SHAPING A CLIMATE RESILIENT KOCHI

Guidance document to develop a comprehensive disaster management plan in Kochi with long-term focus

Cities4Forests

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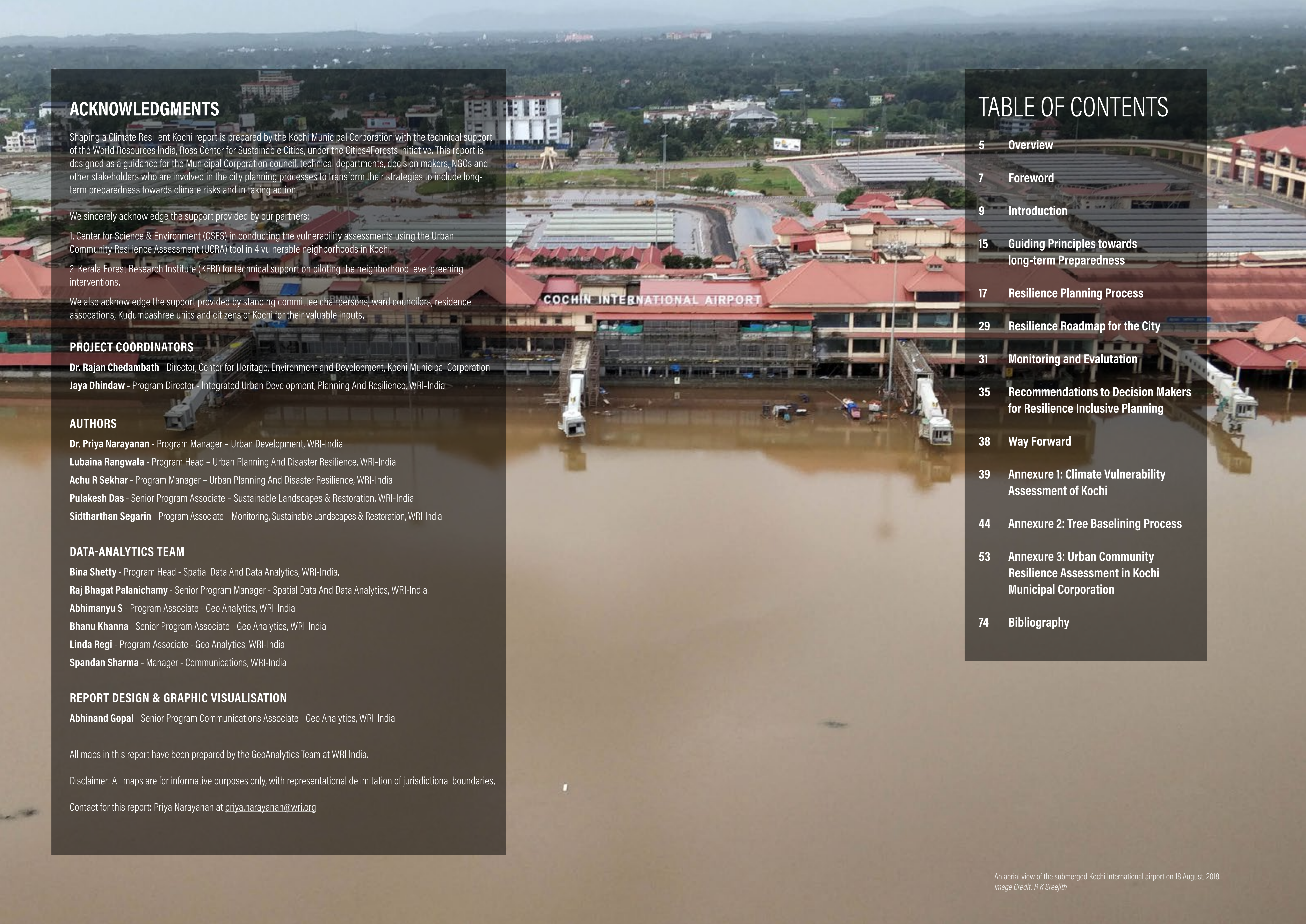

ACKNOWLEDGMENTS

Shaping a Climate Resilient Kochi report is prepared by the Kochi Municipal Corporation with the technical support of the World Resources India, Ross Center for Sustainable Cities, under the Cities4Forests initiative. This report is designed as a guidance for the Municipal Corporation council, technical departments, decision makers, NGOs and other stakeholders who are involved in the city planning processes to transform their strategies to include long-term preparedness towards climate risks and in taking action.

We sincerely acknowledge the support provided by our partners:

1. Center for Science & Environment (CSES) in conducting the vulnerability assessments using the Urban Community Resilience Assessment (UCRA) tool in 4 vulnerable neighborhoods in Kochi.

2. Kerala Forest Research Institute (KFRI) for technical support on piloting the neighborhood level greening interventions.

We also acknowledge the support provided by standing committee chairpersons, ward councilors, residence assocations, Kudumbashree units and citizens of Kochi for their valuable inputs.

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Disclaimer: All maps are for informative purposes only, with representational delimitation of jurisdictional boundaries.

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An aerial view of the submerged Kochi International airport on 18 August, 2018.
Image Credit: R K Sreejith

Image Credit: Avin CP

OVERVIEW

The guidance document is envisioned as a 'roadmap' to set the strategy for the development of a comprehensive and forward-looking City Disaster Management Plan (CDMP), targeted at the City Disaster Management Cell and all agencies involved in drafting the CDMP. It is developed under the auspices of the Cities4Forests initiative, of which Kochi is a part. This document has two clear objectives:

1. Provide guidance to adopt robust risk analysis and evidence-based vulnerability assessment methodologies to drive actions towards a long-term resilience vision for developing a climate resilient city.

2. Integrate climate change priorities in city and local-action plans, sectoral interventions and strategic projects – with focus on importance on Nature Based Solutions (NBS) and Capacity Building for Climate Resilience.

This document focuses on climate induced natural disasters, extreme weather events and slow-onset climate risks alone; and will not consider other hazards such as chemical, nuclear or biological disasters. The document will also highlight the importance of community engagement, localized data collection methods, and the need for multi-stakeholder participation to adequately reflect the needs of vulnerable populations in a city's CDMP.

The two key elements that the guidance document will highlight for cities to include in their CDMP for long-term preparedness are:

Nature: Integrating NBS into city level planning: helping cities identify interventions at different scales

Human: Collaborating with communities and assessing their needs to help in co-creating a path towards more sustainable and resilient cities

This document is intended for city planners, community-based organizations, and international development organizations interested in including Nature-based Solutions as part of city resilience planning and enhancing resilience capacities in poor and vulnerable communities by including them in the decision-making process. Local development organizations, community leaders, and community rights advocacy groups looking to develop resilience diagnostics and engage in participatory planning with community members may also find it valuable.

Fishermen work on Chinese nets, Old Cochin, Kochi, India. June 2008.
Image Credit: Adam Jones

FOREWARD

Kochi is the first city in India to be a part of the Cities4Forests global platform that supports cities to recognize their interdependence with the world's forests, and use their own political, economic and social power to protect and manage those forests for human well-being. Through Cities4Forests we raise awareness of the benefits of forests and other natural infrastructure. The Cities4Forests platform has provided an enabling environment in garnering the political support needed for catalyzing change on the ground. It provides the technical assistance to inform policy and projects using robust data analytics, policy and on-ground research, multiple stakeholder dialogues and demonstration projects. This guidance document also has a compendium of the on-ground support and technical assistance towards integrating climate-centric long-term resilience strategies to the city's disaster management plan (CDMP). The compendium will provide details on the current vulnerabilities, importance of incorporating a Nature-Based Solutions (NBS) approach, critical stakeholder engagements that is required and clear recommendations towards resilience and long-term preparedness for the CDMP.

An elephant procession in Jew Town, Kochi.
Image Credit: nicnac1000

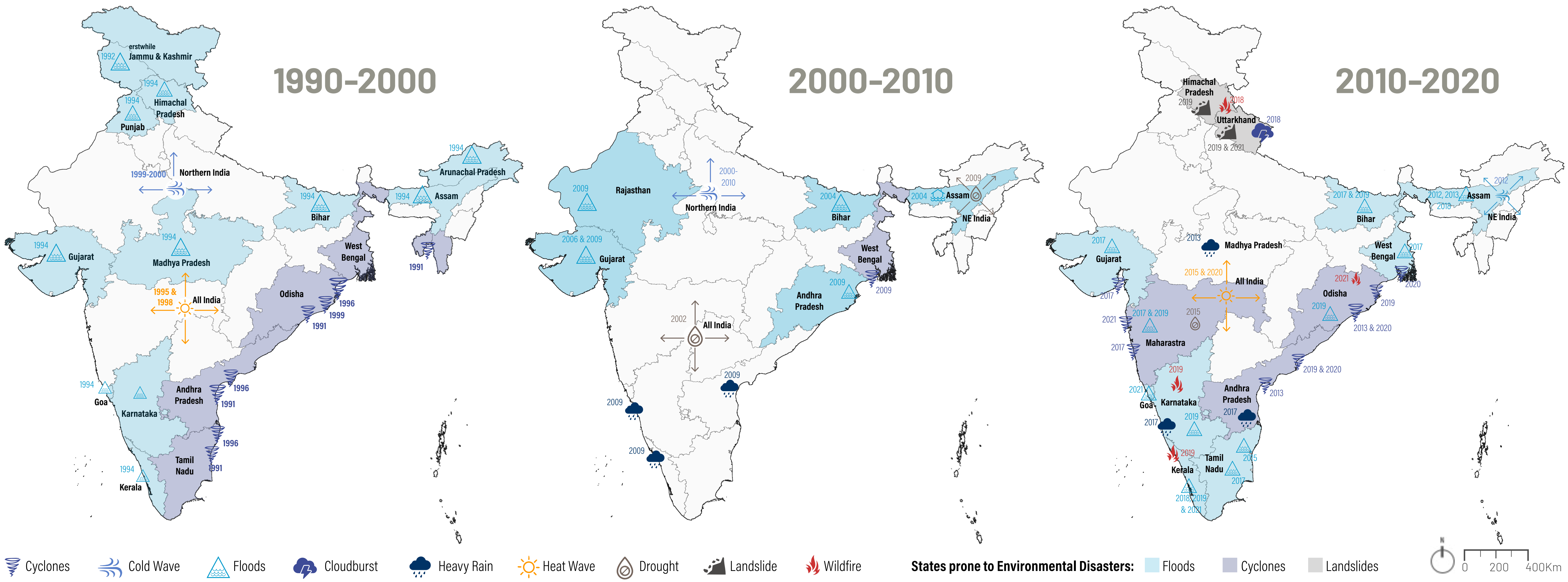
CHAPTER 1

INTRODUCTION

Climate change is one of the most important stressors for cities now and will remain so in the future. As India continues to urbanize, the urban population will soar from 340 million in 2008 to a projected 590 million in 2030. By 2030, the number of cities with populations of more than 1 million will grow from 42 to 68. There is ample scientific evidence that for cities, some aspects of climate change may be amplified, including heat (since urban areas are usually warmer than their surroundings), flooding from heavy precipitation events and sea-level rise in coastal cities over the next few decades.

The strategic geographical location of India, with 7,500 kms of coastline, the complex Himalayan topography to the north, the Thar desert in the west, fertile plains to the east, and the Deccan Plateau and Ghats in the south, comes with its own challenges. This is further accentuated by the unique monsoon system in India. The most recent IPCC AR6 report predicts that in India the south Asian monsoon will intensify over time resulting in extreme flooding and other related weather events.

Figure 1 | **India Disasters History Map**



Source: Compiled by WRI India Geo-Analytics

India's average temperature has risen by around 0.7°C during 1901–2018, largely due to GHG-induced warming (Krishnan et al., 2020). Rainfall trends show very high spatial and temporal variability with statistically significant decreasing trends in annual as well as seasonal rainfall observed over Kerala, Western Ghats and some parts of central India including Uttar Pradesh, Madhya Pradesh, Chhattisgarh and parts of Northeast India. Gujarat, Konkan coast, Goa, Jammu and Kashmir and parts of east coast show a significant increasing trend in rainfall. Temperature and rainfall are key climate change indicators: cyclones, heatwaves, storm surges etc., are other major climate induced disasters.

In this context, disaster planning and management becomes integral to combating climate change. Considering this, the Disaster Management Act, 2005 was enacted for efficient management of disaster and other matters associated with it. The Act operates at the National, State, District and the local body levels (MoLJ, GoI, 2005).

As per Section 31 of the Disaster Management Act, 2005, District Disaster Management Authority (DDMA) of each district in the country will prepare a City Disaster Management Plan (CDMP) which needs to be approved by the State Disaster Management Authority. The framework of the CDMP is based on the principles of the National Disaster Management Plan (NDMA, 2019) and State Disaster Management Plan (KSDMA, 2016). The plan should also align with the priorities of the Sendai Framework and hence focus on all four phases of disaster management: prevention, mitigation, response, and recovery.

PRIORITY AREAS FOR SENDAI FRAMEWORK

- **Priority 1**: Understanding disaster risk
- **Priority 2**: Strengthening disaster risk governance to manage disaster risk
- **Priority 3**: Investing in disaster risk reduction for resilience
- **Priority 4**: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

In this context, it is important to incorporate locally led planning, adaptation and community resilience capacity building into the disaster management framework. The kind of ground level interventions will form a strong base to long-term resilience building especially in the vulnerable communities.

Another aspect that the guideline document brings conscious introduction by incorporating NBS within an existing Disaster Risk Reduction (DRR) framework as mentioned in Priorities 1-3. Such an approach not only help in risk reduction but also responds to climate change while providing other benefits, such as the preservation of natural resources.

The diagram below (Figure 2) illustrates how the long term climate resilience thinking under the Cities4Forests program can be incorporated into existing CDMP framework; suggesting a broader objective that can influence long-term preparedness actions and enable resilience planning in cities:

Figure 2 | **Long term Resilience Strategies in Disaster Management Framework**

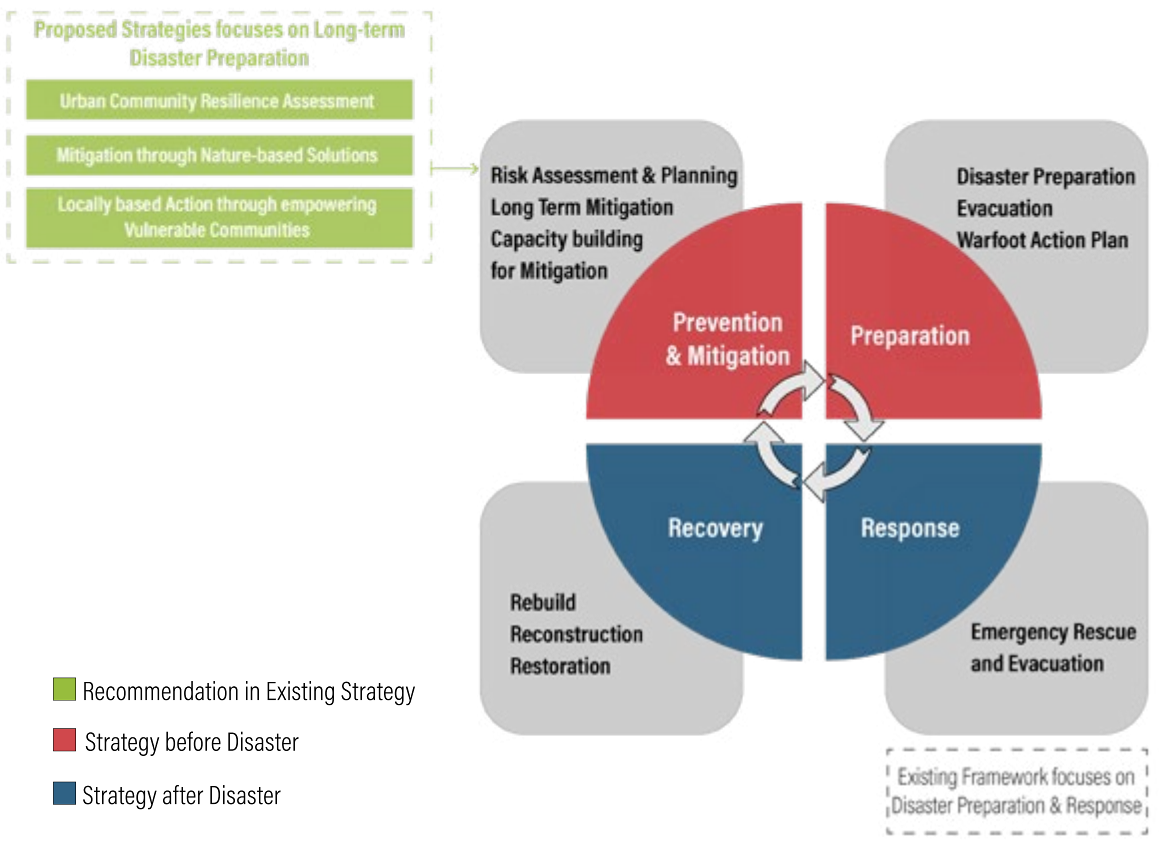


Table 1 | **Gaps and opportunities in disaster management planning**

EXISTING CDMPS IN INDIA (GENERAL)	PROPOSED OUTLOOK OF CDMP
Primary focus on a relief-centric and reactive approach. The focus on long-term preparedness and resilience remains an objective has not been integrated into practice.	A hierarchical resilience based approach with focus on disaster aversion, long term disaster preparation, immediate preparation, disaster mitigation, rescue, evacuation and restoration.
Experience from previous disasters and use of advanced technology clubbed with regional knowledge resulted in more efficient disaster warnings, capacity building for disaster mitigation and evacuation systems (Kerala floods 2018).	Similarly the experiences from previous disasters need to be used to develop long term solutions for disaster resilience and mitigation.
Climate change referred to state the acceleration of natural disasters.	Climate change assessment need to be incorporated as an integral part of disaster mitigation and CDMP need to be regularly updated based on latest patterns in climate change.
Plans are developed with the most vulnerable community/groups in focus as the major benefiter.	Plans to be developed by empowering the most vulnerable community/group as a part of the solution in a bottom up approach
Delineates the duties and responsibilities of the local administration.	Mandatory requirement for budgetary allocation by local administration for climate change and disaster mitigation to be incorporated.

NATURE BASED SOLUTIONS

The International Union for Conservation of Nature (IUCN) at the 2016 World Conservation Congress states actions defines Nature Based Solutions as 'any actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity' (UNEP, 2021). Although the term NBS focuses mostly on forests, it also includes coastal areas, grassland, agriculture land and Peat land. The IUCN Global Standard for Nature-based Solutions includes eight specific criteria and 28 indicators, intended to enable the coherent design, execution and evaluation of nature-based solutions benefits. Some nature-based solutions are primarily intended to contribute to climate mitigation, others may provide mitigation as an additional benefit to their main goal.

While nature-based solutions are a critical for decarbonisation and climate mitigation, they can only be relied upon when combined with other emission reduction approaches that impact energy, transport and industry sectors. Without this multipronged approach, the total mitigation achieved will be insufficient to avoid climate-related risks and disasters (UNEP, 2021)

Image Credit: Anirudh Ganapathy

A day in the life of a fisherman, Kochi, India
Image Credit: Firos NV

CHAPTER 2

GUIDING PRINCIPLES TOWARDS LONG-TERM PREPAREDNESS

Creating an inclusive resilience plan for cities is imperative for long-term preparedness against climate risks. Developing such a plan requires inclusion of local knowledge and experience from communities. To do this, the focus needs to shift from risk management (as conceptualized in many existing CDMP's) to a comprehensive approach that is inclusive of more sustainable development models like nature based solutions and need based stakeholder capacity building in a resilience aspect. Urban planning and decision-making should be more cohesive and focus on long-term vision in design, planning and implementation process.

A) Data-driven decision making:
i. Co-creating and co-producing data through a participatory approach, to improve the understanding of risks, hazards, and vulnerabilities

ii. Invest in ensuring effective communication of data and information to all stakeholders

B) Integrated planning to build long-term resilience:
i. Use participatory methods to develop planning strategies that minimize exposure to risk and maximise adoption capacities

ii. Integrate local knowledge and capacities for building resilience

iii. Assessment of existing policies and regulations in disaster management and other allied sectors that have an impact on building climate resilience and make necessary amendments to ensure sustainability and create synergy.

C) Capacity building in urban governance for people centric decision making:
i. Decentralised approach to risk and resource management through inter-organisational cooperation

ii.Enhanced accessibility to physical and social infrastructure to enhance coping capacities (ensuring equity) in communities and ensuring inclusion in the decision-making process

iii. Endorsing community stewardship and a participatory approach in building resilience

Inclusion of these principles will help broaden the CDMP's focus from rescue, recovery and rebuild to a long-term resilience. The resilience roadmap explains the integration of these principles in the different planning process.

However, while the guiding principles listed here are based on assessments of the existing structure and operationalisation of disaster management planning in India, there is a scope to expand this in future as cities transform.

Recent flooding at Chullikkal, Kochi Summer on 19 May, 2022.
Image Credit: Antony Stevin Rodrigues

CHAPTER 3

RESILIENCE PLANNING PROCESS

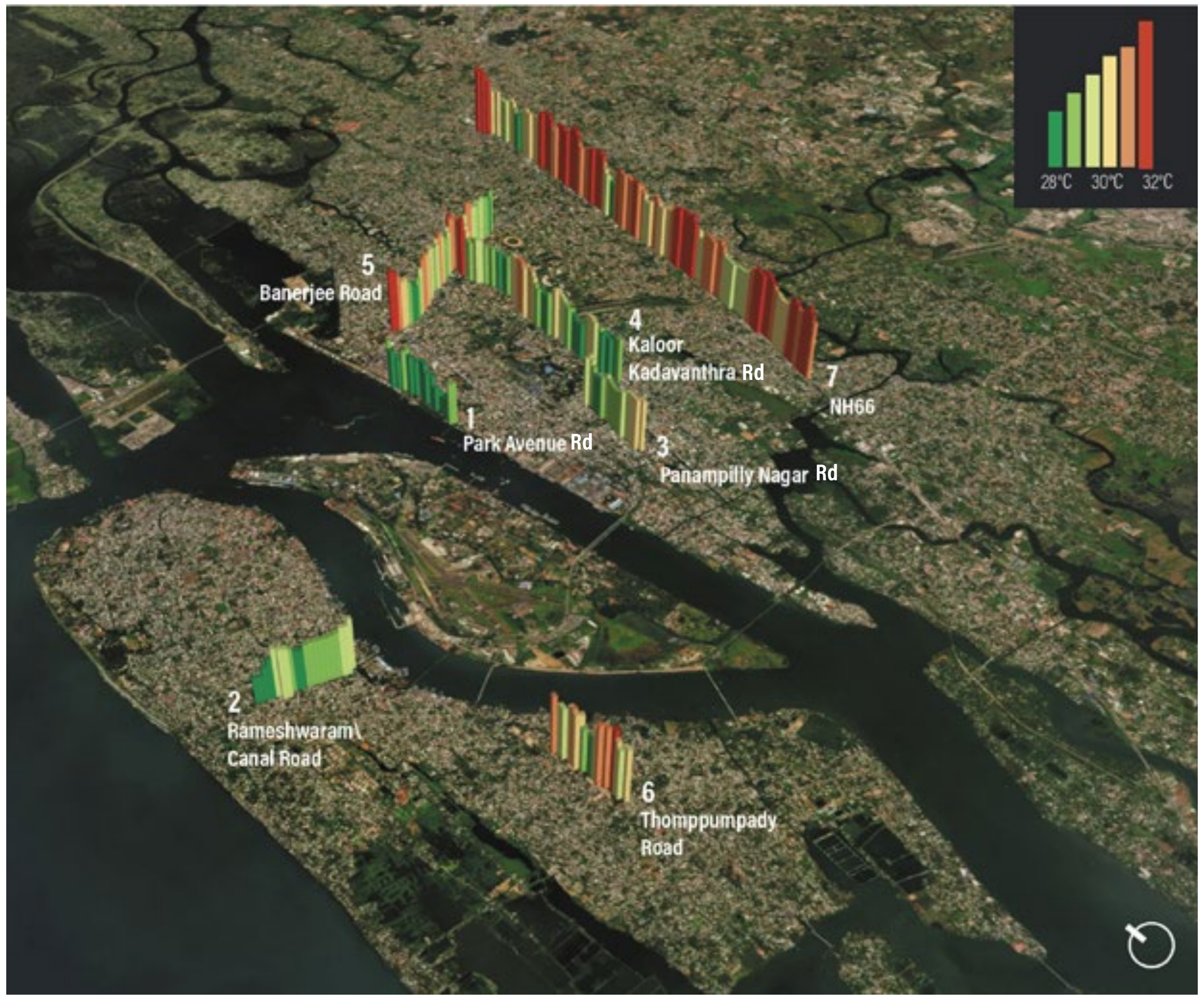
Integrating climate resilience thinking in a city's urban planning approach has been a challenge in most Indian cities. The city or district disaster management departments have the best knowledge, and decades of experience, in dealing with the increasing risks of climate change-induced natural disasters. However, the local planning authorities often do not effectively integrate this knowledge (climate risk and past data) into long-term planning. Further, the vulnerable communities are seldom consulted regarding their concerns and expectations during the planning process. Incorporating the guiding principles (Section D) into the planning process ensures that the resilience aspect is integrated into the CDMP. Focus on data driven approaches, long term objectives and participatory approach will result in developing a resilient framework for disaster management.

Importance of Nature Based Solutions (NBS)

The mitigation impact of NBS on heat stress is proven and visible in rapidly urbanising cities like Kochi. As seen in the analysis below, the heat stress in urban stretches with ample green cover is much lesser than areas of land in the city that is densely populated with buildings.

One such comparison is the average maximum temperatures observed in National Highway 66 which has either mostly baren land or high raised buildings on both sides and the Park Avenue Road running parallel to sustainably managed urban green stretch, Subash park.

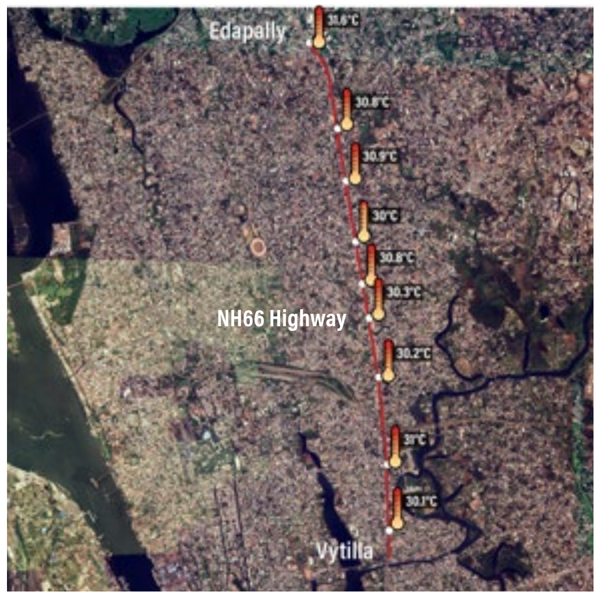
Figure 3 | **Road Surface Temperature Sectional Profiles**

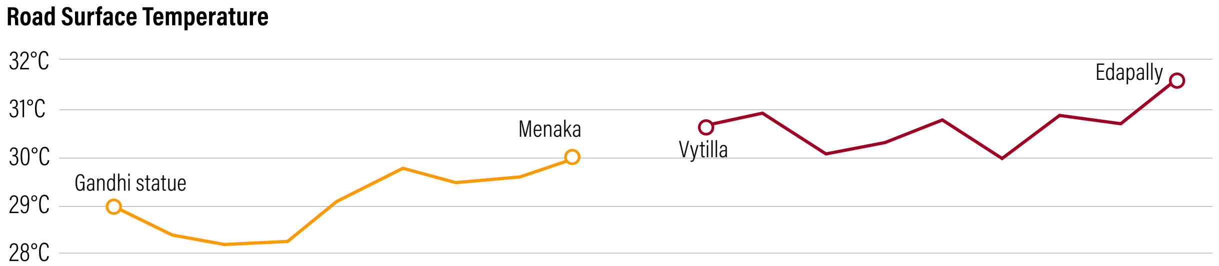


Source: LandSat (USGS/NASA); Google Earth Pro 2021; Analysis by WRI India

Name	Min. Temp	Max. Temp.	Range	Mean	Road Width	Abutting Land Use Type
1. Park Avenue Road	28.1°C	30°C	1.9°C	29.2°C	13.8m	Recreation, Administration, Education
2. Rameshwaram Canal Road	28.8°C	30.2°C	1.4°C	29.7°C	8.2m	Mixed, presence of water body
3. Panampilly Nagar Road	29.5°C	30.3°C	0.8°C	29.9°C	45m	Commercial, Residential
4. Kaloor-Kavanthra Road	29.3°C	30.8°C	1.5°C	30°C	22m	Commercial
5. Banerjee Road	29.4°C	30.9°C	1.5°C	30.1°C	22m	Commercial
6. Thoppumpady Aroor Road	29.5°C	31.1°C	1.6°C	30.3°C	15m	Education, Mixed
7. NH66 Highway	30°C	32°C	2°C	30.6°C	45m	Commercial

Figure 4 | **Comparitive Analysis of Park-Avenue Road and a segment of NH66 highway**





1. Park Avenue Road

The road surface temperature along the 2km stretch from Gandhi statue to the Mullassery canal.

7. NH66 Highway

10km segment from Vytilla to Edappally junction of the national highway shows higher road surface temperature than others.

Source: LandSat (USGS/NASA); Google Earth Pro 2021; Analysis by WRI India.
Image Credit: Achu Sekhar

The proposed resilience planning framework in this document is based on WRI's community resilience approach (Lubaina Rangawala, 2018) that focuses on increasing individual and collective resilience capacities, while strengthening social networks and their abilities to perform essential functions during and after extreme events. It aims to bring diverse stakeholders on a collaborative platform to discuss urban risks, vulnerabilities, and institutional gaps, and the opportunities to leverage community knowledge in bridging these. This chapter lays out the steps for developing a roadmap to integrate long-term resilience actions in urban planning and disaster preparedness, while focusing on the needs of those living in vulnerable neighborhoods.

The roadmap for resilience laid down in this document is an outcome of detailed assessments conducted in Kochi based on the UCRA tool and data based assessments as detailed below.

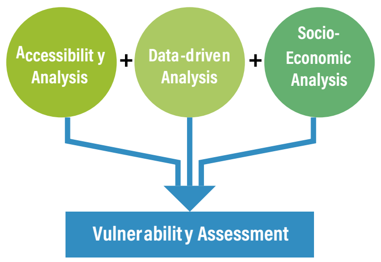
Climate Risk and Vulnerability Assessments

Identifying areas in the city that are more exposed to varied climate change-induced natural disasters and slow-onset events are an essential step in identifying climate risks and assessing vulnerability. Vulnerability can be defined based on multiple parameters some of which are geographical whereas others could be fiscal or even social.

For example, poor communities are also more sensitive to climate risks and often live-in under-served areas of the city with limited access to essential urban services and amenities.

A deep assessment of associated vulnerabilities need to be identified and charted in order to have a comprehensive understanding of climate risks in a city. A series of such indicators have been identified for Kochi and mapped as an initial step in developing a comprehensive disaster management plan. The indicators for vulnerability assessments are divided into 3 different categories including data driven risk analysis, accessibility analysis and socio-economic analysis.

Figure 5 | **Vulnerability Assessment Components**



A. Data-driven Risk Analysis

Climate induced disasters are increasing in frequency and causing extensive damage in natural assets and communities alike. Measuring and representing the increasing risk to inform research and decision-making has improved considerably with the aid of data analytics. Modern data collection/analysis tools and methodologies need to be incorporated into the decision-making process to ensure the vulnerabilities and associated risks are mapped more accurately and efficient mitigation measures are adopted.

Geoinformatics tools should be used to ensure that the risk analysis is data driven. Figure 6 shows the impact of urbanisation contributing to rise in temperature in Kochi, which was studied using satellite data. It also illustrates out how increase in green spaces within the city can help reduce temperatures as well. Satellite imagery and open source geoinformatics information is easily assessable by ULBs which needs to be used for disaster planning.

In Kochi, the spatial assessments highlight that about 31% of the city's population is exposed to temperatures above 30°C (Figure 7) and 26% of the city's population lives within the flood plain (Figure 8). Further Wards 2,3, 5, 36, 44 & 61 specifically can be identified as the most vulnerable communities in the city to climate risks (Figure 9).

Figure 6 | **Evidence of Heat Stress in Kochi: Mean Land Surface Temperature versus Land Cover**

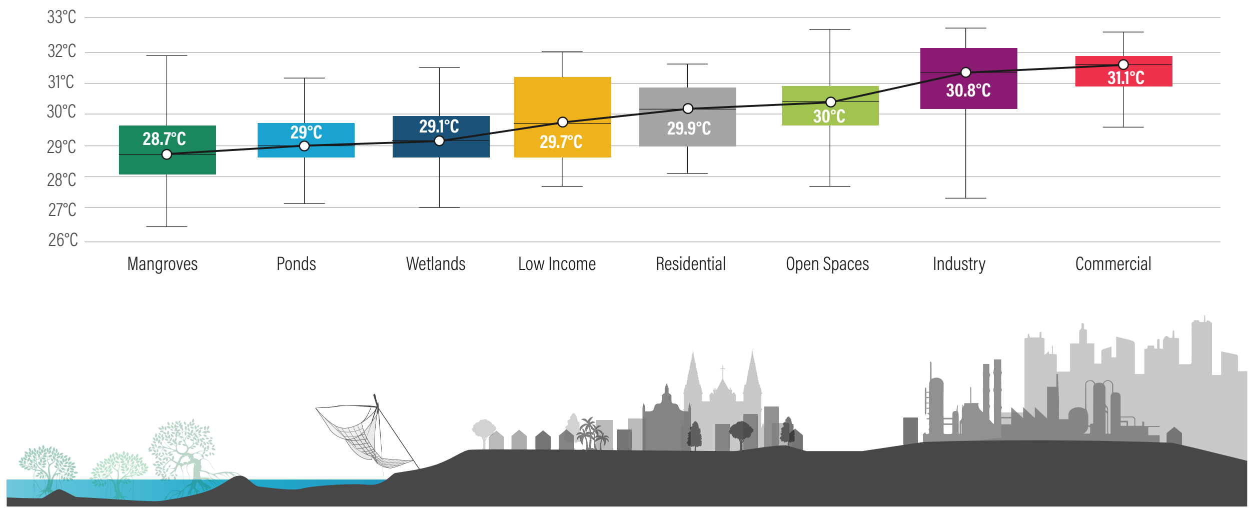
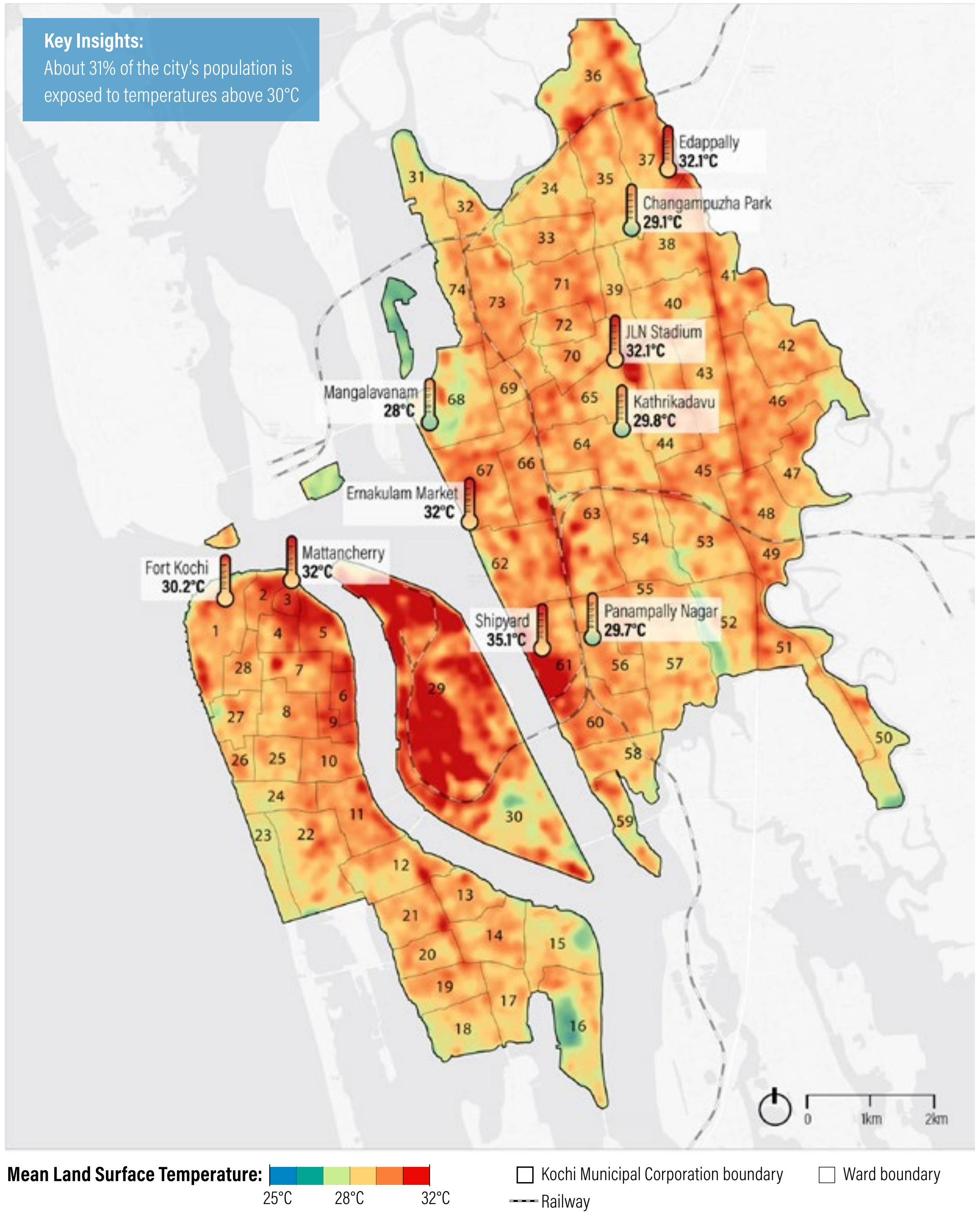


Figure 7 | **Mean land surface temperature in Kochi**



Source: LandSat USGS/NASA; ESRi Grey BAse Map; Analysis by WRI India

Note: Each pixel in the map represents the average LST computed using LandSat8 imagery for the following dates: 2 Feb 2017, 6 Feb 2018, 8 Jan 2019, 12 Feb 2020

Figure 8 | **Potential Flood Risk Areas in Kochi Municipal Corporation**

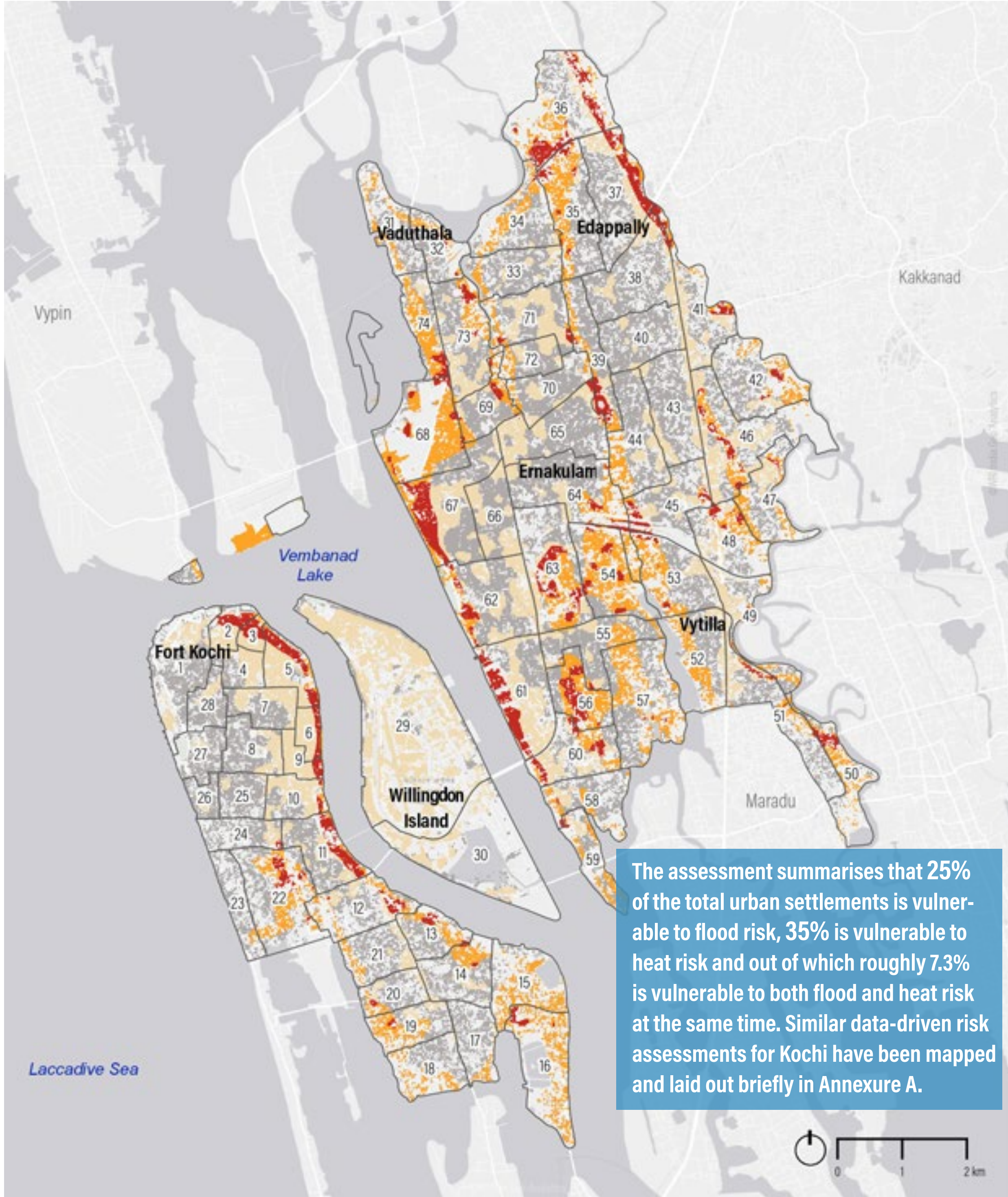
Flood Susceptibility Zones: Flood Plains Settlements Settlements in Flood Risk Areas

Source: NCESS 2010; Sentinel ESA; Analysis by WRI India

Importance of Recurring Vulnerability Assessments

While implementing a data driven approach of climate change mitigation, it is critical to account for need for frequent upgradation of the climate vulnerabilities and mitigation strategies. The mapping of previous climate threat and disasters and changing trends in climate patterns (including the most recent ones). Disaster risks are not the same over a period of time, but more evolving based on frequent change even in other terrestrial elements.

Figure 9 | **Settlements Vulnerable to both Heat and Flood**



Settlements vulnerable to Flood (24.6%) Settlements vulnerable to Heat (above 30°C) - **34.8%** Settlements

Kochi Municipal Corporation boundary Ward boundary Settlements vulnerable to both Heat & Flood - **7.3%**

Source: NCESS 2010; Analysis by WRI India

For example in Kochi, the maps developed before the 2018 and 2019 mega floods, alone will be inadequate for identifying the floods plains in the region. The data from before the floods and a combination of both 2018 & 2019 flood maps need to be utilised to identify vulnerable localities, make projections and develop further mitigation action.

B. Accessibility Analysis

Accessibility to services is a key element in defining resilient communities. Better access to information and services enables better resilience to climate risks and disasters. In order to develop a pro-active and comprehensive disaster management system in cities, it is critical to assess the status of accessibility to these basic services. The severity of criticality of services is dependent on the types of climate vulnerability in the neighborhood.

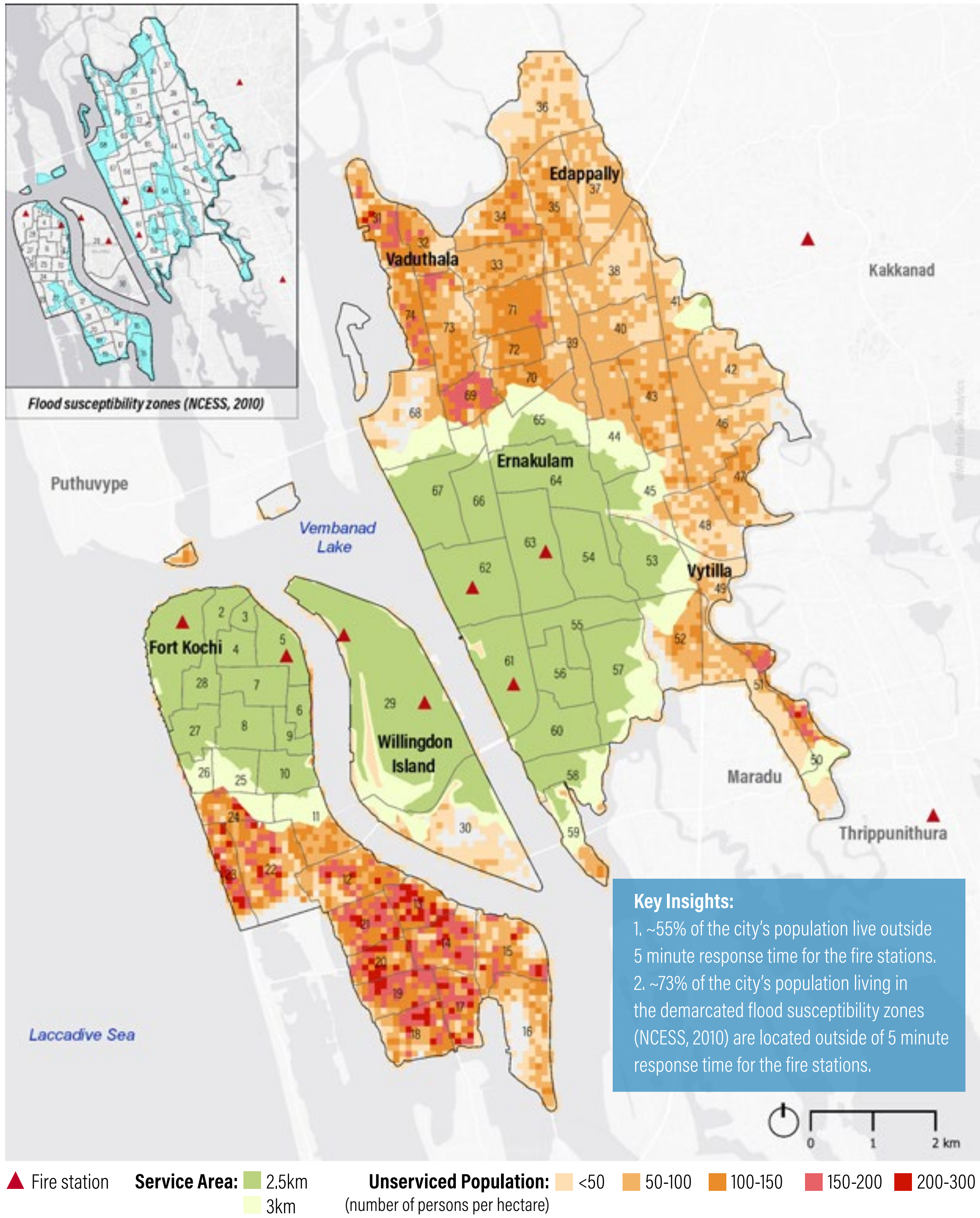
In Kochi four underserved neighborhoods were studied to analyse their access to basic amenities like hospitals, disaster relief centres, fire and rescue services among others during climate disasters. This helped identify the most vulnerable group of people who require focus on healthcare, rescue and evacuation when a disaster strikes. For instance, wards 15, 16 & 22 are susceptible to flooding and at the same time at a distance of more than 3 kms from the nearest fire station (Figure 10), as well as do not have an approved flood relief camp within a distance of 5 km radius by road. This leads to the assessment that the population of these 3 wards are least disaster resilient compared to other flood susceptible wards as they cannot be immediately rescued or relocated in time of a flash flooding incident. This needs to be addressed by providing required infrastructure (Figure 11).

A summary of assessment of some critical accessibility parameters in Kochi is provided in table below as an example:

Table 2 | **Disaster risk related accessibility analysis in Kochi**

CLIMATE RISK/DISASTER	ACCESSIBILITY PARAMETERS	OBSERVATIONS IN KOCHI
Heat stress	Access/Distance to open spaces and green spaces	64% of population do not have immediate access to public green spaces or playgrounds for recreation within 10 minutes of walkable distance. About 55 % of this population with limited access to recreation spaces also faces exasperated risk of heat stress (>30 °C LST)
Urban flooding, Tidal attacks, Sea erosion	Access/Distance to relief camps	About 26% of city's population live within flood susceptibility zones. 77% of this population living in flood susceptibility zones, have access to designated relief shelters within 2km.
Urban flooding, Tidal attacks, other accidents	Access of Fire and rescue services	73% of population living in demarcated flood risk zones and 55 % of overall city's population live outside 5 min response time from the fire stations. Edakochi & Palluruthy regions which are prone to flood risks, are outside this 5 min service area.
Any natural disasters	Access/Distance to government hospitals	78 % of city's population has access to government hospitals/ health centres within 1-2 km distance.

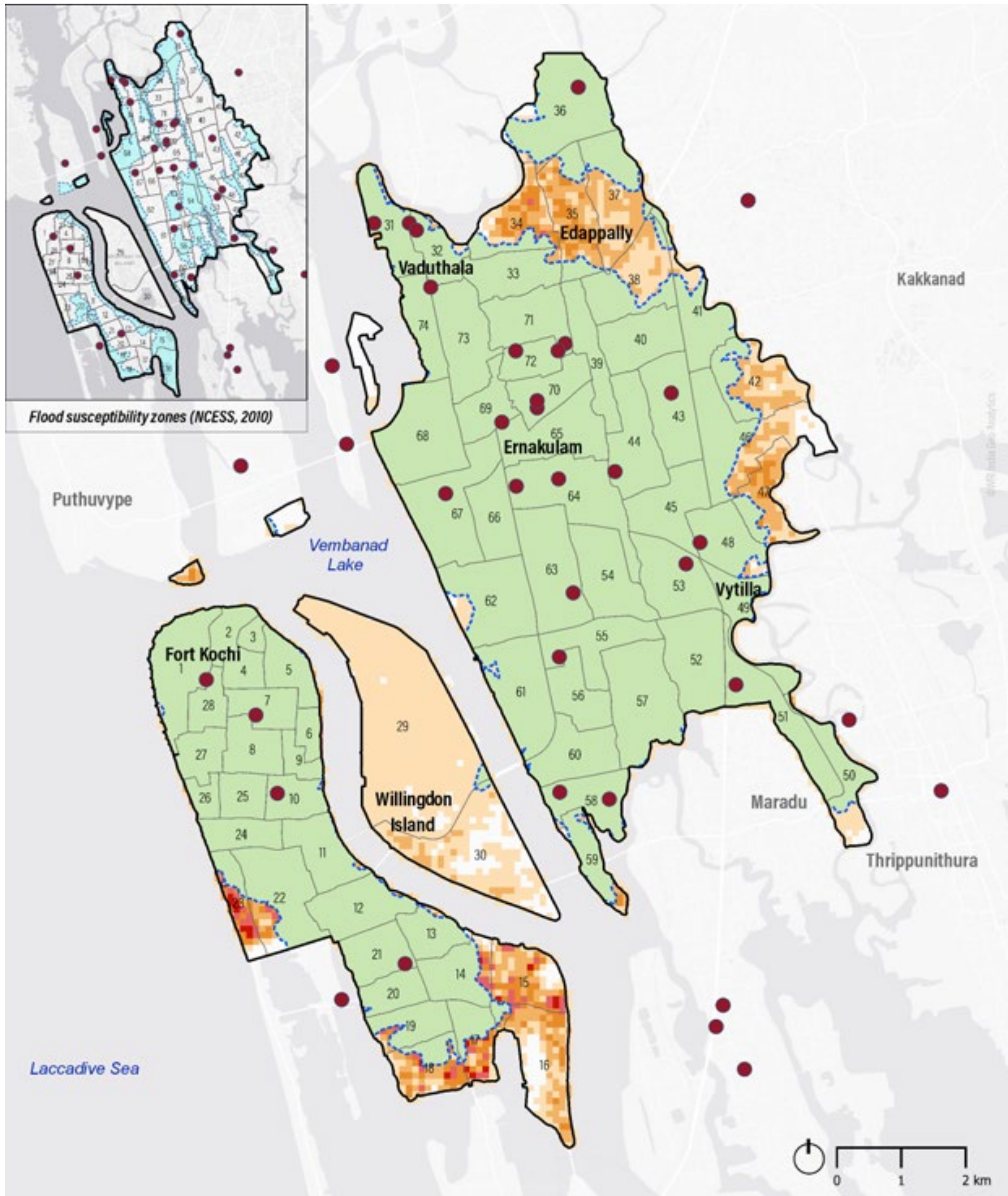
Figure 10 | **Communities that are not within Immediate Service Area of Fire Stations**



Source: NCESS 2010; KMC 2013; Analysis by WRI India

Note:
1. As per the Standing Fire Advisory Committee (SFAC) under the Ministry of Home Affairs, 3 to 5 min response time is considered ideal for fire station in urban areas (ARDC, 2012).
2. As per Kochi City Mobility Plan 2007, average vehicular speed during peak hours (Morning 9 AM to 10 AM and evening 6 PM to 8 PM) is 30 kmph, and for the lean hours is 35 kmph. Based on this, service area of 2.5 km and 3 km for both peak and lean hours are computed.

Figure 11 | **Communities lacking Immediate Access to Relief Camps**



● Monsoon Relief Camp **Area covered in 60 minute walk:** Service area category (A) 1.8 km at 300 m per 10 minutes
Service area category (B) 4.8 km at 800 m per 10 minutes

Population Density in Service Area Category B: <50 50-100 100-150 150-200 200-300
(number of persons per hectare)

Source: KSDMA 2021; NCESS 2010; Analysis by WRI India

Note:
1. Average distance covered in 10 minutes by walk in Indian conditions is: 300m for a caregiver with an infant or a stroller; 800-1000m for an adult (Bernard van Leer Foundation, 2018).
2. Shelter sites should be within one hour walk and within 5 km of dwellings (NCDM, 2002).

C. Socio-economic Analysis

Analyzing the population on a socio-economic aspect to derive climate resilience is important to identify individual household capacities to resist, survive and bounce back from climate related disasters.

The assessments are made at two different scales: individual household level and community level. For an individual household level, in depth assessments need to be made where multiple parameters need to be assessed under 3 critical lens: social coherence, community participation and economic stability. The city disaster management plan can use these findings to develop locally relevant disaster preparedness strategies for vulnerable neighbourhoods. Capacity gaps are determined for the following criteria: social cohesion, collective preparedness, governance and political engagement, built environment, risk perception, communication and awareness, and economic resources.

Whereas community resilience captures communities' potential to respond to climate-induced natural disasters and learn from, adapt, and transform their essential functions and environments based on experience. Communities' collective responses to climate-induced natural disasters are stronger, better-coordinated, and more effective if members share strong social bonds (Daniel P. Aldrich, 2015) (Baussan, 2015) (Douglas Paton, 2001); and communities are politically well organized. Community resilience is determined by measuring the complex relation between aspects of social cohesion, political engagement, collaboration during disaster response and recovery efforts, and the state of the built environment. Through extensive field survey – primary household surveys, focus group discussions, and topical workshops with community members – the resilience needs and capacity gaps in vulnerable communities can be determined.

An extensive socio-economic study was conducted among vulnerable communities in Kochi using the UCRA tool over a period of 3 months. The UCRA assessment of vulnerable localities in Kochi reveal that not more a quarter of the households in none of these communities have contact to the local councillor (who is the primary contact of the Local Government in case of a disaster). Further not even 15% of the households are aware about any community organisations or NGOs that can support them in times of a disaster. This is less than even 5% in Gandhi Nagar colony, where more than 50% of the households are migrant workers.

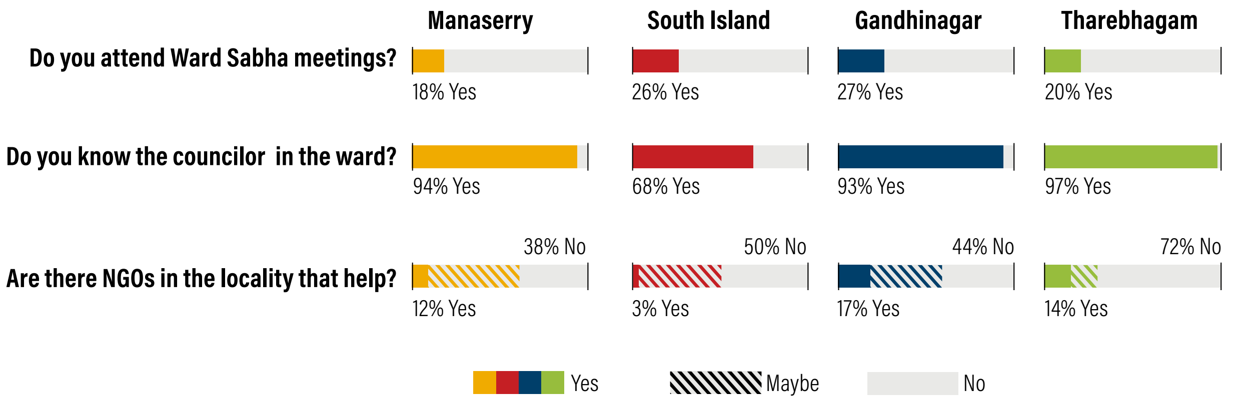
Such vulnerabilities in the community will have major negative impacts on disaster resilience and even more during the time of need for rescue and evacuation. Such socio-economic gaps in climate resilience are a grassroot level vulnerability that needs to be addressed in a comprehensive disaster management plan. A concise report of the socio-economic vulnerability assessment in Kochi using UCRA tool is attached as Annexure C. A summary of findings from the UCRA assessment is shown in a tabular format below that highlights on the need for urgent policy level interventions in strengthening risk preparedness and providing monetary support to vulnerable communities for climate resilient development especially in the locality of Island South.

Table 3 | **Summary of UCRA in Kochi**

Categories/Indicators	Tharebhagam	Manassery	Island South	Gandhinagar	Overall
Risk Preparedness	3	3.2	2.6	3.2	3.0
Communication and Awareness	4	4.4	3.8	4.2	4.2
Economic Resources	3.2	3.3	3.0	3.3	3.2

Very Vulnerable Slightly Vulnerable Not Vulnerable

Figure 12 | **Socio-Political Assessment using UCRA tool in Vulnerable Communities**



Conducting an in-depth vulnerability & resilience mapping includes five basic steps, as explained in the WRI's urban community resilience report (Lubaina Rangawala, 2018) as listed below:

- Identify vulnerable neighborhoods in the city based on the climate risk and vulnerability assessment for the city.
- Conduct physical field surveys and identify active social networks, or community-based organizations active in the area, as local partners to conduct field surveys
- Execute field survey using the random sampling method for household surveys, gender- and age-segregated focus group discussions (FGDs), and additional FGDs, if needed, to capture other dimensions of social vulnerability due to occupational, caste or religious discrimination
- Analyse the findings using a standard scoring template (refer to Annex C) to reveal resilience capacity gaps
- Develop a report of recommendations necessary to bridge gaps and increase resilience capacities in vulnerable neighborhoods

To summarise the findings of the UCRA in Kochi, it is recommended that, for effective implementation of localized disaster preparedness it is critical to enable inter-institutional data sharing, develop inter-organizational engagements and empower diverse institutional arrangements across state and other non-state actors.

Recent flooding on Karikkamuri Road, Kochi Summer, 2022.
Image Credit: Achyutha Krishna Anumalla

CHAPTER 4

RESILIENCE ROADMAP FOR THE CITY

The concept of resilience building needs to be incorporated into the planning process by setting specific objectives that need to be achieved over specific time periods. The targeted objectives and actions are recommended based on Urban Community Resistance Assessments conducted in Kochi (attached as Annexure 3) and detailed. There are some measures like planting, rejuvenation of water bodies that can be achieved immediately while others focusing on behavioral change require considerable time.

The roadmap considers the existing systems, capacities to derive the actions, scale of implementation, time period and the desired outcome till a complete transformation may be achieved for moving towards a resilient city.

Described below is the roadmap for Kochi, which ca be adopted by any Urban Local Body as well. The recommendations are divided into three categories: Nature Based Solutions (NBS), community capacities and institutional capacities. The measures that can promote resilience in cites the colors **green, blue** and **orange** in the table represent how they reflect the guiding principles **Data-driven decision making, Integrated planning to build long-term resilience** and **Capacity building in urban governance** for people centric decision making respectively mentioned in Section C.

Table 4 | **Resilience roadmap towards a resilient city**

Category	Intermediate measures (less than a year)	Disaster Preparedeness (1-3 years)	Resilience Planning (5-10years)
Nature Based Solutions *(Tactical interventions in form of projects, incorporating scientific knowledge and regional wisdom)*	Identifying vulnerable locations for application of NBS	Mapping of open spaces Identifying potential restoration sites for improving urban greenery (Annex B) Community engagement for identification and earmarking of green spaces Developing/maintaining flood resilient infrastructure (rain pits/rejuvenating ponds/wetlands) Making key partnerships for technical support Specific annual budgetary allocations for integrating and maintaining NBS in cities	Include NBS in master plans and other city development plans Eg: planned wetlands, multi-storied forests etc. – the operational aspect of including NBS in the plans should be well explained. Develop sustainable flood resilient business Engage local people by employing them in sustained green projects
Community capacities (implementation of specific government led programs for disaster resilience capacity building in identified stakeholders in the community)	Identifying climate disaster-specific vulnerable communities Gap assessment on resilience capacities	Building capacities to understand climate change and disaster associated with climate change Building community and individual climate resilient capacities Forming and training of cluster/ neighbourhood level disaster resilient champions Technical assessment and identification, training of communities for retrofitting towards mitigating effects of extreme climate change	Building awareness on saving for disasters/invest in secondary business Planned relocation to less disaster-prone spaces
Institutional capacities *(Capacity building programs/reforms focused on inter governmental procedural/ policy/systems upgradation as well as in other allied institutions)*	Identifying the key stakeholders based on the challenges identified (Climate specific) Initiate quarterly planning and assessment meetings between stakeholders Develop city-level and ward-wise action committee for building disaster resilience	Regular mapping of climate related disasters, and resilience building of communities based on long-timepredictions (eg: decide to relocate, capacitize communities based on changing coastline) Capacity building on engaging social networks in resilience building process Enabling multi-stakeholder collaborations Develop a 'Knowledge hub' with ULBs as co-ordinating body to pool together global best practices, ideas and experience on disaster resilience techniques/technologies Develop ward-level disaster resilience action plans Engage ULB/district level officials in disaster management training and capacity building	Building awareness on saving for disasters/invest in secondary business Planned relocation to less disaster-prone spaces

CHAPTER 5

MONITORING AND EVALUATION

The Monitoring and Evaluation (ME) framework focus on engaging multiple stakeholders in the city to endorse long-term resilience planning. The proposed ME framework will help cities develop a more inclusive preparedness-oriented CDMP. Table 5 outlines the structure of the ME framework that has been developed for Kochi as detailed in Table 2. The recommendations are in line with the concepts studied in detail under the Cites4Forests program.

The recommendations are in form of activities which needs to be implemented in a specific time bound manner, for which the city needs to allocate resources as well. The activities are specific to incorporate community resilience and NBS aspects into the disaster planning framework, thus propagating and ensuring the incorporation of the concept of long term resilience while planning and implementation.

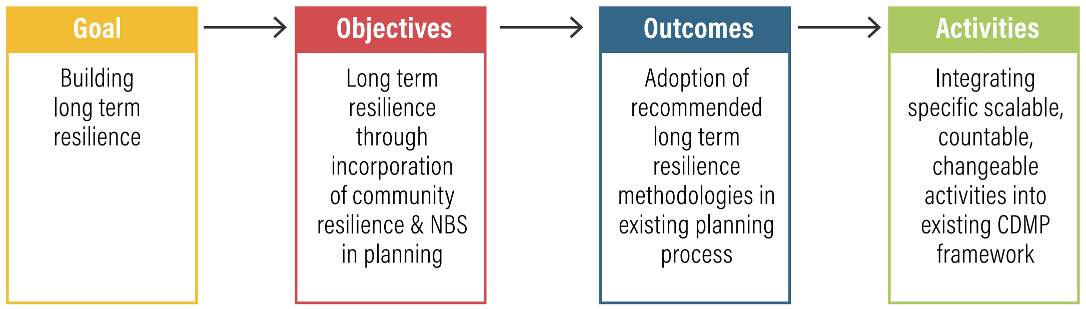


Table 5 | **Monitoring and Evaluation Framework**

Output	Action	Benchmark	Target by 2026	Immediate Measures	Responsible Departments
Increase in green infrastructure	Identify potential greening opportunities prioritising heat stress neighbourhoods	10-12 sq.mt. per person (public open spaces) – URDPFI, 2014 Kochi (0.4 % open and green spaces) Reduction of heat stress days in affected neighbourhoods	Planting native species of trees for heat mitigation in every heat stress affected neighbourhoods	Open/green space mapping with community involvement Earmarking locations for creation of green spaces with community support Formation of community groups for safeguarding green spaces	**Lead Agency:** Urban Local Body **Contributing Stakeholders:** Social Forestry Department (State), Revenue Department (District/ULB), Town Planning Department (District/ULB), Road Transport Department (State), Irrigation Department (State)
	Reactivating accessibility to open spaces including grounds and parks		Active policy/bye-law in place for ensure accessibility to open areas to the public	Better awareness on need of maintenance of open spaces Immediate maintenance measures to remove waste and debris from open spaces and maintain open spaces as accessible and usable.	
Establishing a framework for effective and continuous capacity building	Disaster resilience capacity	69% literacy rate observed in vulnerable communities on disaster awareness - UCRA survey, 2021	100 % literacy on disaster awareness in vulnerable communities Continuous training framework established Building a culture for safety and resilience	Institutional capacity building for overall resilience mapping Identifying suitable methods of information dissemination Design a city level IEC campaign along with other agencies Assign Nodal officers at community level (preferably health inspectors) to ensure regular capacity building programs are conducted at optimum time intervals Training of trainer's program to create local champions, who are well trained and can further influence/train large section of the community on disaster resilence	**Lead Agency:** Urban Local Body **Contributing Stakeholders:** DDMA, Disaster Management Cell (ULB), Health Department (ULB), LSGD (State), State run Training Institutions
	Access to financial and social programs by government and other agencies	Average social cohesion score is roughly 67% 67 % of the households in the community feel a sense of solidarity	Increased financial and social protection Ensure more than 90% score is achieved for social cohesion	Develop micro-finance schemes for disaster-vulnerable communities Develop climate disaster insurances Develop insurance schemes for natural assets against natural disasters	**Lead Agency:** LSGD (State) **Contributing stakeholders:** Government Financial Support Institutions, ULBs

CHAPTER 6

RECOMMENDATIONS TO DECISION MAKERS FOR RESILIENCE INCLUSIVE PLANNING

The key recommendations for different levels of decision makers that need to be largely addressed to ensure resilience building while they are involved in disaster management planning are mentioned below:

Decentralised decision-making

- Strengthen social cohesion through promoting Self Help Group activities
- Better engagement of ASHA workers and health inspectors through their capacity building

People-centric governance: ensure people's participation in the decision-making process

- Ensure better participation of the public in Sabha meetings
- Better documentation of grievances from people's representatives and development of custom-made solution packages

Data sharing across different departments for decision making

- Formation of a disaster management committee at the city level, with regular meetings for data sharing, validation and decision making

Top to Bottom:
1 - Kavaki initiative was inaugurated today at Edward Memorial Government School, Veli, Fort Kochi by the Hon'ble Kochi MLA Shri. K.J. Maxy presided by the Hon'ble Mayor of Kochi Municipal Corporation Adv. M. Anilkumar in presence of Standing committee chairs, Councillors and other officials on Dec 19,2021.
2 - Planting native trees as part of the project
3 - New saplings arrived at Cottolengo Brothers Care Home, Kochi.
4 - Prospective site at Edward Memorial Government School, Veli, Fort Kochi.

THE KAVAKI INITIATIVE: A NBS SUCCESS STORY IN KOCHI

The Kavaki initiative was launched by the Kochi Municipal Corporation (KMC) with the technical support of WRI-India under the Cities4Forests program to convert available open spaces in the city to urban grooves. 'Kavu' or Traditional grooves were a part of Kochi's rich heritage and culture. They acted as natural habitat within cities where flora and fauna flourished and was preserved by the local community. But over time as the city urbanized most of the kavus were cleared for urban infrastructure.

Under the Kavaki initiative KMC is developing micro urban grooves similar to the traditional groves but excluding the religious aspects which will provide multiple ecosystem services including reducing the impact of heat stress in the city and act as rainwater sink for ground water recharge & flood mitigation.

The trees for the sites are sourced from Kerala Forest Research Institute (KFRI) ensuring only native tree species, most adaptable to each specific site conditions (including salt water penetration, flooding, etc) are planted and maintained, adding to the biodiversity of the region. The most critical aspect of the Kavaki initiative is the involvement of local stakeholders. Kavaki sites are developed on even limited space available on public land as well as institutions (both public & private), residential colonies, along major roads and within private properties. This increases the scope of planting in the city which has minimum public open space as well as provide ownership to the regional stakeholders ensuring better maintenance of the Kavaki sites.

Identifying the sites and developing the sites were part of a 4 step strategy. As a first step, KMC & WRI-India with the support of Center for Environment, Heritage & Development (C-HED) conducted mapathon events in Kochi where general public, ward councilors and other stakeholders helped identify vacant land where the Kavaki project could be implemented. Secondly the mapping team of WRI-India identified most vulnerable localities in Kochi that are prone to urban flooding and heat island effect. The vulnerability maps and vacant plot maps were overlayed to identify the potential Kavaki sites. As the final step, with the help of ward councilors the regional stakeholders in every identified site was given awareness and capacity building on the need of ecological solutions like the Kavaki. Later convinced stakeholders became part of the movement and the Kavaki sites were developed.

The first phase of the Kavaki initiative of 1500 trees was a success and KMC is looking forward expand the project to other parts of the city through incorporating it into the municipal budget of 2022-23.

WAY FORWARD

Building Long term climate resilience is imperative since climate change impacts have a cascading effect on lives and livelihoods. The City Disaster Management Plan has a key role in ensuring a strategy for the city in mitigation, prevention, preparedness, rescue and relief, and in capacity building for multiple stakeholders involved in the disaster management process. Some immediate actions for a city to take towards operationalizing the recommendations in the guidance document for resilience planning are as follows:

• Establish a ULB-level disaster management committee ULB level disaster management committee is a mandate according to the Disaster Management Act, 2005. Taking measures to ensure that this committee is operational not only during disaster rescue and relief but is active in planning for long-term resilience building.

• Drafting a comprehensive city disaster management plan A ULB level City Disaster Management Plan need to be developed that is comprehensive of disaster mitigation and post disaster management activities. The disaster mitigation needs to include the recommendations including Nature Based Solutions and stakeholder capacity building for long term sustenance as described in this document. The plan also needs to incorporate a detailed strategy for deriving detailed vulnerability assessment at a city level and developing data based solutions.

• ULB to draft by-laws to ensure funding for long term climate resilience building. Having a budgetary allocation is imperative for building a climate resilient infrastructure. Funding needs to be listed and ULB's should ensure implementation sustainable projects like NBS including its operation and maintenance for long-term preparedness.

• Encourage data-driven decision-making and information sharing approaches among stakeholders Cross-learning and sharing information is key to efficient planning. The stakeholders involved in the resilience planning process should advocate strong willingness to share and learn so we can take inclusive and informed decisions.

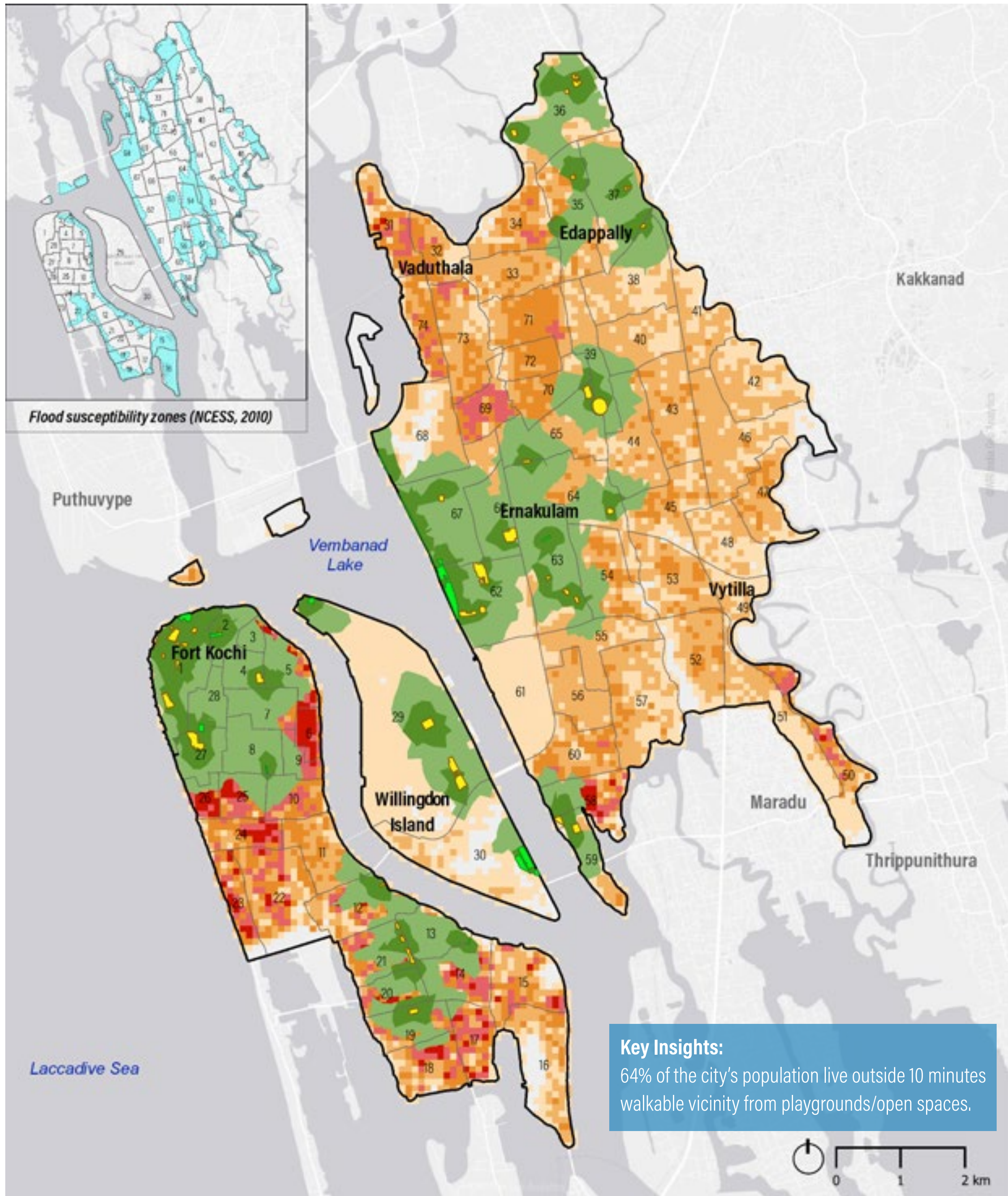
• Enable higher community participation for inclusiveness, ownership and long-term resilience building Community participation is key to building long-term resilience. This is, in part, due to the capacities that are built (or leveraged) as a result of co-designing solutions and the sense of ownership that creates. For this, individual efforts and community practices should be acknowledged, appreciated, and furthered. Such an effort was taken in Kochi to identify the potential spaces for urban greening in Kochi for heat mitigation. Details of the community participation intensive data mining exercise is detailed in Annexure B.

Figure 12 | **Critical Stakeholders for Comprehensive Resilience Building**

Annexure 1: Climate Vulnerability Assessment of Kochi

Image Credit: Achu R Sekhar

Figure 13 | **Access to Open Spaces**



Open Green Spaces
Playgrounds
Flood Susceptibility Zones

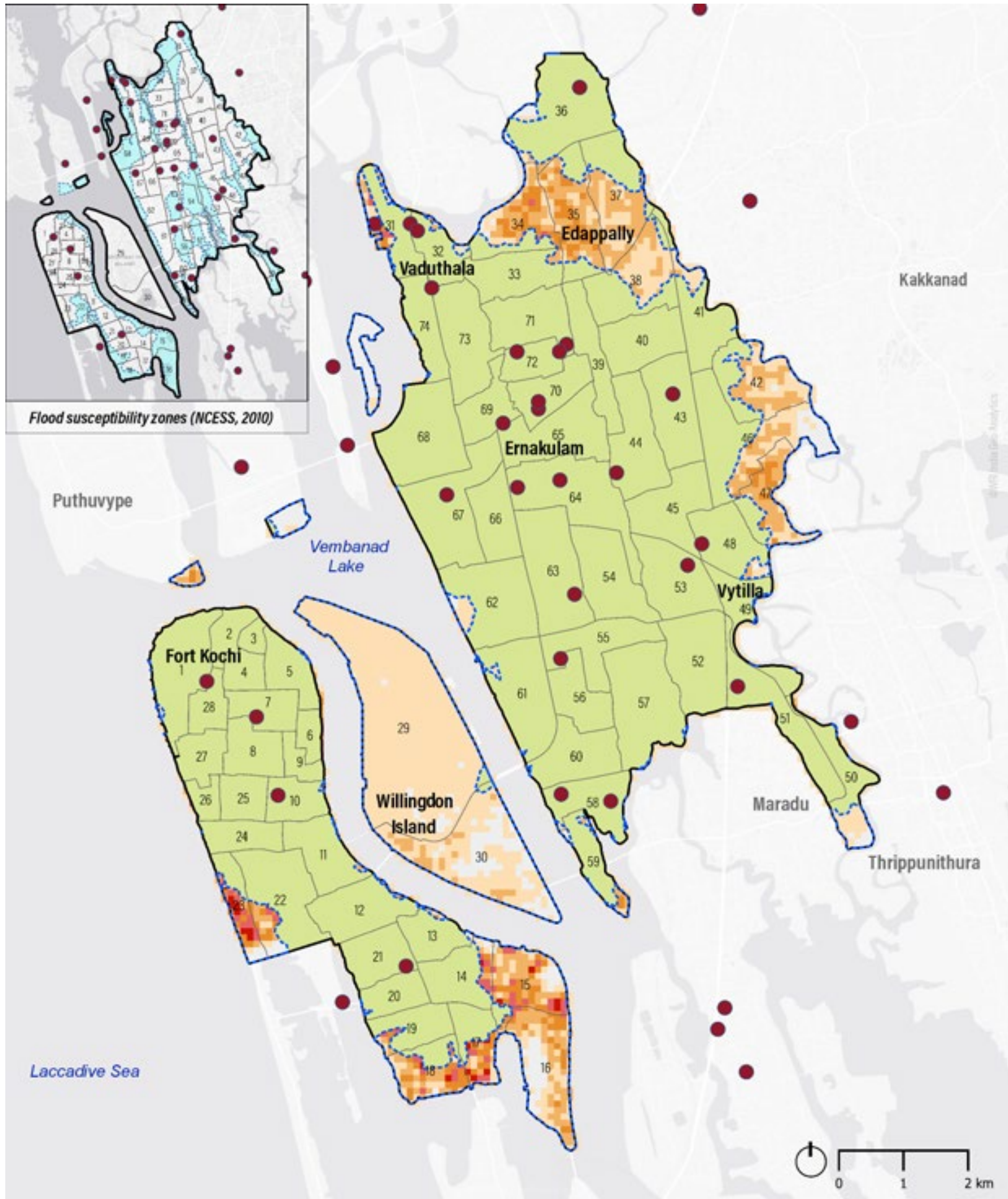
Population with Walkable Access: within 300m | within 800m

Population with Limited Access: <50 | 50-100 | 100-150 | 150-200 | 200-300
(number of persons per hectare)

Source: KSDMA 2021; NCESS 2010; Analysis by WRI India

Note:
Average distance covered in 10 minutes by walk in Indian conditions is: 300m for a caregiver with an infant or a stroller; 800 - 1,000m for an adult (Bernard van Leer Foundation, 2018).

Figure 14 | **Access to Relief Camps**



Monsoon Relief Camp
Flood Susceptibility Zones

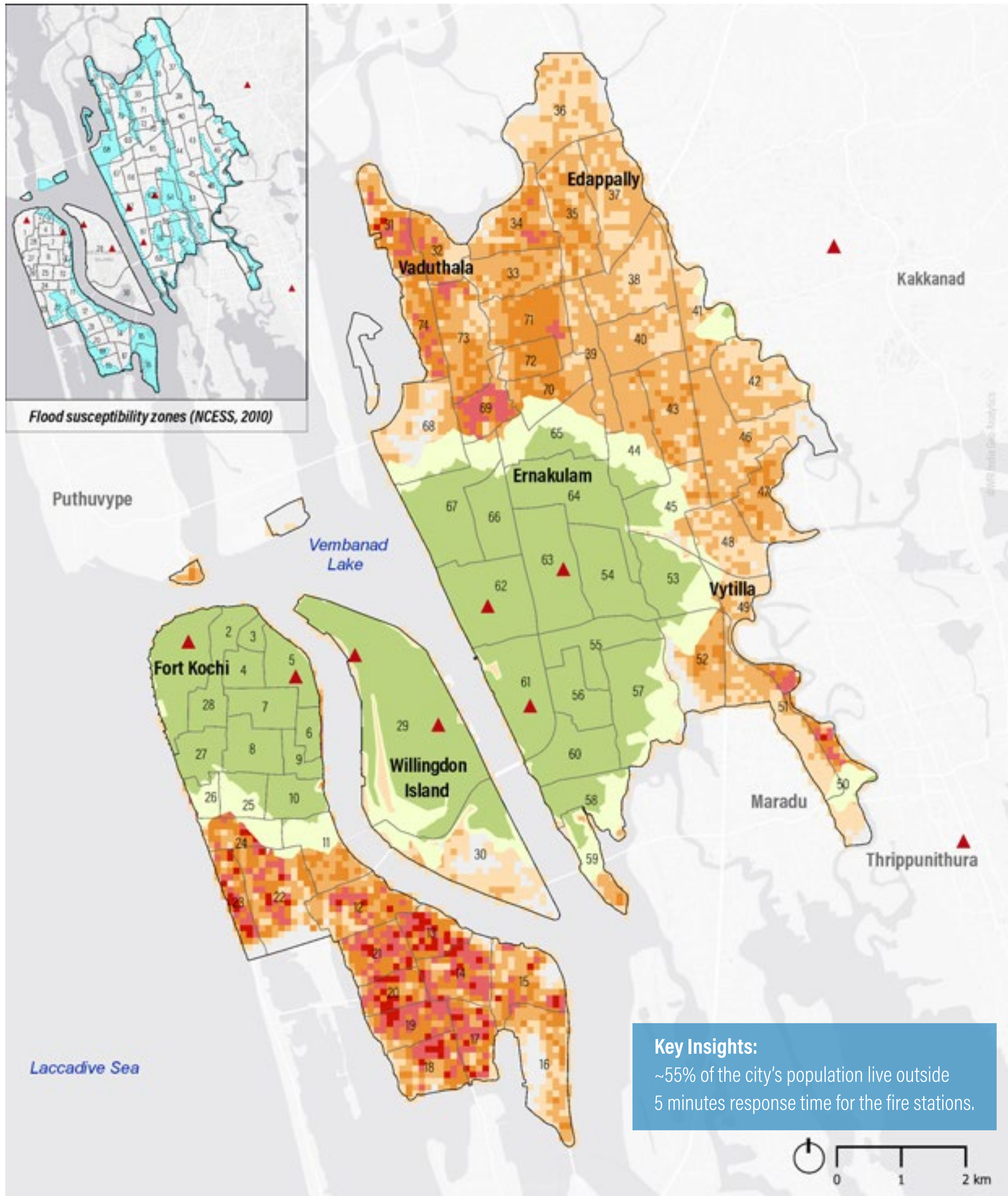
Area covered in 60 minute walk: Service area category (A) 1.8 km at 300 m per 10 minutes
Service area category (B) 4.8 km at 800 m per 10 minutes

Population Density in Service Area Category B: <50 | 50-100 | 100-150 | 150-200 | 200-300
(number of persons per hectare)

Source: KSDMA 2021; NCESS 2010; Analysis by WRI India

Note:
1. Average distance covered in 10 minutes by walk in Indian conditions is: 300m for a caregiver with an infant or a stroller; 800 - 1,000m for an adult (Bernard van Leer Foundation, 2018).
2. Shelter sites should be within one hour walk and within 5 km of dwellings (NCDM, 2002).

Figure 15 | **Access to Fire & Rescue Services**



▲ Fire station **Service Area:** 2.5km 3km **Unserviced Population:** <50 50-100 100-150 150-200 200-300 (number of persons per hectare)

Flood Susceptibility Zones

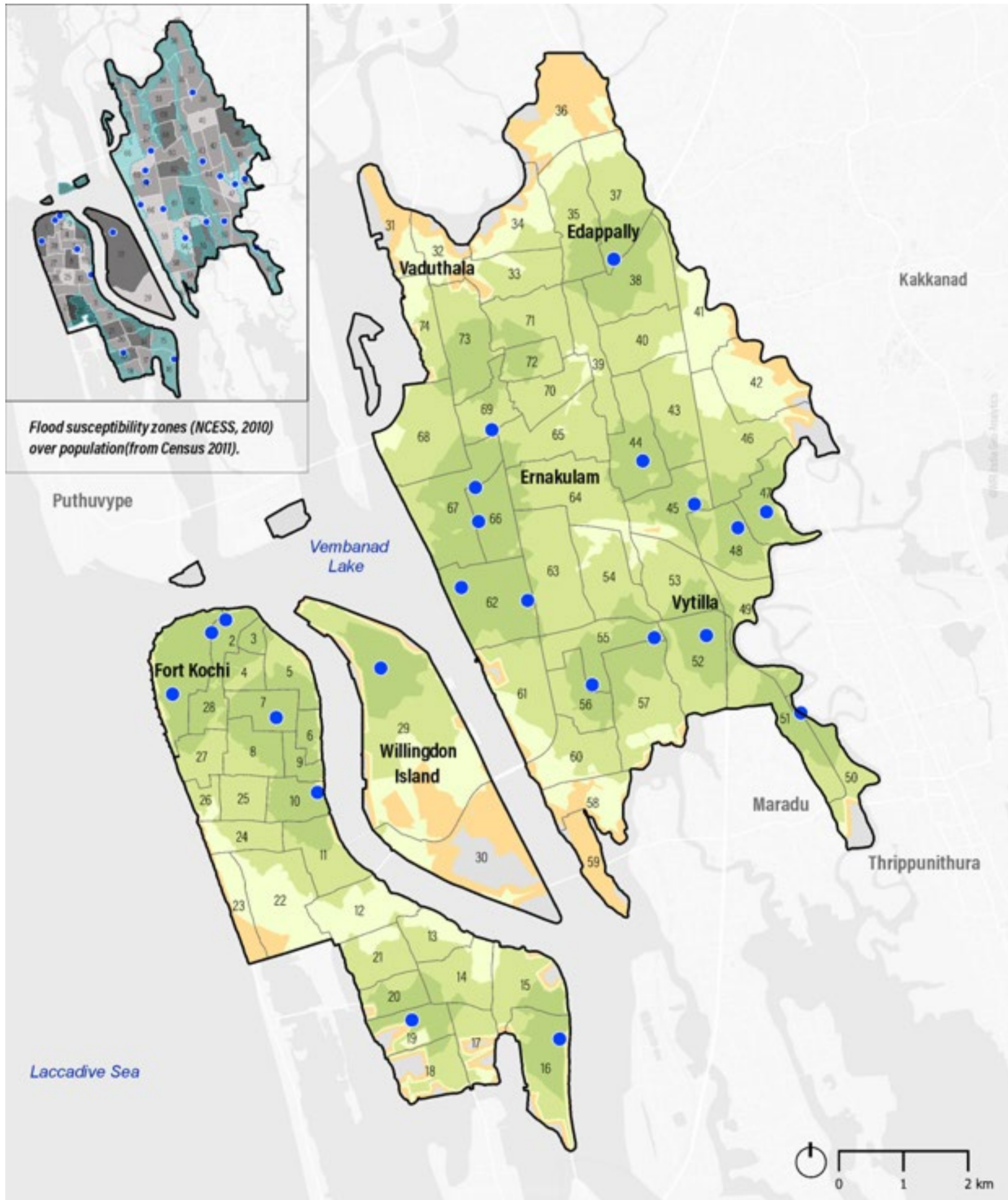
Source: NCESS 2010; KMC 2013; Analysis by WRI India

Note:

1. As per the Standing Fire Advisory Committee (SFAC) under the Ministry of Home Affairs, 3 to 5 min response time is considered ideal for firestation in urban areas (ARDC, 2012).

2. As per Kochi City Mobility Plan 2007, average vehicular speed during peak hours (Morning 9 AM to 10 AM and evening 6 PM to 8 PM) is 30 kmph, and for the lean hours is 35 kmph. Based on this, service area of 2.5 km and 3 km for both peak and lean hours are computed

Figure 16 | **Access to Government Hospitals**



● Government Hospital **Service Area:** 1km 2km 3km 4km

Flood Susceptibility Zones **Ward Population:** 4,000-7,000 7,000-10,000 10,000-13,000 13,000-15,000

Source: Census 2011; NCESS 2010; Analysis by WRI India

Notes:

1. Ward boundaries in the inset is pertaining to census 2011, which was updated and published by KMC in 2013. The main map uses the updated ward numbers and boundaries.

2. As per the Working Group on Emergency Care in India- Ministry of Road Transport & Highways, the average Site Response Time for ambulance services i.e. the time from receiving the call to reaching the (affected) site for accepted calls should be no more than 10 minutes.

3. As per Kochi City Mobility Plan 2007, average vehicular speed during peak hours (Morning 9AM to 10 AM and evening 6PM to 8 PM) is 30 kmph, and for the lean hours is 35 kmph.

4. Derived based on notes 2 & 3, in 10 minutes during the peak hours an ambulance can cover more than 4 km by road.

5. Census 2011 boundaries are used for the map inset Flood Susceptibility Zones. The latest administrative ward boundaries (74 wards) is used for the Access Map.

Annexure 2: Tree Baselining Process

Aalmaram/ Peepal tree (Scientific name: Ficus religiosa) at Residency Street
Image Credit: Kavaliltt/Wikimapia

Top to Bottom:
1, 2 - Data Mapathon conducted in Kochi
2 - Presentation to concerned stakeholders and critical inputs from State Government
3 - New saplings being planted at the inauguration of Cities for Forests Project in Kochi.

Table 6 | **Detailed Tree Baselining Process**

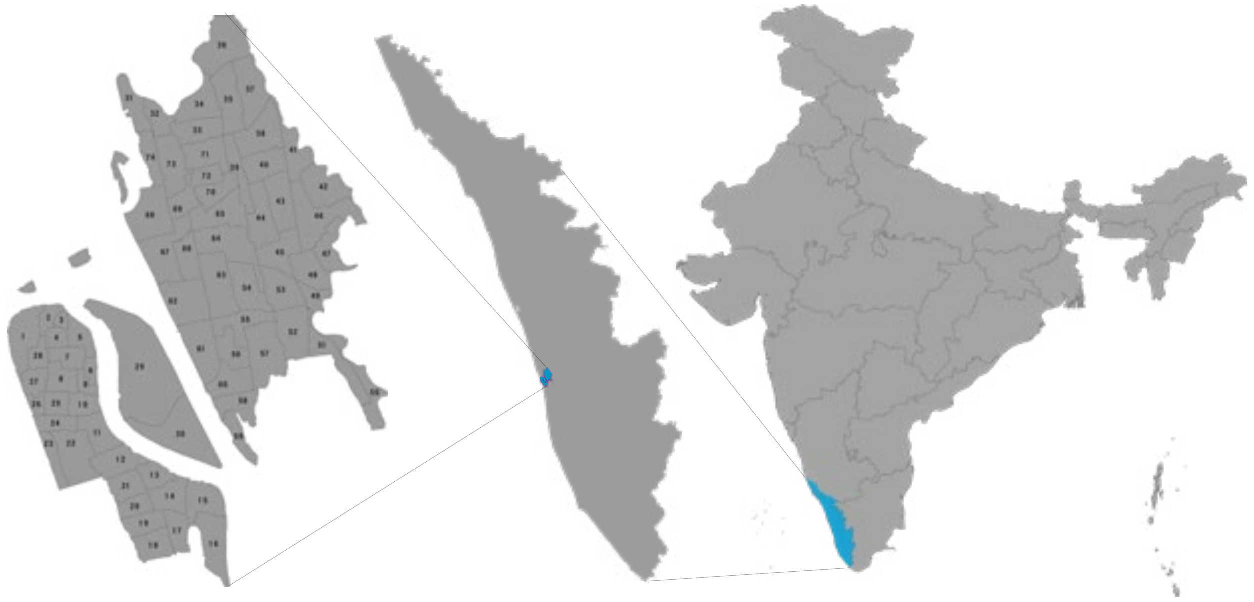
PREPARATORY PHASE	TECHNICAL & OPERATIONAL PHASE	IMPLEMENTATION PHASE
1. Plan for data collection & implementation through early consultations with stakeholders 2. Conduct survey exercise (e.g.: mapathon) to collect data on tree cover, land use and potential restoration sites and typologies	3. Set baseline, identify restoration interventions & develop restoration potential through spatial and statistical analysis with data from mapathon & field visit. 4. Validate restoration potential areas and the interventions and identify land ownership 5. Develop a matrix of opportunities and barriers to prioritize the potential sites, scale and typologies for restoration.	6. Validate restoration potential findings through stakeholder consultation 7. Identify tree species for plantation 8. Conduct training and develop nurseries with self-help groups (SHGs) 9. Undertake plantation with community and local partners

Participatory approach was used to collect data for spatial baseline number of trees, potential areas for restoration and restoration interventions. Mapathon is an intensive, multiday event focused on collection and interpretation of spatial data. It is a participatory exercise developed based on the tool Collect Earth to systematically assess a landscape.

Collect Earth is a data collection platform developed by the OpenForis Initiative of the Food and Agriculture Organization (FAO). Collect Earth enables assessing a landscape using very high-resolution satellite images available in Google Earth and Bing maps in conjunction with the Google Earth Engine.

The participatory mapathon brings together students who are trained in Collect Earth with local participants from Kochi with intimate knowledge of the landscape. Kochi being a highly heterogenous urban area, the participatory approach enables collecting detailed and more accurate information from the local population.

Figure 17 | **Political Map of Kochi Municipal Corporation**



Kochi Municipal Corporation
Population: 0.7 million
Density: 7,139 persons/km²
Literacy: 96%

Kerala
Population: 37.7 million
Density: 928 persons/km²
Literacy: 94%

India
Population: 1,210 million
Density: 328 persons/km²
Literacy: 73%

Source: Census 2011; KSMDC 2021

Key Activities of Mapathon

The process of mapathon for Kochi was undertaken in the following steps:
Step 1 – planning phase

Step 2 – preparatory phase that includes:
i. identifying exclusion area & delineating area for mapathon data collection
ii. developing sampling plots
iii. preparing survey cards

Step 3 - conducting mapathon

Step 4 - analysis and results

Step 1: Planning phase

WRI India discussed the process and requirements of mapathon with the Centre for Heritage, Environment and Development (C-HED), Kochi, which functions as the research and development wing of KMC. A series of meetings and discussions were carried out to demonstrate the process of mapathon and emphasize the importance of participation of ward councillors and residents of Kochi in the exercise. These discussions helped bring the ward councilors onboard for the mapathon. Participants invited for the mapathon included ward councilors, members of resident welfare associations, self-help groups and residents of Kochi. The invitations were extended to all 74 wards of KMC such that it included required representations from all the wards. Student volunteers, who would be trained in the Collect Earth tool, were invited from St. Teresa's College, Kerala Agriculture University and School of Architecture, Mookambika Technical Campus.

Step 2: Preparatory Phase

i. Identify exclusion area and delineate area for mapathon data collection
As a first step to identify preliminary restoration potential for Kochi, field visit was carried out between October 15 and 17, 2019 in KMC. About 120 ground control data points on land use/land cover was collected (WRI India 2019). A preliminary spatial analysis of land use/land cover was developed using the ground control points through supervised classification of Sentinel-2 satellite imagery at 10-meter resolution. The land use/land cover map enabled identification of exclusion areas and delineated area for mapathon data collection. About 40% of KMC comes under exclusion areas which includes highly built-up areas and shallow water. After exclusion, remaining area was delineated for mapathon data collection and further assessment. Areas delineated for mapathon data collection included waterbodies, vegetation, mixed vegetation, mixed built-up and mixed vacant land (Figure 18).

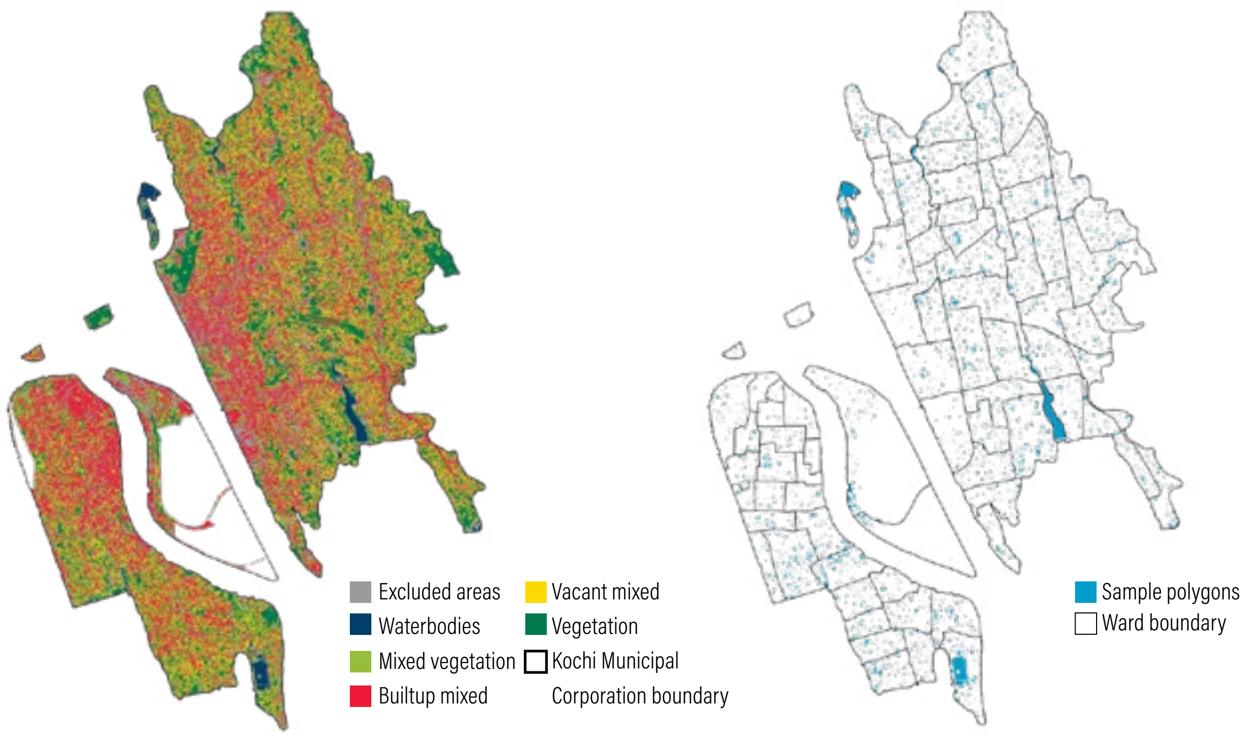
Inland waterbodies included canals, ponds and marshy wetlands. Notably, large lengths of the canals are narrow (Kerala shipping and inland navigation corporation limited 2017) in KMC. As the resolution of Sentinel-1 satellite imagery is low at 10 meters for an urban landscape, delineation of canal and canal banks in the narrow canals of KMC was a limitation in land use/land cover analysis. Hence, the canals were included to identify canal banks for potential spaces of canal bank plantations. Similarly, ponds were included to identify potential for plantation around ponds. Coastal marshy wetlands were included to identify potential for mangrove plantations that are ecologically appropriate and suitable to the conditions of land use. At 10-meter resolution, the land use/land cover classes also had mixed categories. Mixed classes were generated due to the highly heterogenous nature of the urban landscape and low resolution of imagery to analyse urban features.

These mixed categories were identified with one dominant land use/land cover class. Mixed classes included mixed vegetation with predominant vegetation cover, vacant mixed with predominant vacant land and built-up mixed with predominant built-up features.

ii. Develop sampling plots for mapathon Polygons generated from the land use/land cover classification were used as sampling plots. About 80,000 polygons were generated from the land use/land cover classification. 6,000 polygons were sampled using stratified random sampling. These 6,000 polygons cover about 7% of the area delin-eated for mapathon data collection (Fig. 18).

iii. Prepare survey cards
Collect Earth survey card was prepared using the OpenForis Collect Earth tool. Sample forms can be seen in Figure 18. Detailed questionnaire of the survey form is available in Annex 1.

Figure 18 | **Survey cards in Collect Earth**



Step 3: Conduct Mapathon

Mapathon was conducted by pairing student volunteers with participants from the landscape to collect data using the Collect Earth tool. Student volunteers were trained on the Collect Earth tool and provided demonstrations and hands-on training to assess the plots using Collect Earth with inputs from local participants. Participants from the landscape, including ward councillors, resident welfare association members and other representatives from the ward, provided information about the landscape in the survey questionnaire. Detailed information about the plots in a specific ward were provided by the participants represented by the respective ward. For each sample plot, data was collected for the following attributes: number of existing trees, land use, presence of potential to improve tree cover, restoration interventions and land ownership. In addition to the sampling plots, the ward councillor or the representatives from the ward also provided information on additional areas where they observed potential to improve tree cover. This information was captured separately in additional plots. This way, the process ensured extending the intricate local knowledge of local people to all key areas, capturing potential areas to improve tree cover in KMC. Figure below shows data collection being carried out by the participants.

Two-phase mapathon and challenges faced during assessments in Kochi

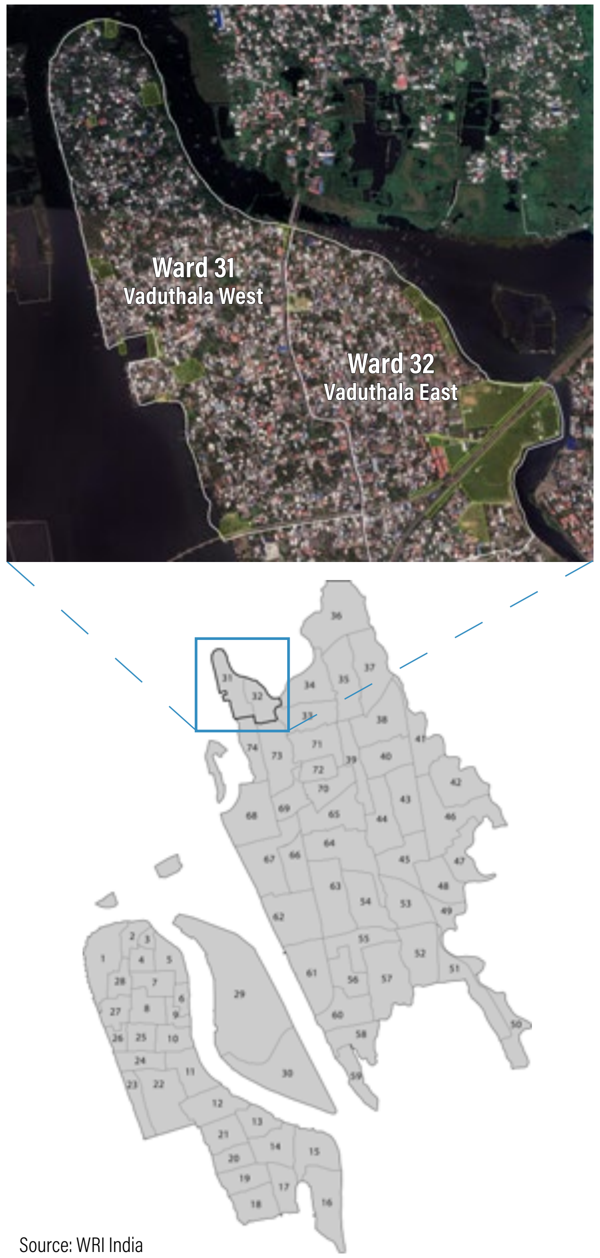
First phase of mapathon was held between January 9 and 11, 2020 at St. Teresa college, Kochi. Participants in the mapathon included 30 female student volunteers paired with 60 local people from Kochi, including 34 female and 26 male participants. The local participants included Kochi Mayor, ward councillors, representatives of the ward members and resident welfare association members. In the first phase, 2,740 sampling plots and 1,314 additional plots were assessed across 32 wards in KMC.

Second phase of mapathon was carried out between February 25-26, 2020, at Alapatt Heritage, Kochi. Participants included 1 female and 6 male student volunteers paired with 5 local people (1 female and 4 male participants) from Kochi resident welfare association members. In the second phase, 220 sampling plots were assessed from 4 wards in Fort Kochi region and ward number-54.

CHALLENGES

- Mapathon depends on participation of people with local knowledge. Participation of local people was absent in some of the wards resulting in underrepresentation
- Data collection on wards that have larger area and higher sampling plots was time-intensive, resulting in lesser spatial coverage as representatives did not stay longer than 3 hours.

Fig 19 | **Wards identified for restoration in Mapathon**



Source: WRI India

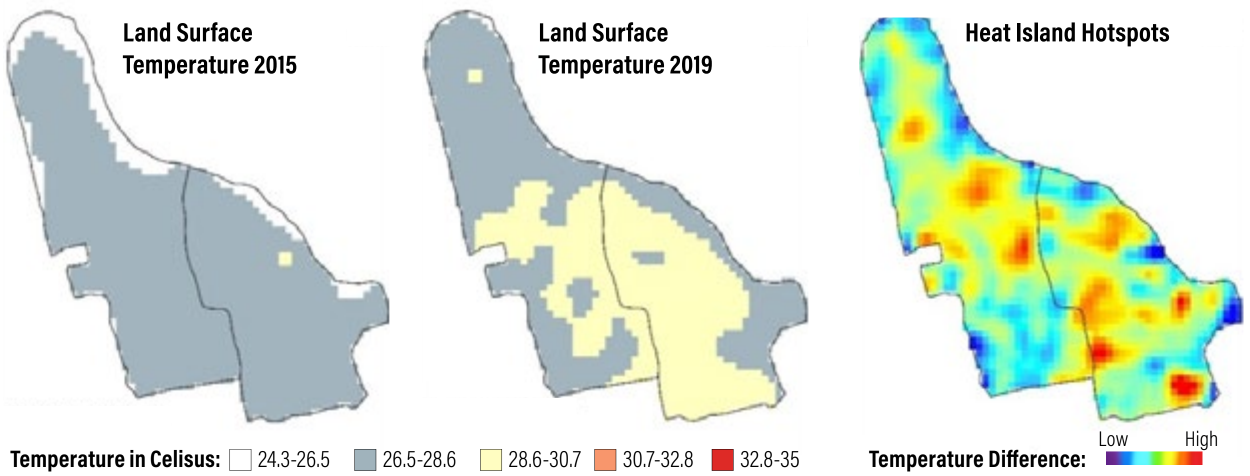
Step 4: Analysis and Results

Data analysis was carried out for spatially contiguous wards for which mapathon data was collected. Data available for spatially contiguous regions include the wards 1, 2, 4-10, 27 and 28, part of Fort Kochi region, wards 31 and 32 of Vaduthala region, and wards 34 and 35 of Elamakkara.

Among these spatially contiguous regions for which mapathon data is available, Fort Kochi and Vaduthala regions are prioritized for preliminary analysis. Fort Kochi region observes convergence of other activities of Cities4Forests in Kochi such as coastal public space interventions and urban water resilience. Vaduthala and Elamakkara regions are a contiguous stretch of land. Potential for restoration observed was high in Vaduthala, but very less in Elamakkara (Field visits carried out between February 27 and March 1, 2020). Heat island effect was also significant in the wards of Vaduthala (see Figure 20). Hence, based on higher restoration potential and heat islands, Vaduthala region was prioritised for preliminary analysis along with Fort Kochi region.

Data analysis was carried out using mapathon data. Data collected from the first and second phase mapathon were compiled, cleaned and then analysed. Collect Earth Saiku1 and Microsoft Excel were used for data cleaning and quantitative analysis. Preliminary results presented here includes tree baseline for the year 2019 and restoration interventions identified through Mapathon. These results of preliminary statistical outputs are discussed in following two sections for the two prioritized regions - Fort Kochi and Vaduthala region.

Figure 20 | **Location of Vaduthala West (31) & Vaduthala East (32) in Kochi with Heat Stress**



Fort Kochi Region

Preliminary statistical analysis carried out for Fort Kochi region includes eleven wards. The ward numbers of Fort Kochi region are 1, 2, 4, 5, 6, 7, 8, 9, 10, 27 and 28. The region covers an area of 663 ha. After excluding areas where restoration is not possible, the area considered for sampling to collect data through mapathon is 487 ha. Sample of 398 plots assessed in mapathon were used to develop the baseline tree count.

Tree Baseline - 2019

Baseline of trees for 2019 is developed from the mapathon data. Baseline tree estimates for the year 2019 in Fort Kochi region is 39,366 trees (Table 1).

It is observed that more than three-fourth of the assessed region has tree cover in Fort Kochi. Most prominent species found in the region are coconut (Cocos nucifera), jackfruit (Artocarpus heterophyllus) and mango (Mangifera indica). Coconut tree is the most prominent species. It is present in more than half of the tree-covered area of Fort Kochi region, which explains the high density of tree cover. Other tree species found are arecanut (Areca catechu), peepal (Ficus religiosa), raintree (Samanea saman or Albizia saman), banyan (Ficus benghalensis), neem (Azadirachta indica), tamarind (Tamarindus indica), gulmohar (Delonix regia), Ashoka (Polyalthia longifolia), bamboo (Bambusa sp) and devil tree (Alstonia scholaris).

Table 7 | **Tree baseline in 2019 for Fort Kochi region**

Region	Wards	Number of Trees	Density of Trees (Trees per hectare in 2019)
Fort Kochi	1, 2, 4, 5, 6, 7, 8, 9, 10, 27 and 28	39, 366	59

Landscape Restoration Interventions

Through mapathon, the participants identified restoration interventions in KMC. Existing tree-based interventions identified by the participants in Fort Kochi include home garden, parks with trees, boundary plantation, plantation in entire plot, linear plantation and canal bank plantation. Based on the potential for improving tree cover and land use of the sampling plots, participants from Fort Kochi identified potential tree-based interventions in the region. The potential restoration interventions identified by the participants are (i) plantation in entire plot, (ii) canal bank/ mangrove plantation, (iii) boundary plantation, (iv) dispersed trees, (v) linear plantation and (vi) home garden.

The potential and land use/land cover of restoration interventions identified is provided in Table 2. Further analysis and refining restoration interventions need to be carried out with inputs from literature and field visits. Identified restoration intervention will be validated through stakeholder consultation.

Table 8 | **Restoration Interventions, its potential and the land use/land cover for Fort Kochi region**

LAND USE/LAND COVER	POTENTIAL RESTORATION INTERVENTIONS IN FORT KOCHI REGION					
	Plantation in entire plot	Boundary plantation	Canal bank/ mangrove plantation	Dispersed trees	Home Garden	Linear Plantation
Builtup	2%	7%	2%	-	37%	6%
Vegetation	1%	3%	-	4%	1%	1%
Roads	1%	2%	-	-	1%	7%
Open Land	16%	11%	1%	1%	2%	1%
Waterbody	_	_	1%	-	-	-

Vaduthala Region

Preliminary analysis is carried out for Vaduthala region to assess baseline number of trees and restoration interventions. Vaduthala region includes the ward numbers 31 and 32, which spreads over an area of 150 ha. After exclusion of areas where restoration is not possible, the area assessed for mapathon in Vaduthala includes 110.92 ha. Sample of 124 plots were assessed in mapathon for Vaduthala region. Baseline of tree count was developed from these sampled plots.

Tree Baseline - 2019

Baseline of trees for 2019 is developed from the Baseline tree estimates for the year 2019 in Vaduthala region is 5,650 trees (Table XX).

It is observed that about 70% of the assessed region has tree cover in Vaduthala region. Major tree species found in the region is same as identified in Fort Kochi, which includes coconut (Cocos nucifera), jackfruit (Artocarpus heterophyllus) and mango (Mangifera indica). Coconut is the most prominent tree species, present in more than 80% of tree covered area of Vaduthala region. Other tree species found are arecanut (Areca catechu), peepal (Ficus religiosa), raintree (Samanea saman or Albizia saman), banyan (Ficus benghalensis), neem (Azadirachta indica), tamarind (Tamarindus indica), gulmohar (Delonix regia), bamboo (Bambusa sp) and devil tree (Alstonia scholaris).

Table 9 | **Tree baseline in 2019 for Fort Kochi region**

Region	Wards	Number of Trees	Density of Trees (Trees per hectare in 2019)
Vaduthala	31 and 32	5,650	38

Landscape Restoration Interventions

The participants identified restoration interventions in KMC through the mapathon. Existing tree-based interventions identified in Vaduthala through Mapathon includes home garden, parks with trees, boundary plantation, linear plantation, canal bank plantation and mangrove plantation. Through mapathon, participants from Vaduthala region identified potential tree-based interventions based on the potential for improving tree cover and land use of the sampling plots. The potential restoration interventions identified in Vaduthala region include (i) plantation in the entire plot, (ii) canal bank/mangrove plantation, (iii) boundary plantation, (iv) dispersed trees, (v) linear plantation and (vi) home garden. The restoration interventions identified, its potential and the land use/land cover is provided in Table 4. Further analysis and refining restoration interventions will be carried out with inputs from literature and field visits. Identified restoration intervention and the potential areas for improving tree cover will be validated through stakeholder consultation.

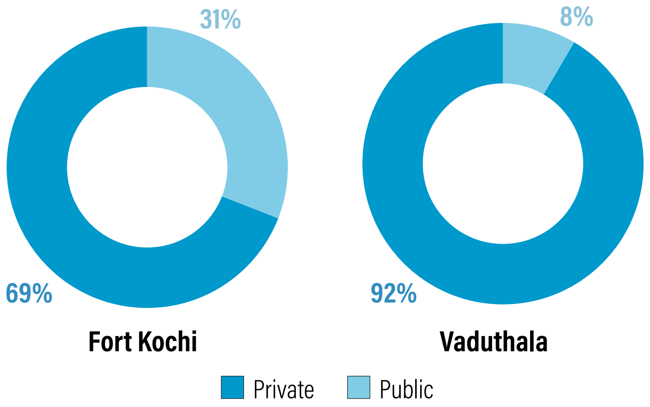
Table 10 | **Restoration interventions, its potential and the land use/land cover for Vaduthala region**

LAND USE/LAND COVER	POTENTIAL RESTORATION INTERVENTIONS IN FORT KOCHI REGION					
	Plantation in entire plot	Boundary plantation	Canal bank/ mangrove plantation	Dispersed trees	Home Garden	Linear Plantation
Builtup	2%	8%	-	2%	27%	-
Vegetation	-	4%	-	10%	1%	-
Roads	-	-	-	-	1%	2%
Open Land	27%	12%	-	4%	2%	-
Waterbody	_	-	2%	-	-	-

Land Ownership

The restoration potential areas reveals that more than 90% of the potential areas are private (Figure 7). Further identification of exact landownership is necessary in consultation with the KMC for validation and implementation.

Fig 21 | **Land Ownership of Potential Restoration Areas**



Fort Kochi

Vaduthala

Annexure 3: Urban Community Resilience Assessment in Kochi Municipal Corporation

Image Credit: Abhinand Gopal

Top to Bottom:
1 - MSW dumped into canals in Saudi Colony
2 - Stakeholder consultation meetings at Vaduthala on urban green opportunities
3 - Impact of tidal attack at Saudi Colony
4 - Raising floor height to mitigate flooding resulted in reduced room height in houses at Palluruthy

UCRA Framework

Assessment of the resilience capacity of the community is an important component of developing the CDMP. The CDMP should be custom-made to cater to the need of society based on its capacity, especially of the most vulnerable elements. The Urban Community Resilience Assessment (UCRA) tool developed by WRI is one such tool to address this critical omission. It helps assess the capacity of the community, and even at an individual level, in a vector format using a scoring system. The system has already been implemented in cities across the globe as part of city development plans for community assessments. Rio de Janeiro in Brazil, Semarang in Indonesia and Surat in India are some cities where the tool has already been used as part of the sustainable planning process.

Engagement using the UCRA Framework

The UCRA framework is implemented in 4 stages: preparation, data collection, data analysis and project planning. In the initial phase, the framework is adapted to the needs of the target city, and then in the following stages, implementation is done including identification of sample size, selection and training of field agents, development of questionnaire based on regional climatic assessment, field data collection, assessment based on indicators, scoring of indicators and deriving the assessment score card. Finally, resilience strategies are developed based on the analysis performed.

Figure 22 | **Visualisation of the UCRA Framework**

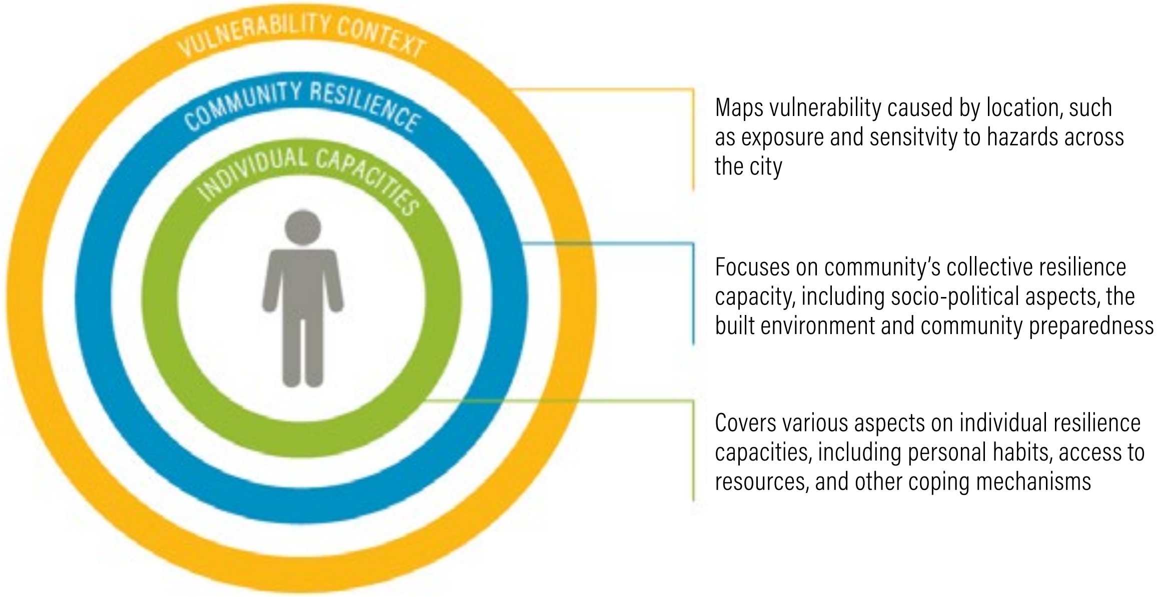


Figure 23 | **UCRA Methodology**

Phase 1 - PREPERATION
Adapting the framework to a new city

Phase 2 - DATA COLLECTION
Collecting primary & secondary data for the 3 dimentions

Phase 3 - DATA ANALYSIS
Completing the assessment and scoring indicators

Phase 4 - PROJECT PLANNING
Co-developing resilience strategies

Implementation of UCRA tool in Kochi

UCRA framework was implemented in Kochi Municipal Corporation by WRI with support of local partner CSES. The UCRA tool was implemented in 4 localities that best represent vulnerable society in the locality with the support of local stakeholders. The localities include Manassery, South Island, Gandhi Nagar & Tharebhagama. While Manassery is a coastal locality dominated in numbers by the fishing community, South Island is mostly comprised of migrant neighbors. Gandhi Nagar is located at the heart of the city.

Figure 24 | **UCRA Project – Pilot locations in Kochi**

☐ Kochi Municipal Corporation boundary
☐ Ward boundary
Jetty Station
Railway Station
Metro Station
Metro
Highway
Railway

Source: WRI India 2021; Google Earth Pro 2021

1. Manaserry

The sea facing ward 23 has a majority of households involved in fishing. Saudi is affected by the sea and during monsoon people rehabilitate temporarily.

Problem: sea erosion; sea attack during high tides

2. Tharebhagam

Within ward 12, low income neighborhoods involved in daily wages and fishing. Chirakkal and Pallichal selected for sample household survey.

Problem: adjacent to water body; no disposal system

3. South Island

Ward 30 is located on the southern side of Willington Island, comprised of low-income high-density Tamil migrants involved in construction and manual labor.

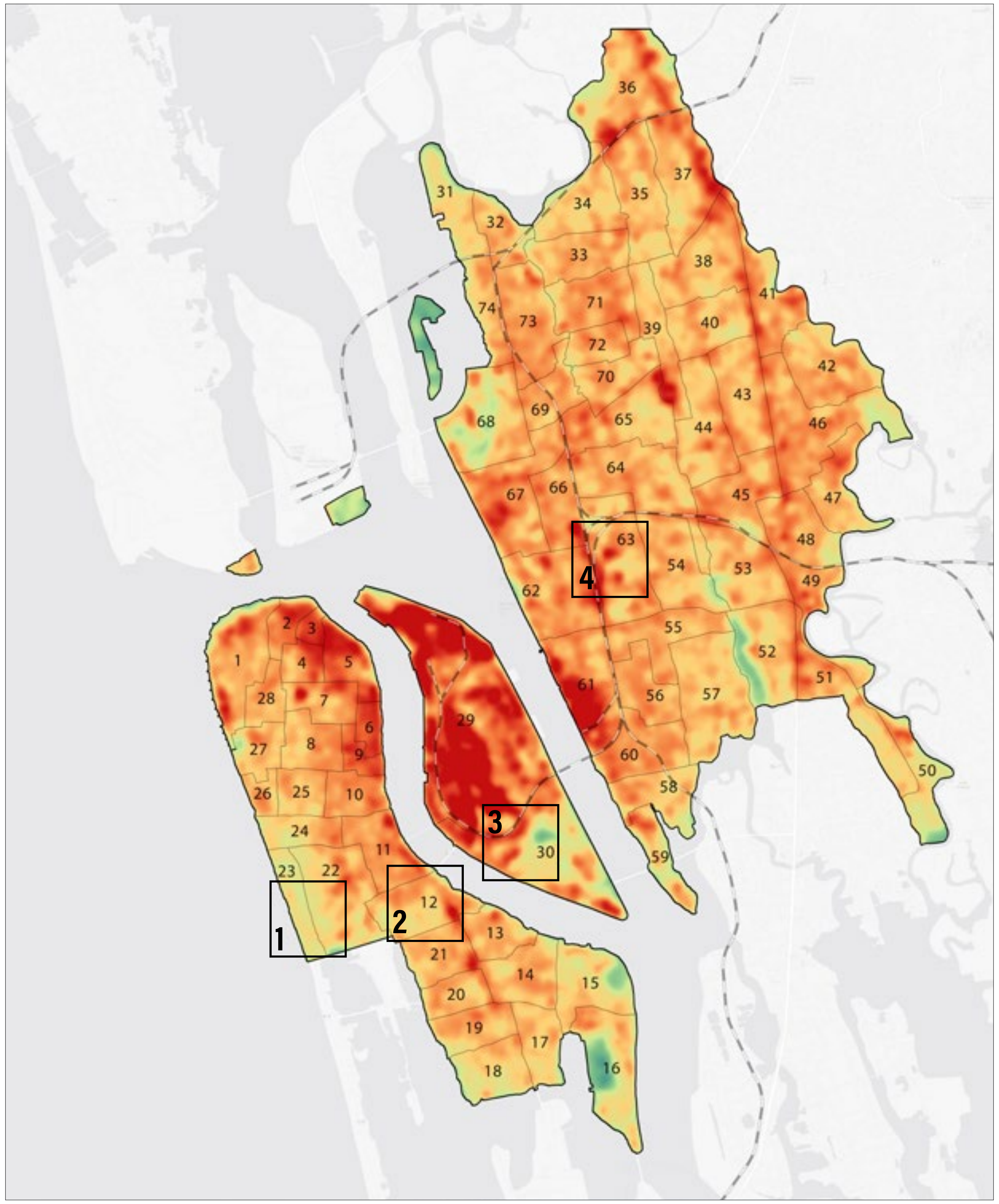
Problem: water-logged during high tide and heavy rain; poor provision of toilets

4. Gandhinagar

P&T Udaya colony in ward 63 has low income households engaged in informal work in waste picking, domestic help and industrial labor

Problem: severe water-logging during monsoon

Figure 25 | **Land Surface Temperature across UCRA Locations 2017 - 2020**

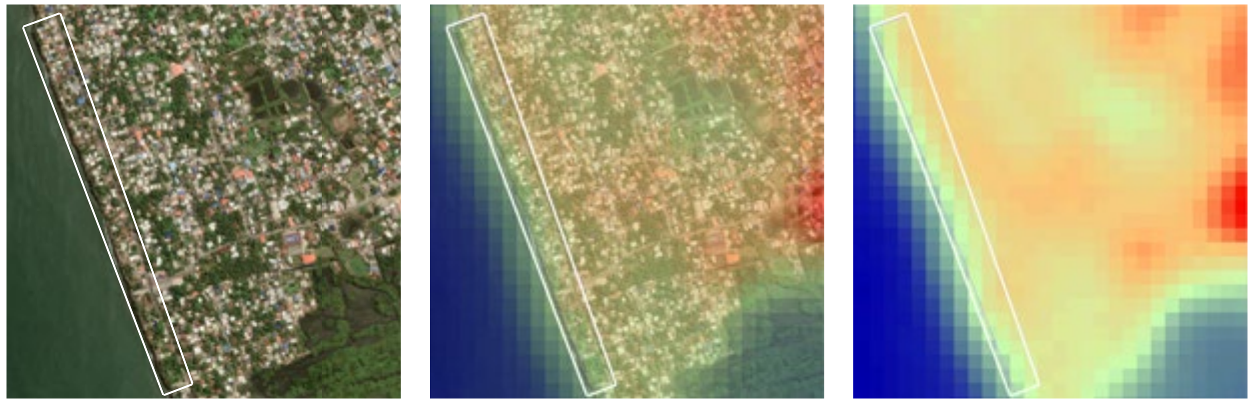


☐ Kochi Municipal Corporation boundary ☐ Ward boundary --- Railway **Mean Land Surface Temperature:** 25°C 28°C 32°C

Source: WRI India 2021; LandSat (USGS/NASA); ESRI grey base map

Note: Each pixel in the map represents the overall average LST computed using LandSat 8 imagery for the following dates: 3 Feb, 2017; Feb 6, 2018; Feb 12, 2020.

Satellite Image 2021 | **Overlapping Satellite with LST** | **Mean Land Surface Temperature 2017-20**



1. Saudi, a low rise mid-income neighbourhood faces immediate dangers from sea flooding and erosion.

2. Chirakkal is a low-income mid-rise settlement on the edge of Kochi Municipal Corporation.

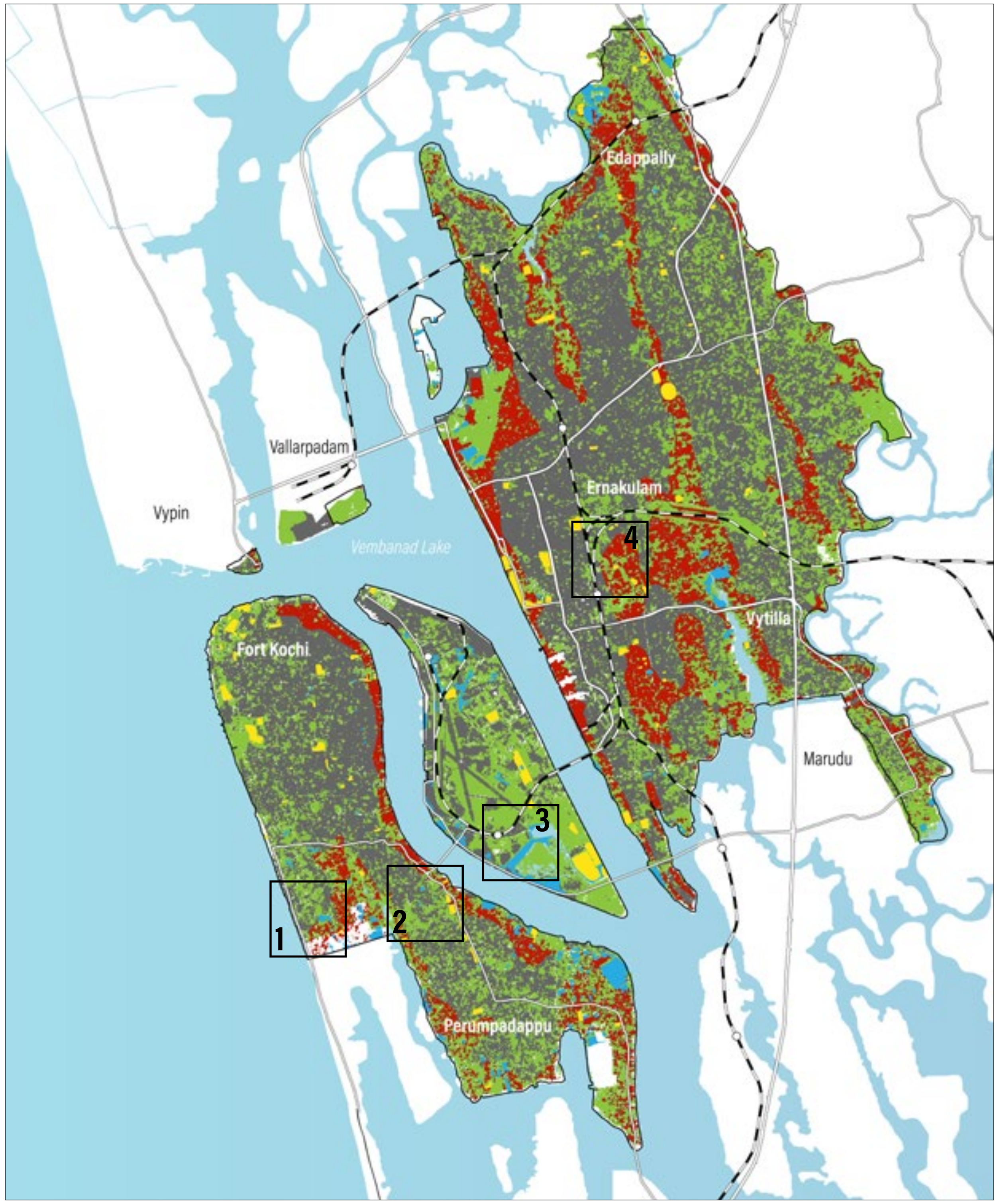
3. Vathuruthy experiences heat island effect due to its constricted location between the Naval Airport and the cold storage facility.

4. P&T Udaya colony lies on the periphery of the railway junction, a petroleum refinery and a warehouse.

Mean Land Surface Temperature: 25°C 28°C 32°C

Source: WRI India 2021; Google Earth Pro 2021; KSDMA 2018; LandSat (USGS/NASA)

Figure 26 | **Climate Impact Assessment in UCRA pilot locations**



☐ Kochi Municipal Corporation boundary
☐ Ward boundary
Highway
Railway
Open Spaces
Vegetation Cover
Built Settlements
Settlements in Flood Risk Areas

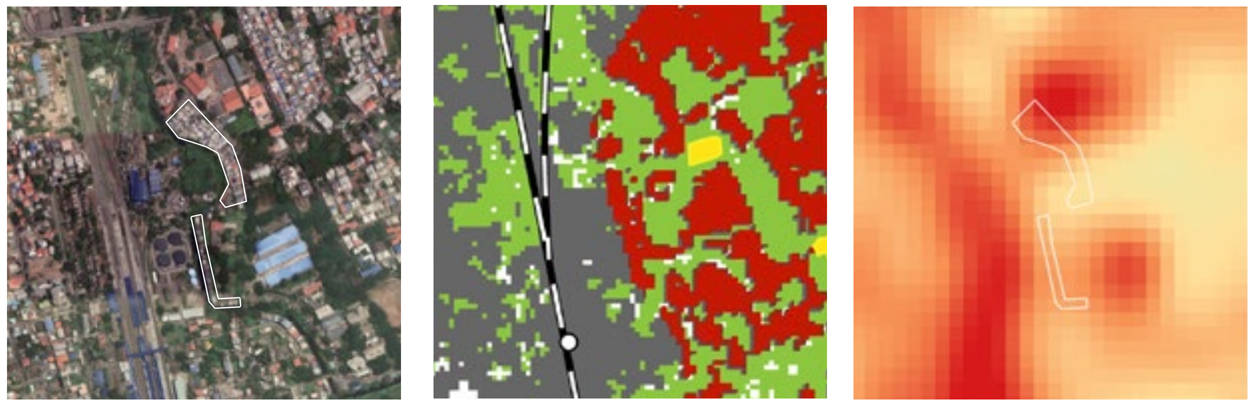
Source: WRI India 2021; NCESS 2010; Sentinel ESA.

Flood Plains | **Flood Risk Areas 2010** | **Mean Land Surface Temperature 2017-20**

1. Saudi, a low rise mid-income neighbourhood faces flooding from sea, soil erosion and inundation during the monsoon.

2. Chirakkal is a low-income mid-rise settlement on the edge of Kochi Municipal Corporation with poor sewage disposal system.

3. Vathuruthy lies on the periphery on the Naval airport and well connected to rail network, but faces severe waterlogging during high tide and monsoon.



4. P&T Udaya colony experiences water-logging and high termpeartures throughout the year.

Mean Land Surface Temperature:
25°C 28°C 32°C

Source: WRI India 2021; Google Earth Pro 2021; NCESS 2010; Sentinel ESA; LandSat (USGS/NASA)

Figure 27 | Stakeholder consultation meeting in Saudi Colony, Kochi

Key Activities of Mapathon

A total of 500 households were surveyed, including 125 houses from each of the 4 neighborhoods. The list of households collected from Anganwadis formed the sampling frame for the selection of households. For the FGDs, in each of the localities, separate discussions were conducted with focus on representatives from elected bodies, community leaders, staff of agencies providing services to these communities, Kudumbashree functionaries, ASHA workers and Anganwadi workers, among other members of the locality. 5 FGDs were conducted of which 2 were exclusively conducted for women residents.

The data collection team consisted of investigators and supervisors, who were given specific training before the data collection exercise. The investigators conducted the house-to-house data collection whereas the supervisors ensured that all houses were covered as planned and the data quality was maintained. The data collected from each of the households were accumulated to derive the mean value for each indicator. The values were later scored in a scale of 1-5 for the purpose of summarising the resilience capacity, where 1 represent 'Not Resilient' and 5 represent 'Very Resilient'.

Figure 28 | Door to Door Data Collection in Udaya Colony, Kochi

Critical Indicators of UCRA Tool and Experience from Case Studies

The data collected using the UCRA tool focuses on information based on community resilience and individual preparedness that can be identified through certain indicators. The data collected can be assessed to derive a participatory planning process for climate resilience.

1. Community Resilience

The community resilience was scored on the basis of selected indicators which were divided into 4 categories including social cohesion, collective preparedness, governance and built environment. In the case of Kochi, there were 34 indicators identified altogether and divided among the 4 categories2. Assessments based on each category are mentioned in the sections below:

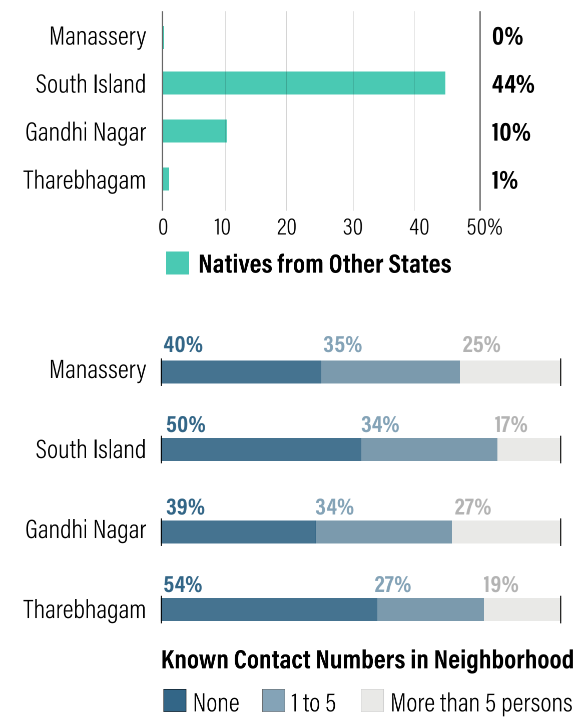
Social Cohesion

In general, it is observed that social cohesion is stronger in communities where residents have commonalities and have been staying together for a long time. In communities where the residents share the same/associated traits including religion, profession, etc. the cohesion is observed to be much higher. In communities where the residents are migrants or from different backgrounds, the social cohesion is observed to be much lesser. Depth of social cohesion plays a major role during crisis management; it leads to better communication and support of people, faster response to disasters and more impactful on-ground resilience action.

In KMC it was observed that in neighborhoods like South Island with a large share of migrant labor and natives of other cities and states, people don't consider the city as their home and have comparatively very less contact with their neighbors. A large portion of such population does not even have contact numbers of their immediate neighbors. Their lack of community engagement results in lesser knowledge on community forums and regional contact persons like elected representatives, which makes them more vulnerable to disaster impacts.

In fact, in order to develop better cohesion between people, strategies need to be developed by the ULB, because irrespective of the locality, at least 2 out of every 10 people do not feel a good level of comfort with their neighbors. This was mostly because of bad conduct of individuals or a group of people in every neighborhood.

Fig 29 | Community Resilience Assessments, Kochi



Collective Preparedness

It focuses on whether the community is prepared or has the capacity to face a disaster, get engaged in rescue or even recover from the disaster as a group.

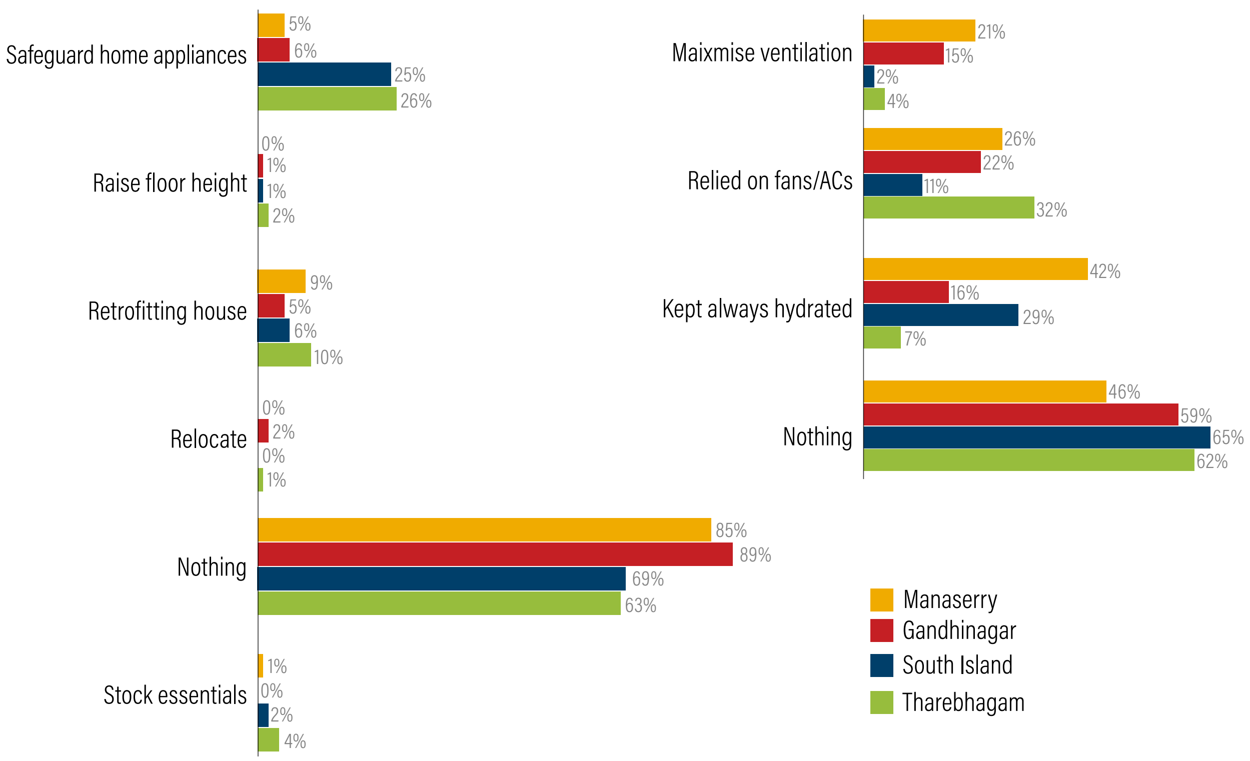
A large portion of the vulnerable communities in Kochi live in a state of continuous fear of climate change and associated disasters. But even communities that experience extreme weather conditions don't do much to reduce the impact of disasters on their own. Often the people are not very interested in disaster preparedness training programs. This stresses on the need for capacity building among vulnerable communities.

In Kochi, where flooding and sea attack is a major concern for most citizens, more than 70% of the vulnerable communities are not engaged in any kind of preparation activities other than quick-fix methods to safeguard their belongings. A sizable share of the population in all the 4 surveyed vulnerable communities are affected by annual seasonal extremities like the monsoon but do not prepare themselves for disasters or disease. While sea attacks are restricted to Manassery, the other three localities – South Island, Tharebhagama and Gandhi Nagar – are subject to water logging, monsoon flooding and extreme heat. Not even 5% of the surveyed population have attended any kind of disaster preparedness training programs. Preparation of mock drills were also negligible. Although the population of severely affected Gandhi Nagar and Manassery localities have access to emergency shelters, almost 40% of the affected population in South Island and Tharebhagama do not have access to or are not aware of any kind of emergency shelters. Even the few numbers of trainings provided were all community-based, mostly by the church and by the fisheries department, Matsyafed and fishermen associations in the fishing-based communities.

Fig 30 | **Collective Preparedness to Floods and Heat Stress by Vulnerable Communities**

Q. What preparations do flood affected households do during onset of monsoon?

Q. What all was done to relieve from extreme heat stress?



Similar is the situation with healthcare-related preparedness. On average, not more than 15% of the population has received any kind of health awareness training, which is clearly reflected in the fact that more than 40% of the vulnerable community households recorded monsoon-related diseases every year, that too mostly viral and respiratory diseases.

It was also observed that households that avoided such monsoon diseases basically relied on simple preparations focused on monsoon diet care (like warm water and heated food) and hygiene alone. Hence, even such basic awareness can do great good for the people. Government health checkups are accessed by only 50% of the population and hence need more reach for better climate resilience.

Further, almost 50% of the population in all the vulnerable areas still lack access to the internet and social media. There are minimal early warning systems for extreme climate except for sea attacks, and most people still depend on TV/radio news channels for any weather update.

Again, except for sea attacks, there is almost zero early warning given for monsoon flooding, water stagnation and other climate disasters to the vulnerable communities. This results in loss/damage of household material, business and agriculture which could have been avoided. In Gandhi Nagar, almost 90% of the households reported such losses that could have been avoided.

Fig 31 | **Health Precautions vs Health Awareness Training received in Vulnerable Communities**

Health precautions adopted during monsoon by families that didnot fall ill during monsoon

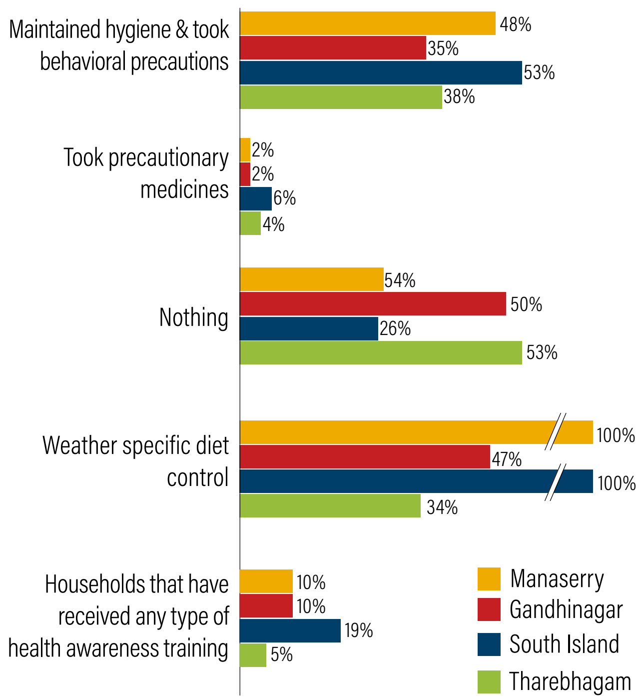
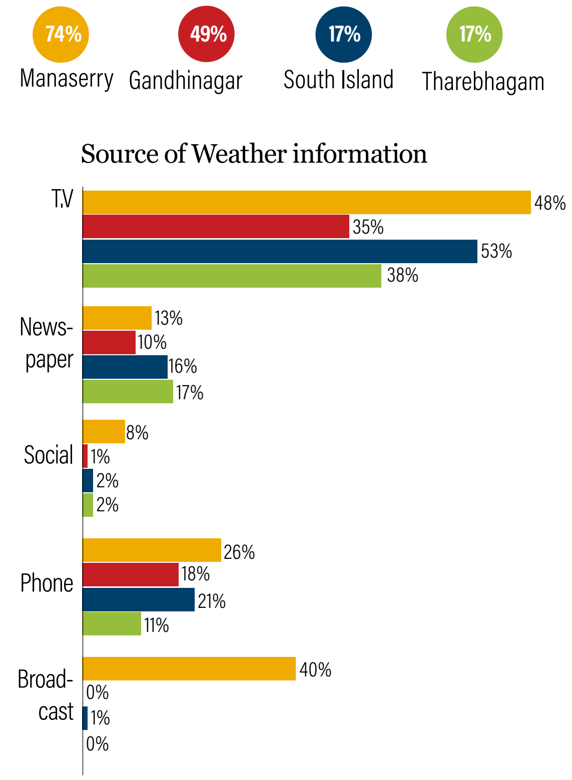


Fig 32 | **History of Early Warnings vs Source of Early Warnings in Vulnerable Communities**

History of receiving Early Warning Information

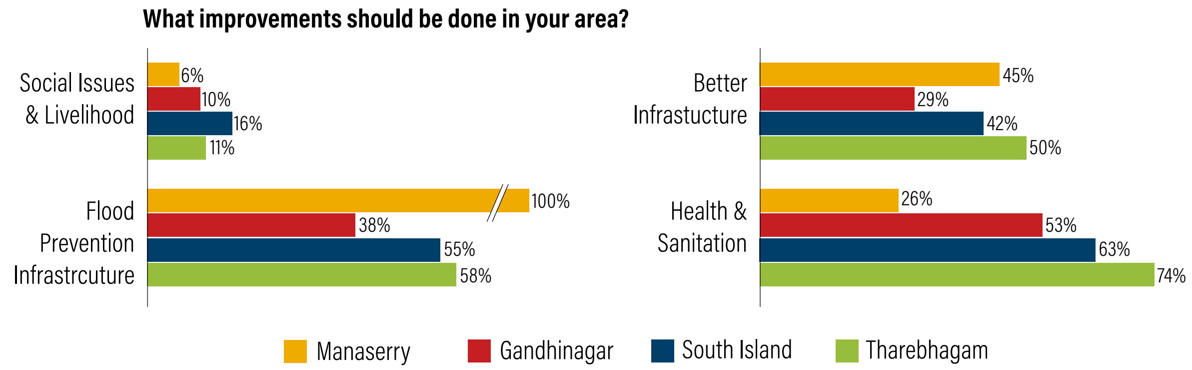


Governance

The connect between the government and the vulnerable community is also critical to ensure disaster resilience. In KMC it has been observed that the vulnerable communities are not involved in the sabha meetings or any community engagements, which results in their concerns not being addressed during the decision-making process. On average, more than 50% of all the vulnerable communities surveyed suggest that a lot of improvements from the government are needed in terms of health, sanitation, flood prevention infrastructure and other general infrastructure. 60% of the population takes water from public wells and does not have access to water connections, which needs to be addressed as it is a major challenge during the flooding seasons.

More than 75% of the households are willing to contribute their time for constructive discussions with government representatives for discussing their issues and deriving feasible solutions. Also, the migrant community in South Island has comparatively less access to the ward councilors and community leaders. Almost 80% of the vulnerable communities do not have any information of any NGO that could be approached during time of a natural disaster.

Figure 33 | **Demand for Improvement in Governance as per the Vulnerable Communities**



Built-Environment

The built environment defines a lot about the vulnerability of a society to climate-related disasters. In all the studied vulnerable societies in Kochi, there exists a strong basic built environment which includes electricity connection, LPG connection, toilets at the household level, recently built pucca houses, approach road to doorstep, waste collection services, etc. But further improvement is required, including sewerage connections, widening of approach roads, frequency of waste collection and most importantly, access to household- level piped water connection.

None of the houses have a proper sewerage connection and waste collection is not frequent in most of the households except in South Island. This results in the flowing of sewage and dumping of solid waste in nearby canal systems and drains, putting the local citizens at a higher risk of infectious diseases. Except for Manassery, in rest of the studied areas, at least a quarter of the households have only asbestos roofing, making them vulnerable to extreme heat and cold. Poor natural ventilation in Gandhi Nagar is a cause for concern, resulting in a need for artificial lighting even during day hours in most of the households. Although approach roads exist for almost all households, a quarter of the households studied have only two- wheeler approaches that will result in difficulty in supply of essentials and transportation of the disabled & people with chronic diseases (cases have been reported by roughly 15% of all studied households). In South Island, 50% of the population has access to only public toilets, which are also compromised during natural disasters. Except for a park in South Island, there is no access to open areas in any of the studied vulnerable societies.

The need for government intervention for building of disaster-resilient public infrastructure is very strong in all the vulnerable communities in Kochi. The strong and urgent need of action from the government varies from flood prevention infrastructure like sea walls, storm wells, storm drains, etc. to public infrastructure like filling of potholes, frequent pest control, etc.

Fig 34 | **Access to Basic Amenities**

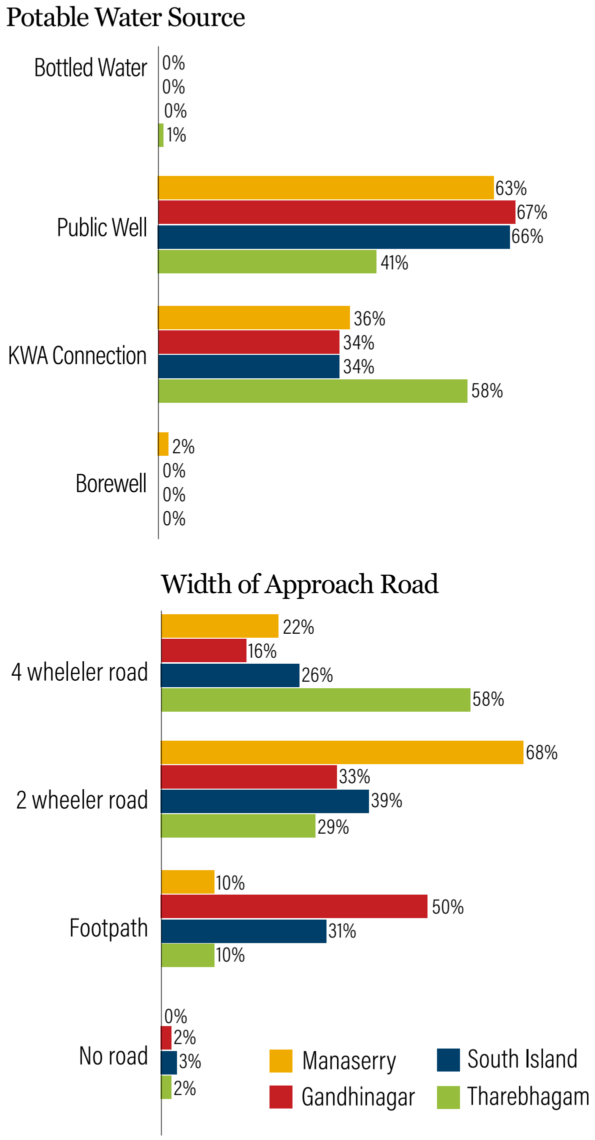
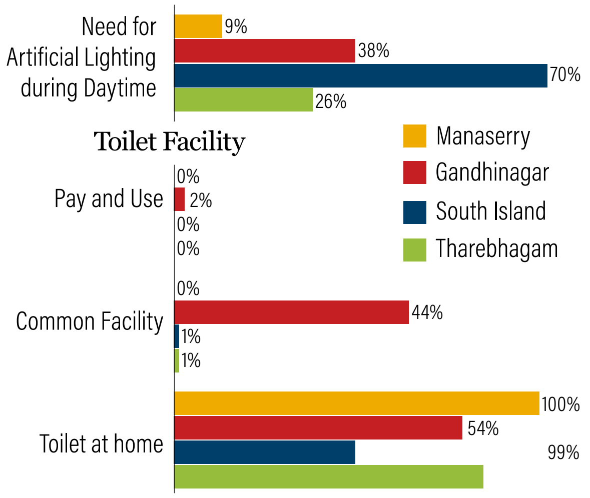


Fig 35 | **Open dumping of waste in South Island**

Fig 36 | **Public tap in Palluruthy, Kochi: Water supply infrastructure becomes more difficult to access as road heights are increased to mitigate urban flooding without proper planning**

Fig 37 | **Infrastructure Needs**



2. Individual Preparedness

The individual preparedness was scored on the basis of selected indicators which were divided into 3 categories including risk perception, economic resources and information and communication. In the case of Kochi, there were 22 indicators identified altogether and divided among the previously mentioned 3 categories:

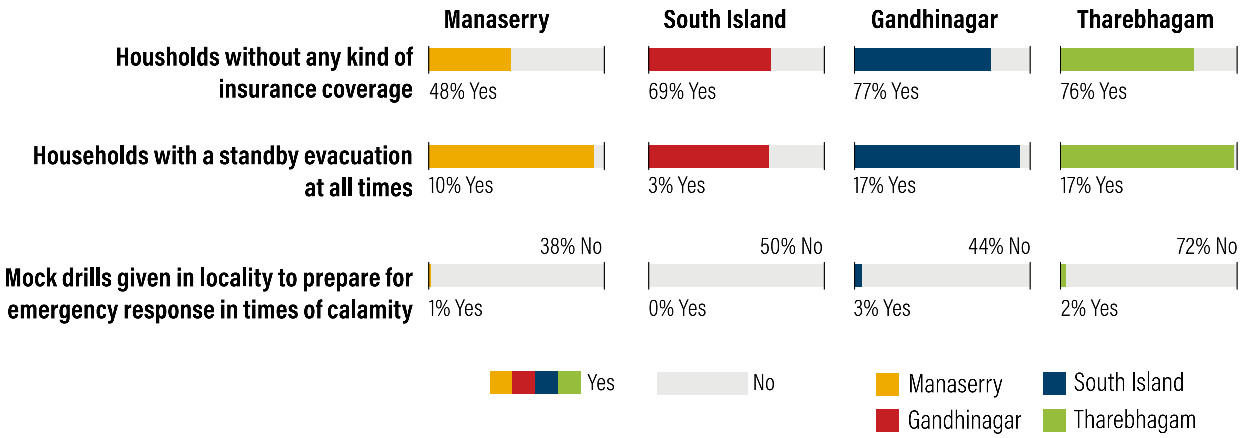
Risk Preparedness

Risk preparedness at individual capacity among households in the vulnerable community is to be assessed and developed to ensure better resilience to climate disasters. Factors including awareness about regional climate extremities, proactive preparedness for disasters, evacuation drills, etc. are lifesaving skills/information during disasters. In general, it has been observed among vulnerable communities that migrant population, people who are new to the city and people who do not have social cohesion are less prepared than others. It is essential the ULB ensures that enough IEC is provided to the vulnerable groups, especially the latter groups, to develop capacity regarding regional climate extremities, their impacts, mitigation methods, first line of contact and evacuation protocol.
In Kochi, it was observed that vulnerability at a household level was more in localities like South Island where migrant population was more. Almost half of them live in rented houses, do not have access to any government subsidies/benefits and depend only on public transport, resulting in comparatively lesser social security.

In general, it was also observed that more than half of the vulnerable population do not have any kind of insurance schemes. Most people at the individual level are not involved in any kind of climate resilience activity as well. Households have not received disaster management training which is evident in their risk preparedness levels as well. Even in locations with high risk of flooding, only 10% households have an evacuation kit ready with them. Further, few people have their important documents saved somewhere else other than their homes. It has also been noted that people fail to identify urban flooding as a climate change disaster and see it rather as a result of mismanagement by the government, but almost everyone has noted increasing annual heat and relates it to climate change.

Figure 38 | **Increasing floor height to mitigate floods results in reduced building height in vulnerable areas (left), Marking of flood water levels in vulnerable households (right)**

Figure 39 | **Risk preparedness in vulnerable communities**



Information and Communication

Authorities need to decide the most suitable medium of IEC with the vulnerable community, based on the level of comfort of the neighborhood. It depends on certain indicators including access to media, time available for communication, language understood and more importantly, their existing knowledge about the problem and its source.

In Kochi, cell phone ownership is impressive in all four neighborhoods, and almost half of the residents have access to an internet connection. A significant share of residents also follows local news, mainly through newspaper, TV and mobile. The percentage of residents who follow weather-related news and weather-related health hazards are slightly more in Manassery and Gandhi Nagar. Television, ASHA/Anganwadi workers and health centre are the major sources of information on weather-related health hazards.

Economic Resources

Analysis of economic resources among the individuals indicates their vulnerable position. Case studies suggest that the most economically vulnerable are the most climate vulnerable as well. Factors including availability of emergency savings, bank accounts, support system of friends/family, mortgageable property, etc. have a critical impact on the vulnerability of each household.

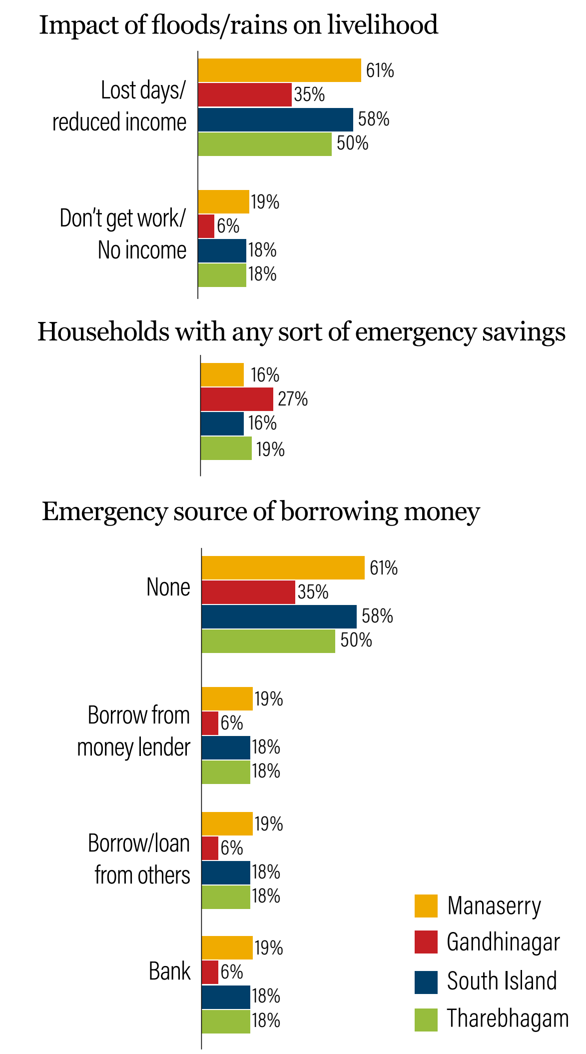
Figure 40 | **Lack of Financial Resources and Proper Capacity Building leads People to Adopt Inefficeint and Unscientific Techniques for Flood Mitigation**

Those classified as vulnerable by the government under SC/ST/OBC categories receive rations and basic care by the local government. It needs to be ensured that others who don't classify in these categories but are vulnerable are also taken care of, especially migrants and the destitute.

In Kochi, less than a quarter of the households that were surveyed have any kind of emergency savings to use when disaster strikes and almost 90% of the households need to mortgage property or take loans from non-banking financial sources. The situation is aggravated by the fact that in localities like Manassery, Gandhi Nagar and Tharebhagama almost 80% of the household's lose income partially or completely during disasters like floods and heavy rains.

Figure 41 | **Less than an quarter of the vulnerable households have any kind of emergency savings that can be used at times of a disaster**

Figure 42 | **Individual Household Level Disaster Vulnerability in Kochi**



3. Inter-connected Resilience Attributes

Support of Social Groups and Disaster Resilience

Active involvement of social groups including NGOs and SHGs has a major contribution towards building the capacity of vulnerable communities and supporting government programs. Social groups ranging from political, community level, neighborhood level to organizational level support during disaster preparedness training, rescue as well as disaster relief operations including providing basic amenities, relief kits, temporary shelter, food and medicine among others

In Kochi it was studied that very few, i.e less than 5% of households in every locality received any kind of disaster preparedness training. Among that, except for a handful of houses in Therebhagam, the rest of the houses were training by social group. Like the Fishermen's associations in the fishermen community at Manassery, the residents associations in Gandhi Nagar and again by the convent at Gandhi Nagar. When it comes to health awareness training also it is Kudumbashrees, political parties and church that has reached the most people

In South Island, the minimal social cohesion of the localities was reflected on the fact that there was no training on emergency response, and only minimal health awareness training, that too which was organized by the ULB. They also reported no support /help was received during time of disasters. Where as Gandhi Nagar which reported better social cohesion than any other locality with active Kudumabashree units and residents associations reported maximum support during time of disasters from neighbors, NGOS, social organisations and even political parties. Government programs got restricted to health awareness like public health camps, trainings and medical checkups. In addition to the ULB, the coast guard has given emergency escape mock drills to every households in Manassery to escape from sea attacks. It was seen in Kochi that the church and convents actively support disaster training, health awareness training and providing emergency shelter especially in Gandhi Nagar and Manassery area.

Nativity and Vulnerability

It was observed that the households in South Island which majorly consists of population from other states, are more vulnerable to disasters because of their lack of social cohesion, access to the peoples representatives and lack of backup emergency resources.

Fig 43 | **Community Engagement Assessment**

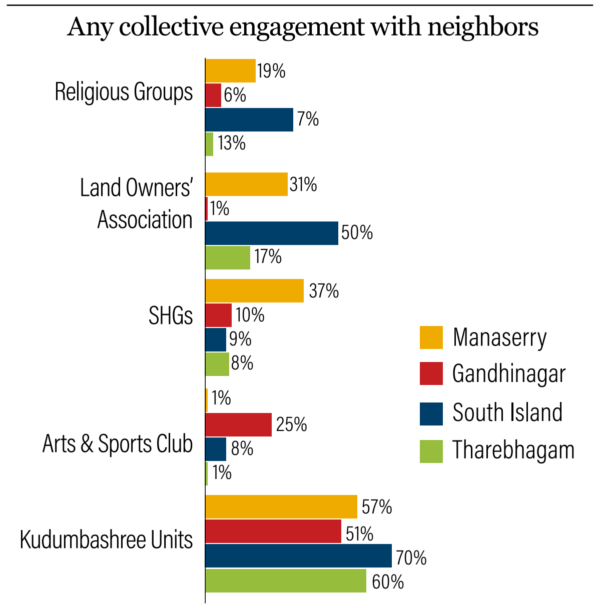


Fig 44 | **Interconnected Resilience Attributes**

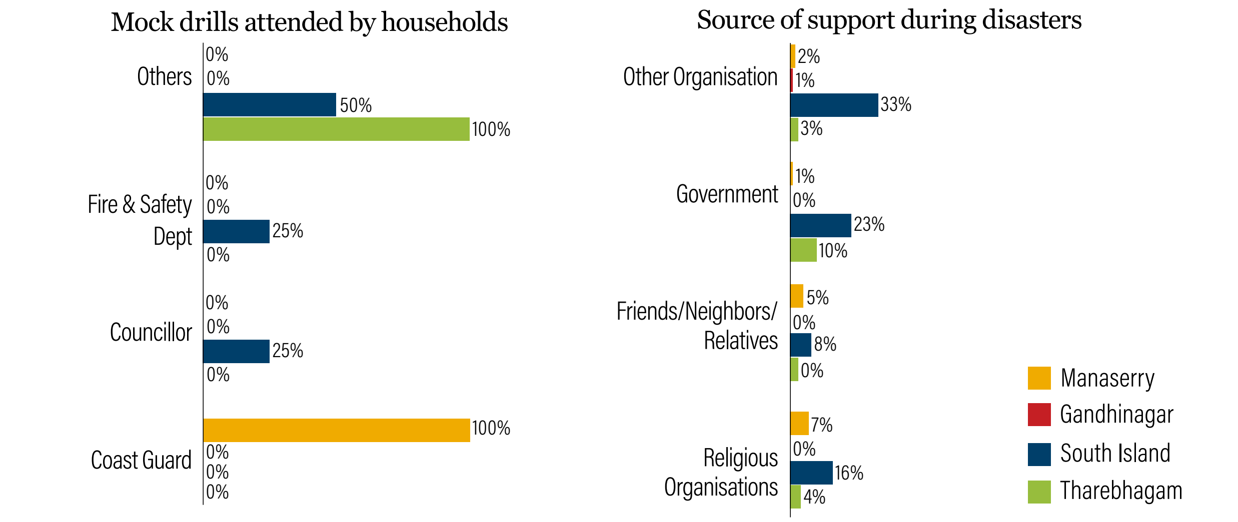


Fig 45 | **Households along the floodline of rivers & canals are at risk of flooding & related health hazards**

Summary of Resilience Assessment

While Social Cohesion is comparatively high in the vulnerability communities of Kochi, its very low in Island South which is majorly occupied by migrant community. But the strong social networks is not reflected in the community preparedness levels in any of the vulnerable neighbourhoods. Government/ political engagement and resilient built environment is also observed to be strong in the vulnerable neighbourhoods.

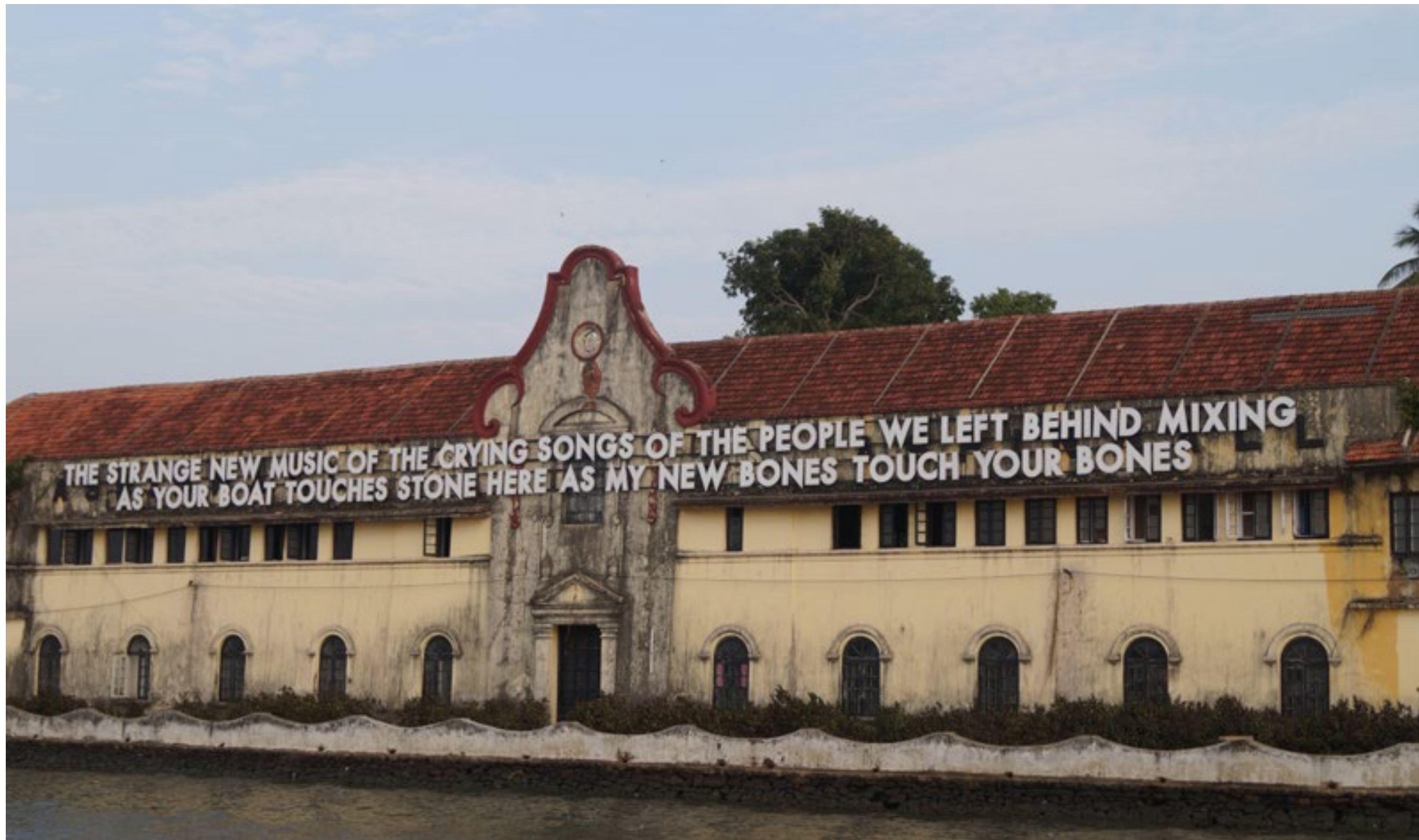
Community Resilience Score Card

CATEGORIES/INDICATORS	THAREBHAGAM	MANASSERY	ISLAND SOUTH	GANDHI NAGAR	OVERALL
A. Social Cohesion	3.2	3.8	2.8	3.6	3.6
1. Size & Strength of Social Networks	3	4	3	4	4
2. Neighbourhood Socializing	2	4	2	4	3
3. Sense of Community Identity	5	5	4	5	5
4. Neighbourhood Preference	5	5	4	4	5
5. Community based Livelihoods	1	1	1	1	1
B. Community Preparedness	1.5	3	1.25	2.5	2.25
1. Community Led Resilience Activities	1	1	1	1	1
2. Community Health Awareness Prog.	1	1	1	1	1
3. Access to EWS	1	5	2	3	3
4. Emergency Shelter	3	5	1	5	4
C. Governance & Political Engagement	3.5	3	3	3.75	3.25
1. Political & City Engagement	3	3	3	3	3
2. Voter Participation	5	5	3	5	5
3. Trust in Community Leader	4	3	3	4	3
4. Non-Governmental Support	2	1	3	3	2
D. Resilient Built Environment	3.8	3.8	4	3.2	3.8
1. Access to Urban Services	4	3	3	4	4
2. Access to Natural Infrastructure	2	1	4	1	2
3. Mobility	4	5	5	4	5
4. Construction Type	5	5	5	5	5
5. Light & Ventilation	4	5	3	2	3

Individual Capacity Score Card

Risk preparedness and economic resources at an individual level is low in all the studied vulnerable neighbourhoods highlighting the criticality of vulnerability to climate change in Kochi. The comparatively high access to information and communication also highlights the scope of better capacity building among the households

CATEGORIES/INDICATORS	THAREBHAGAM	MANASSERY	ISLAND SOUTH	GANDHI NAGAR	OVERALL
A. Risk Preparedness	3	3.2	2.6	3.2	3
1. Perceived Climate Risks	4	5	3	4	4
2. Practice of Resilience Habits	4	4	3	4	4
3. Resilience Kits	1	1	1	1	1
4. Resilience Training	1	1	1	1	1
5. Back-up of Documents	5	5	5	5	5
B. Communication & Awareness	4	4.4	3.8	4.2	4.2
1. Cell phone Ownership	5	5	5	5	5
2. Internet and Social Media Access	3	3	3	3	3
3. Access to Local News	5	5	5	5	5
4. Weather Forecast Awareness	3	5	3	4	4
5. Weather Health Awareness	4	4	3	4	4
C. Economic resources	3.2	3.3	3.0	3.3	3.2
1. Labour & Livelihood Options	2	1	2	2	2
2 Emergency Savings	1	1	2	1	1
3. Health or Life Insurance	1	3	2	2	2
4. Identity proof linked to Social Security	5	5	5	5	5
5. Willingness to Invest in Resilience	5	5	4	5	5
6. Land Tenure	5	5	3	5	4



BIBLIOGRAPHY

Baussan, D. (2015). Social Cohesion: The Secret Weapon in the Fight for Equitable Climate Resilience. American Progress. Retrieved from https://www.americanprogress.org/article/social-cohesion-the-secret-weapon-in-the-fight-for-equitable-climate-resilience/

Daniel P. Aldrich, M. M. (2015). Social Capital and Community Resilience. Retrieved from https://www.researchgate.net/publication/281601274_Social_Capital_and_Community_Resilience

Douglas Paton, D. M. (2001). Disasters and communities: Vulnerability, resilience and preparedness. Retrieved from https://www.researchgate.net/publication/249359249_Disasters_and_communities_Vulnerability_resilience_and_preparedness

Kerala shipping and inland navigation corporation limited. (2017). Feasibility study of development of canals in Kochi. Kochi: National Transportation Planning and Research Centre (NATPAC) and Kerela shipping and inland navigation corporation limited (KSINC).

KSDMA. (2016). Kerala State Disaster Management Plan. Kerala State Disaster Management Authority, Government of Kerala. Retrieved from https://sdma.kerala.gov.in/wp-content/uploads/2018/11/Kerala%20State%20Disaster%20Management%20Plan%202016.pdf

Lubaina Rangawala, K. E. (2018). Prepared Communities. Retrieved from https://files.wri.org/d8/s3fs-public/prepared-communities-implementing-urban-community-resilience-assessment.pdf

MoLJ, GoI. (2005). The Disaster Management Act. Legislative Department, GoI. Retrieved from https://cdn.s3waas.gov.in/s365658fde58ab3c2b6e5132a39fae7cb9/uploads/2018/04/2018041720.pdf

NDMA. (2019). National Disaster Management Plan. Ministry of Home Affairs. Retrieved from https://ndma.gov.in/sites/default/files/PDF/ndmp-2019.pdf

NIUA. (2020). Climate Smart Cities - Assessment Framework 2.0. MoHUA. Retrieved from https://www.niua.org/csc/assets/pdf/CSCAF_2_Booklet.pdf

UNEP. (2021). Nature Based Solutions for Climate Change Mitigation. United Nations Environment Programme (UNEP), Nairobi and International Union for Conservation of Nature (IUCN), Gland. Retrieved from https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/37318/NBSCCM.pdf

WRI India. (2019). Field data collection carried out between October 15 and 17, 2019 in KMC. Kochi.

ACRONYMS LIST

CDMP	City Disaster Management Plan
C-HED	Center For Heritage Environment & Development
CSCAF	ClimateSmart Cities Assessment Framework
DDMA	District Disaster Management Authority
DRR	Disaster Risk Reduction
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GHG	Green House Gas
IUCN	International Union for Conservation of Nature
KFRI	Kerala Forest Research Institute
KMC	Kochi Municipal Corporation
KSDMA	Kerala State Disaster Management Authority
LSGD	Local Self Governance Department
LST	land Surface Temperature
ME	Monitoring and Evaluation
NASA	National Aeronautics and Space Administration
NBS	Nature Based Solutions
NCESS	National Centre for Earth Science Studies
NDMA	National Disaster Management Authority
NGO	Non Governmental Orgranisation
NIUA	National Institute of Urban Affairs
SHG	Self Help Group
UCRA	Urban Community Resilience Assessment
ULB	Urban Local Body
UNEP	United Nations Environment Programme
URDPFI	Urban and Regional Development Plans Formulation and Implementation
USGS	United States Geological Survey

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