgate.net/publication/265248895\\_Solid\\_Waste\\_Management\\_-\\_Agra\\_City](https://www.researchgate.net/publication/265248895_Solid_Waste_Management_-_Agra_City)].
- 9 Slum Free City Plan of Action - Agra. 2013. Hyderabad: Regional Centre for Urban and Environmental Studies. Retrieved from [[http://mohua.gov.in/upload/uploadfiles/files/23UP\\_Agra\\_sfcg-min.pdf](http://mohua.gov.in/upload/uploadfiles/files/23UP_Agra_sfcg-min.pdf)].
- 10 *ibid.*
- 11 Vithayathil, T. and Singh, G. 2010. Spaces of Discrimination: Residential Segregation in Indian Cities. *Economic & Political Weekly*. Retrieved from [<http://www.indiaenvironmentportal.org.in/files/file/Discrimination.pdf>].
- 12 Slum Free City Plan of Action - Agra. 2013. Hyderabad: Regional Centre for Urban and Environmental Studies. Retrieved from [[http://mohua.gov.in/upload/uploadfiles/files/23UP\\_Agra\\_sfcg-min.pdf](http://mohua.gov.in/upload/uploadfiles/files/23UP_Agra_sfcg-min.pdf)].



## 2 Endnotes

- 1 Delhi Master Plan. What is Lal Dora? Retrieved from [<http://delhi-masterplan.com/the-lal-dora-opportunity/what-is-lal-dora/>].
- 2 Rupa Kumar, P et al. 2006. “High-resolution climate change scenarios for India for the 21st century”, *Current Science* Vol 90, No 3, 10 February, pages 334–345; also GSDMA/TARU (2005), *Gujarat Vulnerability and Risk Atlas*, Gandhinagar
- 3 A, Revi. 2008. *Climate change risk: an adaptation and mitigation agenda for Indian cities*. Environment and urbanization.
- 4 Government of India. *Economic Survey of Delhi. 2001-02*. Retrieved from [[http://delhi.gov.in/wps/wcm/connect/DoIT\\_Planning/planning/economic+survey+of+dehli/content1/water+supply+and+sanitation/](http://delhi.gov.in/wps/wcm/connect/DoIT_Planning/planning/economic+survey+of+dehli/content1/water+supply+and+sanitation/)].
- 5 Kumar, Rakesh et al. 2005. “Water resources of India”, *Current Science* Vol 89, No 5, 10 September, pages 794–811.
- 6 Gautam, R., N. C. Hsu, M. Kafatos, and S. C. Tsay. 2007. Influences of winter haze on fog/low cloud over the Indo-Gangetic plains, *J. Geophys. Res.*, 112, D05207, doi:10.1029/2005JD007036.
- 7 Ray, C. 2010. *Livelihoods for the Urban Poor: A Case Study of UMEED Programme in Ahmedabad*. CEPT University.
- 8 Unni, Jeemol. 2009. ‘The Unorganised Sector and Urban Poverty’, in *India: Urban Poverty Report 2009*, Oxford University Press, New Delhi, pp. 76-93.
- 9 Chandrasekhar, C.P and Jayati Ghosh. 2002. ‘The Market that Failed-A Decade of Neo-Liberal Economic Reforms in India’, Left Word Books, New Delhi.
- 10 Mukherjee, P. and Saraswati, L. (n.d.). *Levels and Patterns of Social Cohesion and Its Relationship with Development in India: A Woman’s Perspective Approach*. New Delhi: Jawaharlal Nehru University.
- 11 Islam, S. and Winkel, J. 2017. *Climate Change and Social Inequality. ST/ESA/2017/DWP/152*. New York: UN/DESA. Retrieved from [[https://www.un.org/esa/desa/papers/2017/wp152\\_2017.pdf](https://www.un.org/esa/desa/papers/2017/wp152_2017.pdf)].

## 3 Endnotes

- 1 Sirohi, Nishant, 2019. Why the Coastal Regulation Zone notification 2018 is a travesty of environmental justice and puts citizens at huge risk. The Leaflet. Retrieved from [<https://theleaflet.in/why-the-coastal-regulation-zone-notification-2018-is-a-travesty-of-environmental-regulations-putting-citizens-at-huge-risk/>]
- 2 Government of India. 2011. Provisional Population Totals. Retrieved from [[http://www.censusindia.gov.in/2011-prov-results/paper2-vol2/data\\_files/goa/Tables.pdf](http://www.censusindia.gov.in/2011-prov-results/paper2-vol2/data_files/goa/Tables.pdf)].
- 3 Ministry of Housing and Urban Affairs, Government of India. Jawaharlal Nehru National Urban Renewal Mission. Retrieved from [[http://jnurm.nic.in/wp-content/uploads/2010/12/panaji\\_Chapter-3.pdf](http://jnurm.nic.in/wp-content/uploads/2010/12/panaji_Chapter-3.pdf)].
- 4 Pradhan, A. 2016. The Rivers of Goa. India Rivers Week. Retrieved from [<https://indiariversblog.wordpress.com/2017/05/17/the-rivers-of-go/>].
- 5 Group, World Bank. 2011. Cities and Climate Change: Responding to an Urgent Agenda. Washington: World Bank. Retrieved from [<http://public.eblib.com/choice/publicfullrecord.aspx?p=727536>].
- 6 TERI 2018. Climate Resilient infrastructure services Case study brief: Panaji. Retrieved from [<http://www.teriin.org/sites/default/files/2018-03/case-study-panaji.pdf>]
- 7 *ibid.*
- 8 Smith, J., Schellenhuber, H. and Mirza, M. 2001. Vulnerability to Climate Change and Reasons for Concern: A Synthesis. Retrieved from [[https://www.preventionweb.net/files/8387\\_wg2TARchap191.pdf](https://www.preventionweb.net/files/8387_wg2TARchap191.pdf)].
- 9 McGranahan, G., D. Balk, and B. Anderson, 2007. The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and Urbanization*, 19(1), 17-37.
- 10 Malkarnekar, G. 2017. Goa now prone to landslides due to unplanned development - Times of India. The Times of India. Retrieved from [<https://timesofindia.indiatimes.com/city/goa/goa-now-prone-to-landslides-due-to-unplanned-development/articleshow/59637073.cms>]
- 11 Rao, P. 2013. Goa road link with Karnataka blocked due to landslide. [online] <https://www.oneindia.com>. Retrieved from [<https://www.oneindia.com/2013/07/03/goa-road-link-with-karnataka-blocked-due-to-landslide-1251072.html>]
- 12 TERI. 2018. Climate Resilient infrastructure services Case study brief: Panaji. Retrieved from [<http://www.teriin.org/sites/default/files/2018-03/case-study-panaji.pdf>].
- 13 Bose, Indrajit. 2015. Goa's Disappearing Khazan Farms are Dying a Slow Death. Down to Earth. Retrieved from [<https://www.downtoearth.org.in/coverage/goas-disappearing--khazan--farms-dying-a-slow-death-6110>]
- 14 Colaco, K. 2018. Goans protest against the CRZ 2018 draft notification - Times of India. The Times of India. Retrieved from [<https://timesofindia.indiatimes.com/entertainment/events/goa/goans-protest-against-the-crz-2018-draft-notification/articleshow/64990274.cms>].
- 15 CRISIL. 2015. Revised City Development Plan for Panaji 2041. Retrieved from [<http://ccpgoa.com/images/Revised%20City%20Development%20Plan%20for%20Panaji%202041.pdf>]
- 16 Directorate of Census Operations, Goa. 2011. District Census Handbook, North Goa. Village and Town Wise, Primary Census Abstract (PCA). Retrieved from [[http://censusindia.gov.in/2011census/dchb/3001\\_PART\\_B\\_DCHB\\_NORTH%20GOA.pdf](http://censusindia.gov.in/2011census/dchb/3001_PART_B_DCHB_NORTH%20GOA.pdf)].
- 17 *ibid.*
- 18 The Times of India. 2016. Streets flood in minutes, life in Panaji grinds to a halt - Times of India. Retrieved from [<https://timesofindia.indiatimes.com/city/goa/Streets-flood-in-minutes-life-in-Panaji-grinds-to-a-halt/articleshow/52737137.cms>].

19 IUCN. (n.d.). Ecosystem-based Approaches to Climate Change Adaptation. Retrieved from [<https://www.iucn.org/theme/ecosystem-management/our-work/ecosystem-based-approaches-climate-change-adaptation>].

**Tandem Research's 'Future Cities' initiative** focuses on three themes: Resilience, Technology & Culture. How do we design cities that are resilient to shocks and changes; that represent an equitable distribution of technology gains; and that are thriving centers for cultural and civic participation?