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लोकहितार्थ सत्यनिष्ठा
Dedicated to Truth in Public Interest

Azadi Ka Amrit Mahotsav



iCED as a Research Hub

2023

An initiative of the
International Centre for Environment Audit and Sustainable Development (iCED)
under the aegis of the
Comptroller and Auditor General of India

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Compendium of Research Papers at iCED

AN INITIATIVE OF THE
INTERNATIONAL CENTRE FOR ENVIRONMENT AUDIT AND SUSTAINABLE DEVELOPMENT (iCED)
UNDER THE AEGIS OF THE
COMPTROLLER AND AUDITOR GENERAL OF INDIA

2023

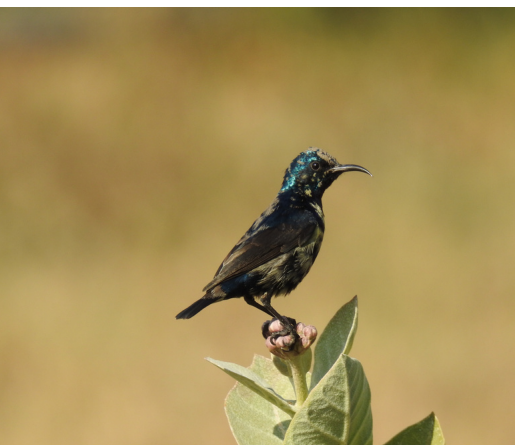














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From the Director General's Desk



International Centre for Environment Audit and Sustainable Development (iCED) has been set-up under the aegis of the Comptroller and Auditor General of India (C&AG) for capacity building and knowledge sharing in the area of environment audit. It is a designated Global Training Facility (GTF) of the Working Group on Environmental Audit (WGEA) since March 2011, as well as of the Working Group on Extractive Industries (WGEI) of International Organizations of Supreme Audit Institutions (INTOSAI) since August 2016. iCED also conducts training programmes on Environment Audit under the Indian Technical and Economic Cooperation Programme (ITEC) sponsored by the Ministry of External Affairs, Government of India.

Besides, iCED conducts considerable national capacity building on audit of environmental and sustainable development issues for in-house programmes of SAI India.

Till date iCED has trained almost 6081 international and national participants.
Along with focussed and specialised capacity building, iCED has a vibrant in-house research wing related to audit processes including all the governance structures connected with the environment and sustainable development.
iCED now opens a new pathway by also morphing into a specialised Centre of Excellence on the Audit of the Blue Economy, in keeping with the Comptroller & Auditor General of India's vision of harnessing SAI India's decade long experience in conducting environmental audits, to sharpen the knowledge base of public auditors, in this complex emerging area.
This publication introduces the extensive corpus of research undertaken at iCED till date, from in-house contributions and talented external expertise from domain experts, leading environmental think-tanks and Young Professionals/ Interns who have been associated with iCED. Applying a methodological rigour to innovative ideas and audit paradigms, it is hoped that this work, uniquely rooted in iCED's institutional commitment to high scholastic standards, re-centres research excellence at the heart of SAI India's dedication to raising the value and relevance of the global auditing fraternity.

Sayantani Jafa
Additional Deputy C&AG and Director General



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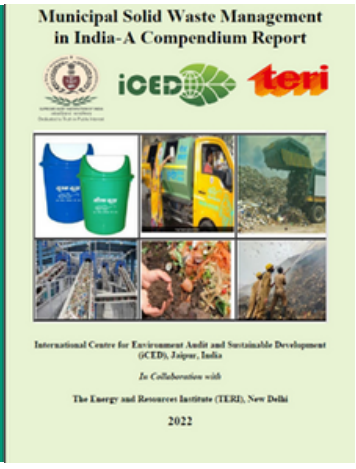
Azadi Ka Amrit Mahotsav

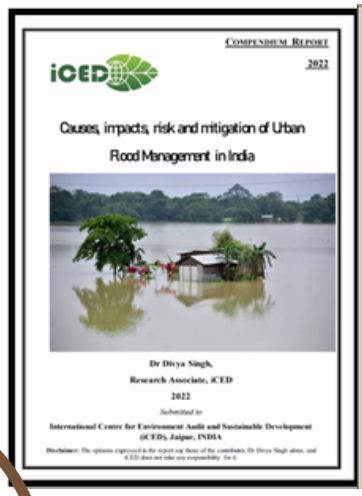
An Introduction to the Compendium of Research Papers at iCED

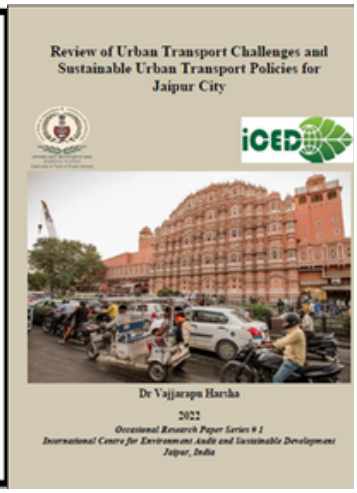
We welcome you to explore the diverse research activities undertaken by iCED, presented in the following pages.



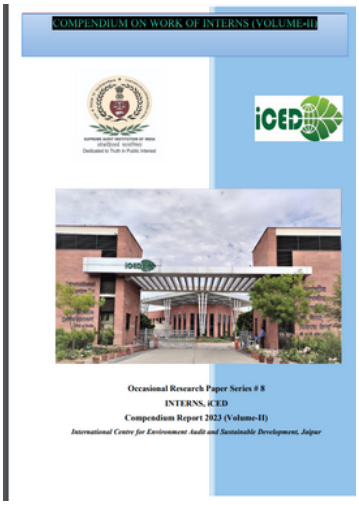




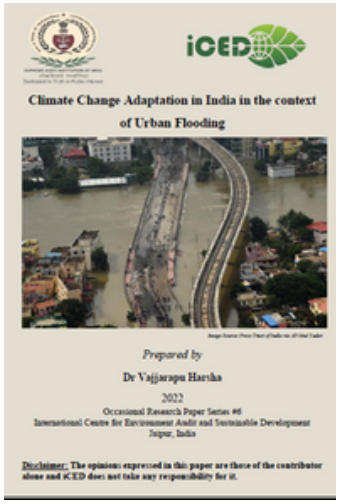




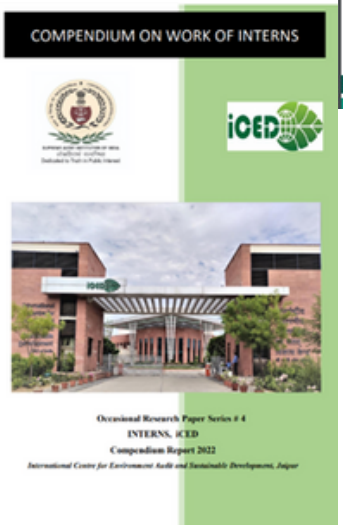
The fulcrum of this original research has been in an Occasional Research Paper Series since mid – 2022. We have glimpses of iCED's global lens through iCED's collaborative research by its addressing of critical issues like Climate Change and Plastic Waste through the Asian Organisation of Supreme Audit Institutions (ASOSAI) and its journals. A cherished outcome of iCED's seminal collaboration with a leading independent environmental think-tank, The Energy and Resources Institute (TERI), is a Compendium on Municipal Solid Waste Management (December, 2022). Dealing with a complex issue, this publication touches upon the challenges in the area, while suggesting a way forward with sustainable waste management strategies.

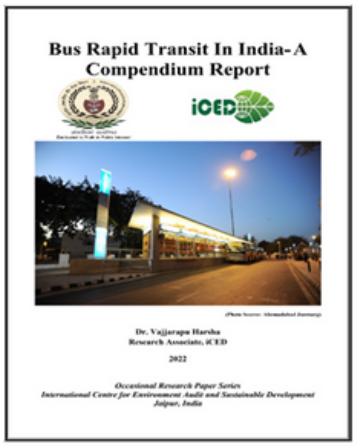












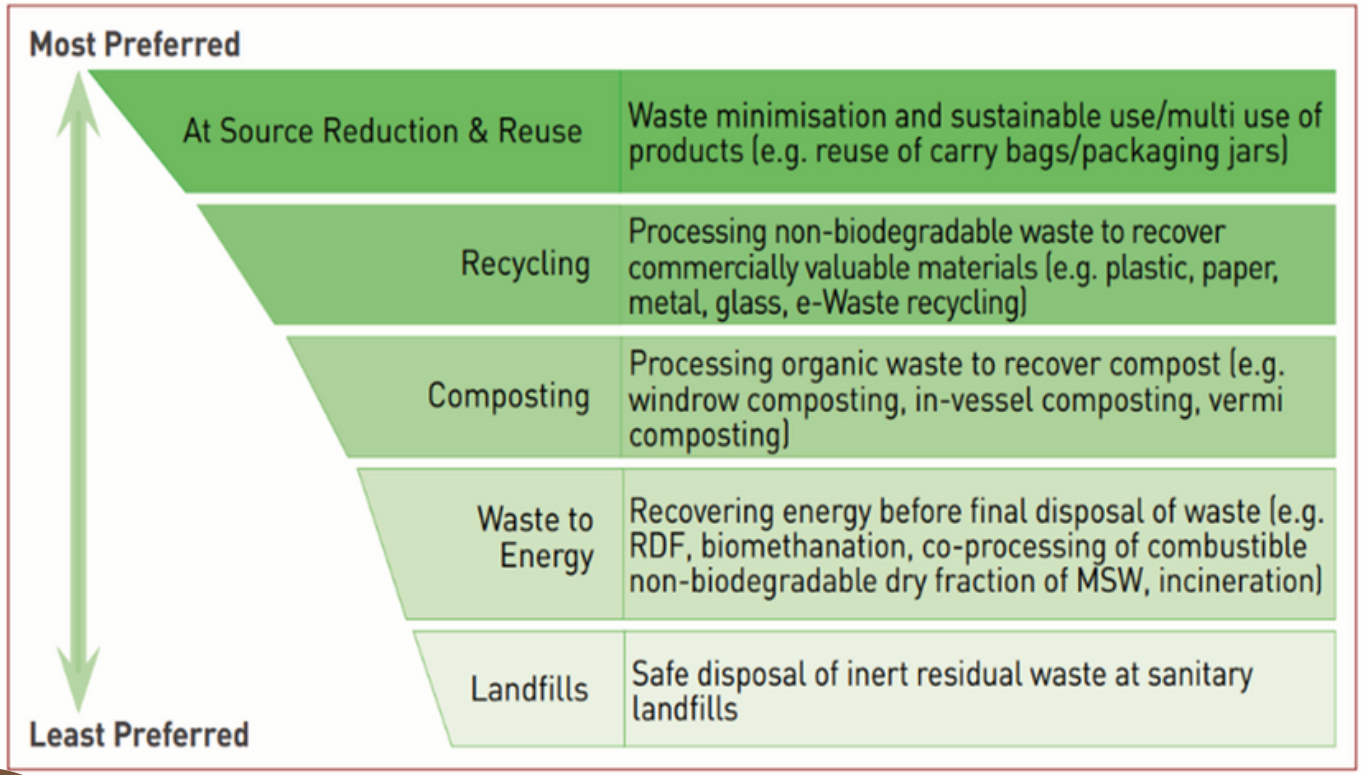
There is the voice of the youth, who have been contributing to research at iCED as Interns since 2017-18. This is a mode to encourage young University students to participate in a Government-academia interface and cultivate knowledge in the field of environmental audit, through iCED's overall innovation-based approach to pedagogic methodologies, including a case study based trainee-centric worldview. The Intern's contributions were consolidated in several Occasional Research Papers published in 2022 and 2023. There is also original research work by Research Associates.

Finally, we present selected articles featured in iCED's quarterly newsletter "Green Files", showcasing SAI India and iCED's in-house researched articles. Forty-four volumes of Green Files have already been published so far, and every quarter sees one more value-addition emanate.

Joint Collaborative Publication of iCED and The Energy and Resources Institute (TERI)- Municipal Solid Waste Management in India- A Compendium Report

Municipal Solid Waste (MSW) is considered a negative externality of developmental processes and poses a major environmental challenge to cities all over the world. MSW includes solid waste like food waste, paper, glass, metals, plastics, textiles, etc., and waste generated from businesses, commercial organisations, and educational institutions. Disposal of waste in an unorganised and improper manner leaves a negative impact on the living conditions of human beings as well as on the larger ecosystem. Unscientific solid waste dumps generate methane, toxic gases, and leachates due to microbial decomposition, resulting in accidental fires adversely impacting micro-climatic conditions. It is also one of the causes of the spread of communicable/non-communicable diseases among human beings and animals that affect livelihood and economic productivity.

Against this backdrop, iCED, Jaipur has developed a Compendium Report which highlights in a non-technical manner the issues related to municipal waste management along with regulatory, policy, and institutional framework to deal with Municipal Waste in an effective manner. This Compendium Report is a seminal and first-of-its-kind collaboration between iCED, Jaipur, and the leading environmental think tank, The Energy and Resources Institute (TERI), New Delhi, in 2022.



Hierarchies in Integrated Solid Waste Management

Source: Expert Committee for revision of MSWM manual (2013-15), cited in CPHEEO, 2016

While emphasising the 3Rs of Solid Waste Management, i.e. reduce, reuse, and recycle, the study has pointed out important steps of Municipal Solid Waste Management (MSWM) like waste minimisation (waste minimisation and sustainable-use/multi-use), waste collection, source segregation, waste transportation, and waste processing and treatment through recycling (processing of non-biodegradables to recover commercially valuable materials) and recovery (in the form of composting, generating energy, refuse-derived fuel, and bio-methanation, etc.). Integrated Solid Waste Management (ISWM) is an approach that involves all the sectors and stakeholders, while focusing on the principles of 3Rs. ISWM prefers landfills the least and source reduction and reuse the most.

Community-based MSWM in Surat, Gujarat

The awareness campaign "Surat Khubsurat", helped citizens emotionally connect with the city's initiatives towards source segregation and 100% door-to-door collection.

Surat Municipal Corporation has designated eight locations for collection of plastic waste.

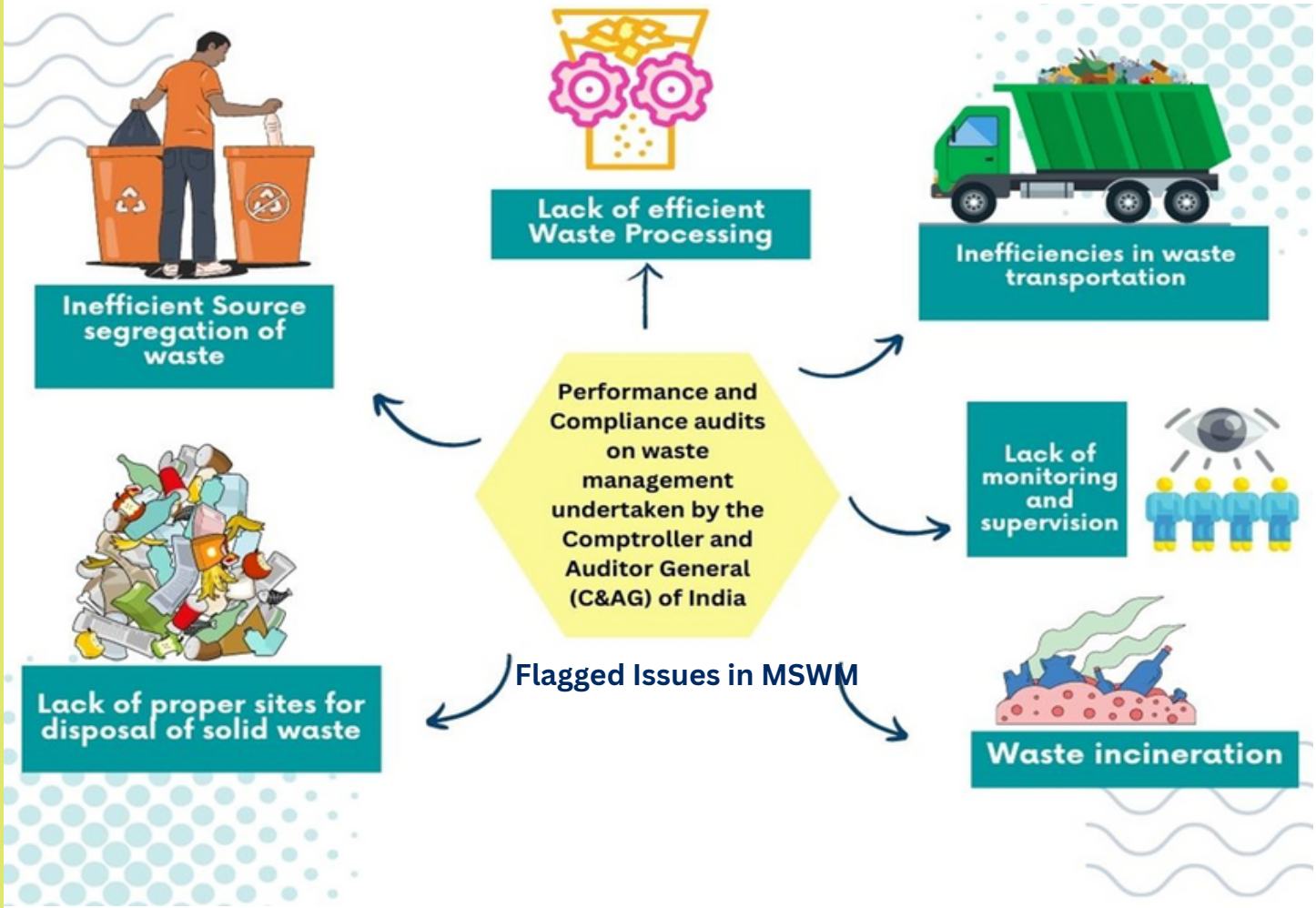
Segregated valuable plastic waste is collected from households and streets with the help of NGOs, rag-pickers, plastic collection centres etc.

To maintain cleanliness and community-level participation in SWM, payments are made to the residential and non-residential societies, on production of a completion certificate by the society.



The Compendium Report marks good practices in life-cycle of solid waste management, with focus on ISWM technique to deal with issues in solid waste management. Community-driven solid waste management in Surat, Gujarat has been a remarkable success in the Indian context (diagram above).

This report also highlights some of the compliance and performance audits undertaken by the Comptroller and Auditor General (C&AG) of India. The audit reports broadly examined the role of agencies/departments in the assessment of different kinds of waste and their risks to the environment and health, adequacy of policy, and planning for waste management. Performance Audit on Management of Waste in India (2008) and Performance Audit on Waste Management in Indian Railways (2022) are some of the exemplary audit reports of the C&AG of India on waste management, highlighted by the study. Major red flags marked by the audit reports are given in the figure below.



The report also highlights the sustainable composting practice using kitchen and garden waste, by iCED, at its own campus.



Composting of organic waste at iCED



- Collection and segregation of kitchen waste by using separate bins
- Shredding of organic waste/food waste into pieces
- Dry leaves and garden waste from landscape area mixed
- Organic waste transferred into pits in the garden area
- Mixed with dry garden refuse in the ratio 1:30 with layer of soil and sand at the bottom of pit
- Aerobic decomposition by adding cow dung and activator/bio-clean compost chemical
- Compost is ready within three months

Visuals : Composting of organics waste at iCED

Conclusion and Way Forward

Given the above scenario, this research report emphasises that lack of legal clarity, enforcement issues, co-ordination gap between relevant authorities, and poor monitoring and control systems have aggravated the problem of improper waste management. The audit can help in assessing the risks, validating the controls in place, and also assessing the sufficiency and effectiveness of waste management life-cycles of multiple types of waste, in complying with various laws in force. Apart from this, technological advancement is an important factor that can drive effective waste management in India.



STRIDES IN PROPELLING YOUNG VOICES WITH IMPACTFUL STUDIES

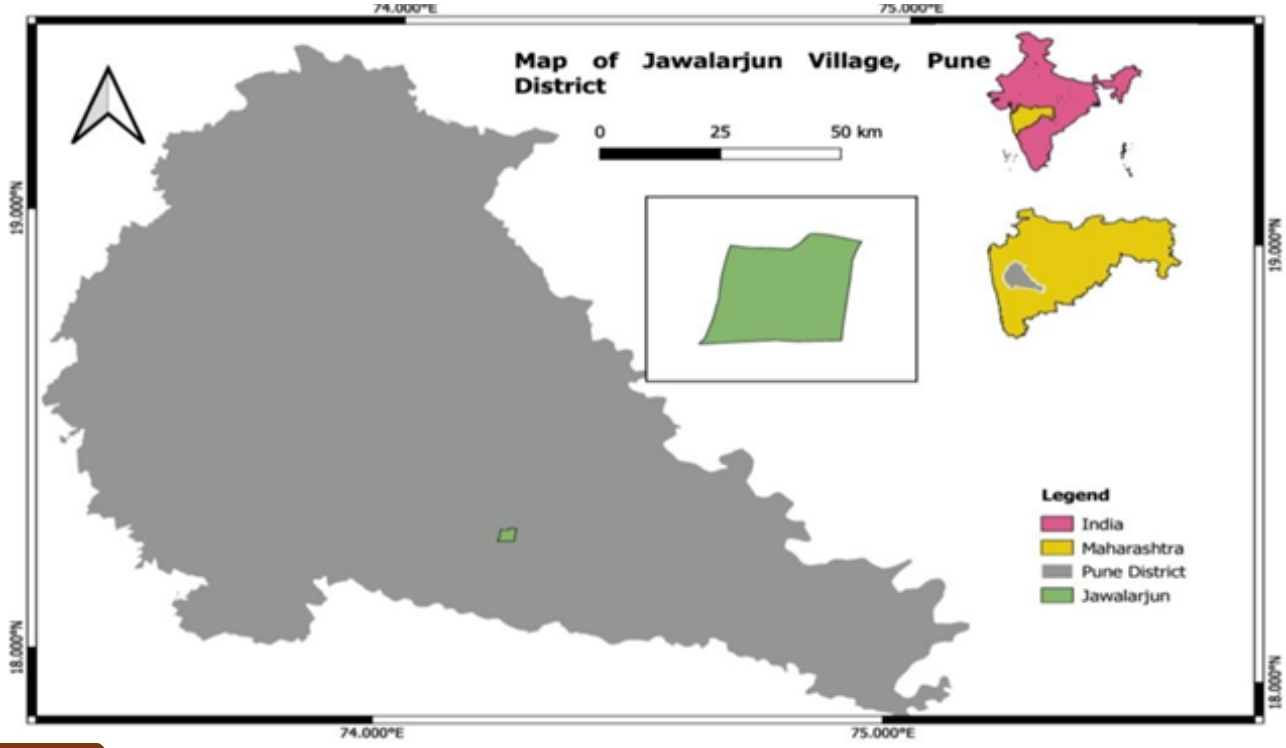
Leveraging new and innovative ideas of young minds aid us in learning new perspectives, adopting emerging tools, and improving understanding of environmental issues. This section showcases some of the analytical studies conducted by the Interns at iCED.



Sustainability Issues in Groundwater Usage and its Management in Rural Areas

India has 17 per cent of the planet's population with only four per cent of the earth's freshwater resources. Increased demand of groundwater for agriculture to produce food for the burgeoning population, cultivation of high water-consuming crops, rural electrification, and improvement in pump technology have changed the paradigm of agriculture from being rain-fed to irrigation-dependent.

The study has highlighted the criticality of groundwater utilisation in rural areas, focusing on Jawalarjun village in Purandhar Block of Pune District, Maharashtra, and the importance of participatory approaches, involvement of Government and other stakeholders, and suitable water conservation structures in reversing the crisis of groundwater depletion. This primary research was undertaken by an erstwhile intern, Shri V. S. Rane, at iCED in July 2022, and was subsequently completed in May 2023.



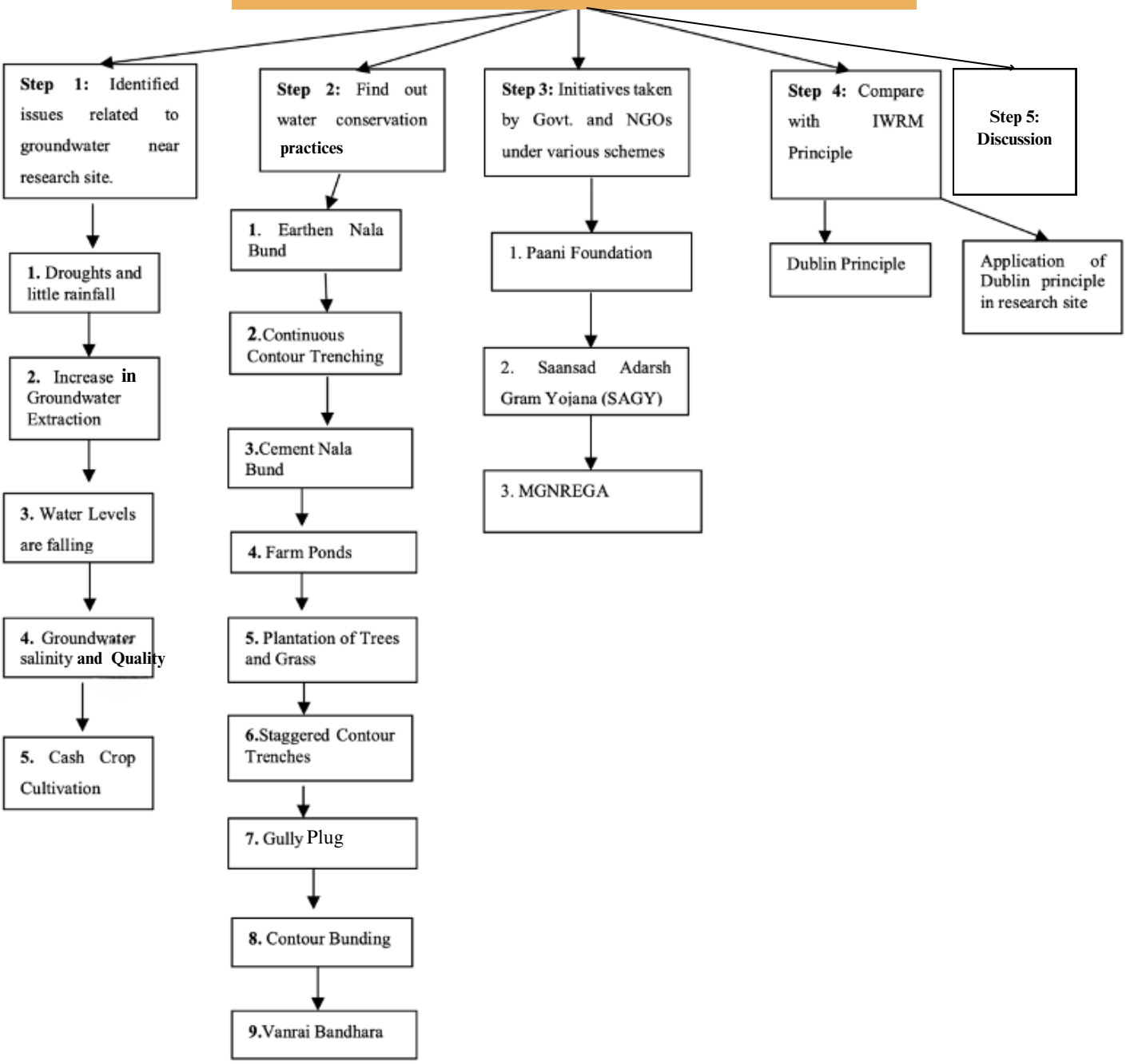
Objectives

(i) To analyse the trend of groundwater availability and its exploitation

(ii) To identify groundwater-related challenges in rural areas and water conservation practices

The study also focused on the use of water conservation techniques to highlight ways to save and store water in aquifers, the role of Government and Non-Governmental Organisations (NGOs) in bringing about a change in the area, and the application of principles of Integrated Water Resources Management in the area.

Study Methodology



Importance for Audit

This research provides useful inputs to audit in understanding the development of an aquifer's water balance, by taking into account inputs and outputs in a ground-water reserve system. The study shows that pan-India information availability on some important geo-hydrological characteristics can serve as a source of information for risk assessment, formulation of audit methodology, and analysis.

Study Findings

- Recurrent drought and scanty rainfall; enhanced extraction of groundwater and dwindling water table; cultivation of water-intensive cash crops, high salinity, nitrate, and fluoride concentration in water are the main problems in Jawalarjun village.
- Structures like Earthen Nala Bund (ENB), Continuous Contour Trenching (CCT), Cement Nala Bund (CNB), Farm Ponds, and plantation of trees and grasses have improved the water scenario in the region.




Water level before and after, in a well, near an ENB structure




Farm Pond (Shet Tale) in Jawalarjun Village, and Water level (Before and after completion of structure)

- The study recommends water conservation structures like staggered contour trenches, gully plugs, contour bunding, and Vanrai Bhandara (Embankment structure).
- The study depicts the applicability of principles like the finite nature of resources, affordability, and participatory approach as enshrined in the Dublin Principles of the International Conference on Water and the Environment (ICWE 1992) [UNESCO-IHE Institute of Water Education, 2014] and Integrated Water Resources Management (IWRM) in the study area (IWA Publishing, 2012).

Municipal Solid Waste Management in three selected cities in India: Indore, Surat and Jaipur

With growing urbanisation, Solid Waste Management has emerged as one of the most critical developmental challenges in urban India. In India, the volume of waste generation has been increasing rapidly over the last few decades.

This primary research was undertaken by an erstwhile intern, Ms Swati Jha at iCED in July 2022 and was subsequently completed in May 2023.

Objectives

To highlight issues in the implementation of sustainable solid waste management practices in three selected cities in India, i.e., Indore, Surat and Jaipur.

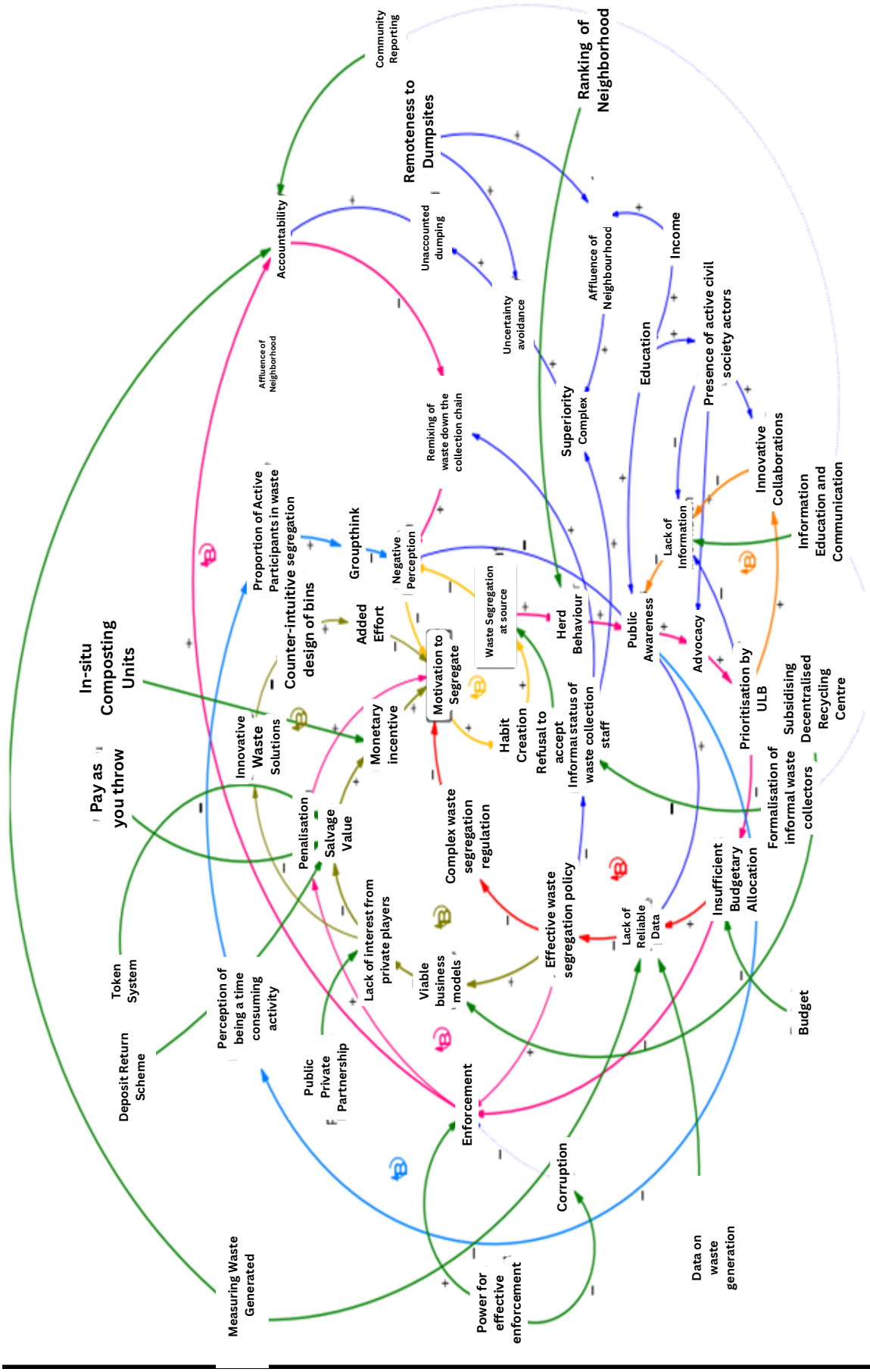
Using Causal Loop Diagrams

Causal Loop Diagrams (CLDs) are used to conceptually model dynamic systems in a holistic manner, to present a big picture, mapping different variables and highlighting interaction among them. These diagrams provide important directions, by summarising otherwise complex relationships, among different variables in a system. These diagrams also reveal the issues and constraints within the system, enabling researchers to factor in variations that occur over time and space.

- A CLD is a visual representation of all the factors and processes, showing how they are interconnected.
- A CLD shows variables represented as texts and causal relationships between them, represented by arrows. Arrows indicate the direction of causality and the nature of the relationships, i.e. whether the direction reinforces the process or performs a balancing act.

The study highlighted the legal and institutional framework for Municipal Solid Waste (MSW) Management in India and attempted to identify the major problems towards MSW Management in the cities of Indore, Surat and Jaipur and to explore possible solutions by using CLDs. Various solutions (Green colour loops) to the problem of waste segregation at source (Pink, Blue and Red colour loops) have been proposed.

Causal Loop Diagram showing the interaction among different components in the process of waste segregation at source





Solution Analysis of Causal Loop Diagram

Deposit Refund Scheme
To tackle the challenges of recycling by offering a financial incentive

IEC activities
To create awareness about the harmful effects of ineffective Solid Waste Management

Allocation of Budget to Business infrastructure
To improve the process of waste segregation

Public-Private Partnership (PPP) model
For proper segregation and collection

Key Study Highlights

- Waste segregation at the door-to-door collection level is the most crucial level for proper management of Municipal Solid Waste Management.
- The cities of Indore and Surat have an extremely efficient waste segregation mechanism which has enabled them to gain top rankings in the past "Swachh Survekshan" surveys.
- However, the city of Jaipur faces challenges in implementing an efficient waste management mechanism to compete with other cities.

Overview of Plastic Waste Management In Jaipur City and Role of Circular Economy and Other Management Techniques

Rapid urbanisation and increasing incomes of people are causing a surge in waste generation (including waste plastic), which is predicted to triple from 62 million tonnes to 165 million tonnes by 2030 (MoEFCC, GoI). This trend is contributing to irreversible environmental damage, making proper waste management a critical concern. The slow growth in recycling rates and the use of single-use products are exacerbating the accumulation of plastic waste in the environment. Plastic waste has a harmful impact on marine life and the eco-system, including creation of dead zones, reduction of oxygen for marine life and harmful bio-magnification of toxic compounds. This primary research was undertaken by erstwhile intern, Shri Manikant Barik and Shri Prateek Kumar, at iCED in July 2019 and September 2020 respectively, to highlight different aspects of circularity in management of plastic waste, involving field studies in Jaipur city and were subsequently completed in August 2022.

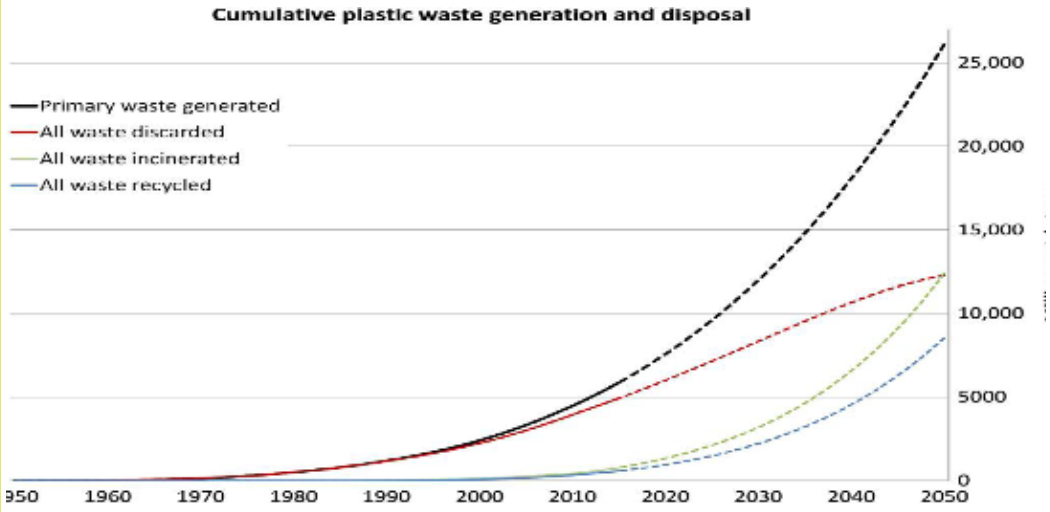


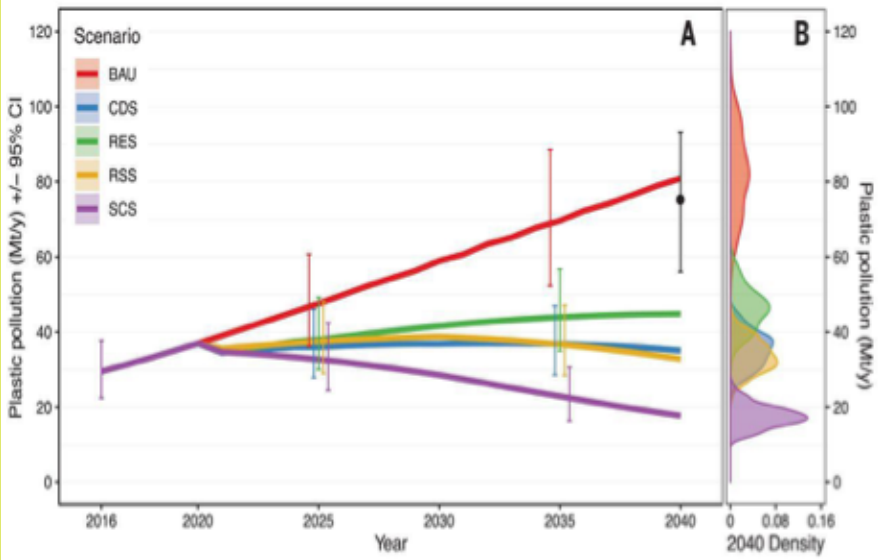
Figure shows cumulative plastic waste generation and disposal (in million metric tonnes). Solid lines show historical data from 1950 to 2015; dashed lines show projections of historical trends to 2050 (Geyer, Jambeck, & Law, 2017)

Circularity in Plastic Waste Management

"Circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models." (The Ellen MacArthur Foundation, 2012)

Sustainable Business Models

The study highlights different sustainable business models existing in different parts of the world and brings out future scenarios for management of plastic waste. Reduction of annual combined terrestrial and aquatic plastic pollution rates in different scenarios such as Business as Usual (BAU), Collect and Dispose of Scenario (CDS), Recycling Scenario (RES), Reduce and Substitute Scenario (RSS) and System Change Scenario (SCS). The diagram below depicts extent of plastic pollution in different scenarios.



Source:Winnie W. Y. Lau et. al. 2020

Pointers for Audit

- Plastic waste generation data at collection points/transfer stations are important from the point of view of audit.
- Lack of involvement of rag pickers was highlighted from field study at Jaipur.

The Study recommends:

- Circular economy approach for plastic waste management,
- Research and development for advanced and environmentally friendly recycling techniques,
- Mechanical recycling,
- Chemical recycling,
- Using bio-based raw materials to recycle or replace plastics,
- Increasing consumer awareness and education

to accelerate the drive for recycling and intergovernmental cooperation for global sustainable development.

Assessment of E-waste with regard to the Management Policy in Jaipur City

The Electronics industry is one of the fastest growing industries in the world and was expected to reach $ 400 billion in 2022 from $ 69.6 billion in 2012 in India (Corporate Catalyst India, 2015). Presence of many harmful materials and chemicals in electronic products is a major concern during the E-waste management phase, which can be hazardous and have the potential to severely impact human health and the environment if they are not handled properly (Wath, Dutt, & Chakrabarti, 2010). Nevertheless, the presence of valuable resources such as copper, silver, gold and platinum makes it attractive to recycle E-waste (Raghupathy, Kruger, Chaturvedi, Arora, & Henzler, n.d.). This primary research was undertaken by an erstwhile intern, Shri Sungrongti, at iCED in January 2020 and was subsequently completed in August 2022.

Scope and Methodology

Data was collected from available literature, as well as field study which included surveys, site visits and interviews with the stakeholders to identify the missing links and problems associated with E-waste management in Jaipur city.

The research had followed purposive method of sampling and specific stakeholders were selected for data collection as per the objectives of the research. The identified stakeholders for this research were:

A. Nagar Nigam Jaipur (NNJ)

B. ETCO E-waste recyclers

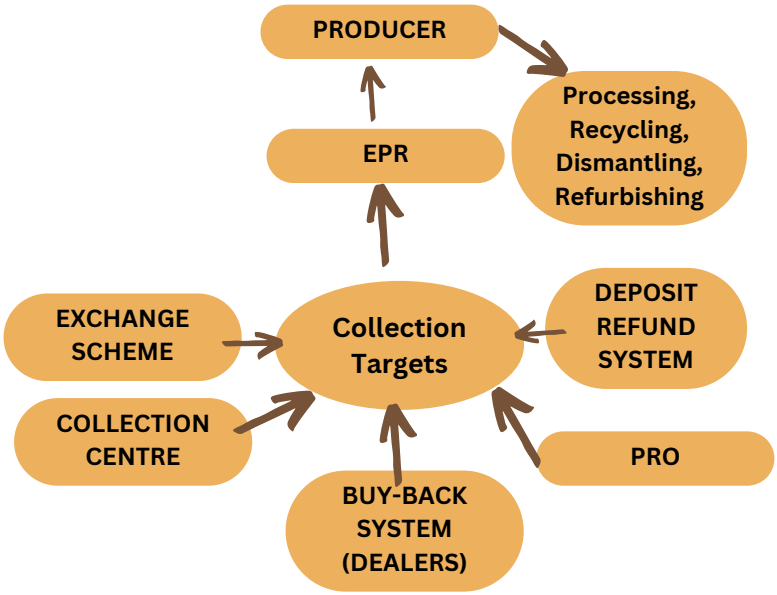
C. Municipal Solid Waste (MSW) Plant

Some other observatory cases were included from -

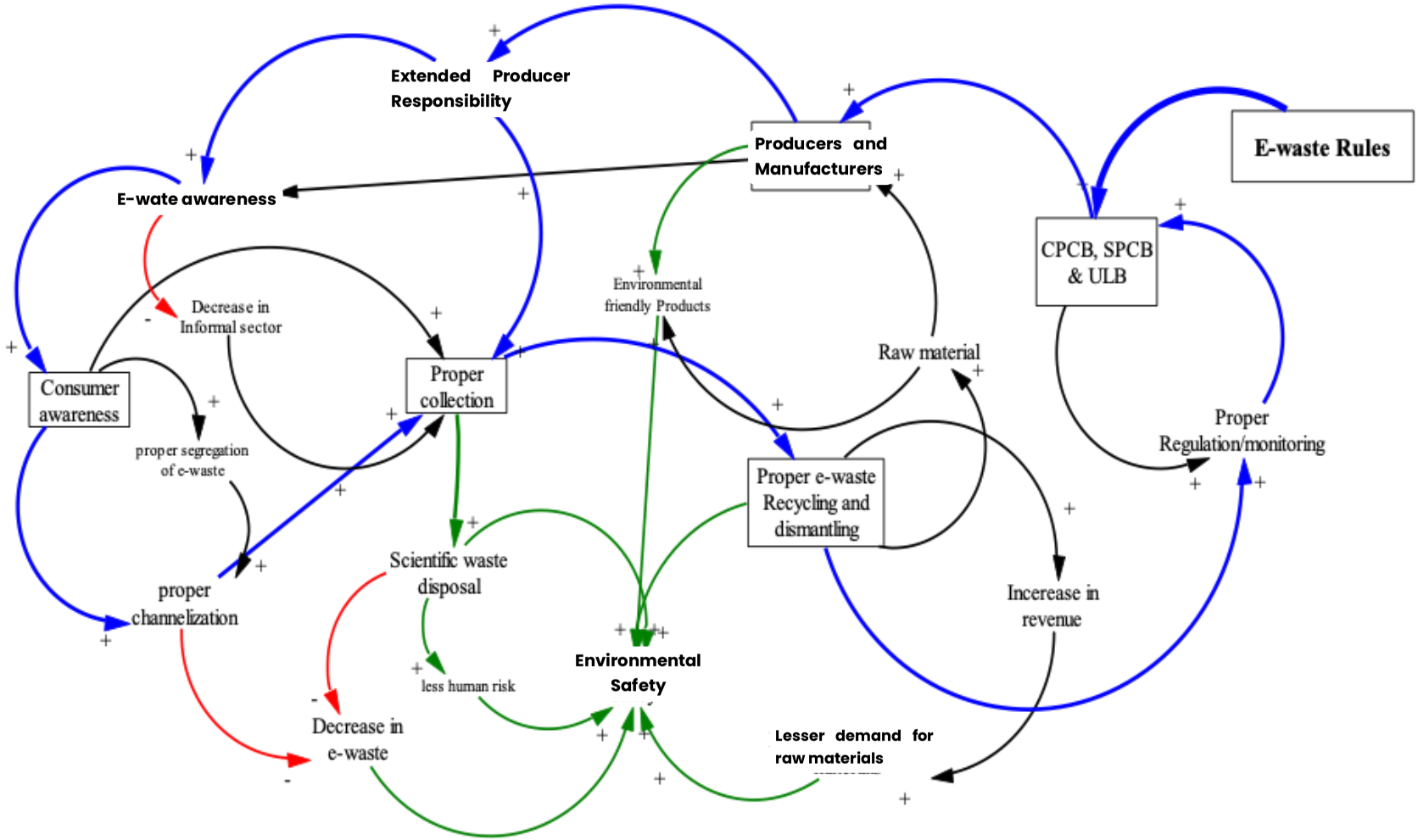
D. Mathuradaspura Dumping area

E. Achrol open dump

The most significant feature of the E-waste Management Rules is the Extended Producer Responsibility (EPR) where the producers of electronic and electrical equipment have the responsibility of managing such equipment after its end of life. The basic framework of EPR is shown here:

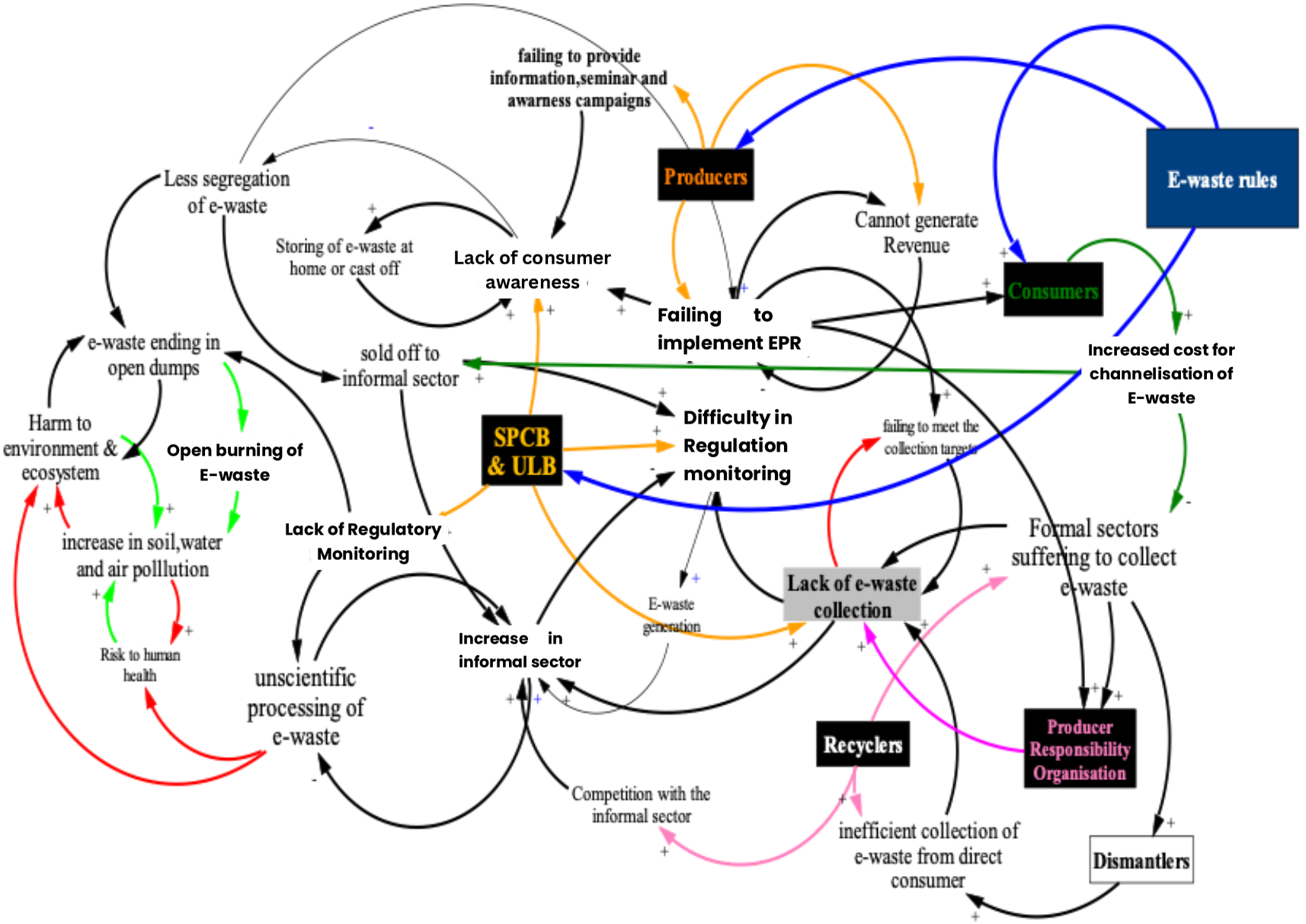


Ideal Flow Scenario of e-Waste



The study has developed Causal Loop Diagrams to depict the ideal flow of E-waste considering no violations and absolute compliance of the E-waste Rules by all stakeholders having their own responsibilities, vis-a-vis present state of management.

Present Flow Scenario of e-Waste



Key Study Highlights

The survey conducted as a part of the study, found that

- Twenty-three per cent of the respondents were keeping the E-waste at home. This was mainly due to the absence of a proper E-waste collection mechanism.
- There was no specific mode of collection of E-waste from different wards.
- There was no procedure for channelising E-waste to authorised recyclers/ dismantlers.
- Lack of general schemes for collection of E-waste under the EPR such as through dealers, collection centres, Producer Responsibility Organisations (PRO), Buy-back arrangement, Exchange Scheme, Deposit Refund System, etc.
- There was only one registered PRO in Rajasthan for collecting and channelling E-waste. The company was not reaching all the consumers for the collection of E-waste.
- There were no specific collection points assigned for the collection of E-waste by NNJ. Only three E-waste Bins, where consumers can drop their E-waste, were provided by ETCO with no specific location and capacity provided by them.
- There were no records of the collection Centre in Jaipur, authorised by the Rajasthan State Pollution Control Board.

The study recommended

- Provision of penalty in case of failure to E-waste collection.
- Producers to provide information and schemes for the recovery of their end-of-life products.
- Incentives for consumers for channelising their E-waste to producers.
- Collection of E-waste must be targeted to all types of consumers.
- Beneficiary schemes to involve consumers in the channelisation of E-waste.
- Advertisement and information sharing platforms should be updated regularly.
- Public E-waste awareness campaigns and workshops should be organised.
- Regular checking/inspection for compliance with the E-waste Rules may be carried out.
- Registered stakeholders under the E-waste management should be regularly monitored and the license of the stakeholders failing to report their annual return to be cancelled.
- The informal sector should be encouraged to come under the formal sector.
- Construction of an E-waste processing plant should be given priority.

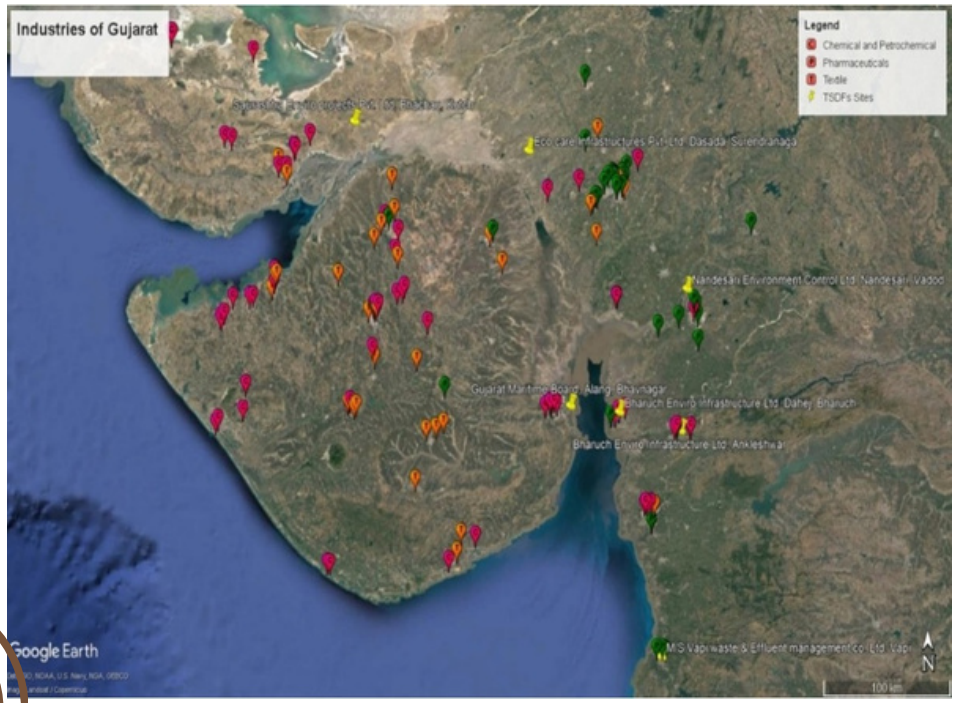
Industrial Hazardous Waste Management in Rajasthan and Gujarat

Hazardous Waste (HW) is a combination of non-biodegradable, toxic, and persistent wastes that pose a substantial hazard to humans, living organisms, or natural resources. HW is classified based on its corrosive, reactive, ignitable, or toxic characteristics. Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDFs) is a costly option for managing industrial hazardous waste in India. HW management includes identifying and quantifying HW, as well as developing and monitoring TSDFs. TSDFs have more stringent regulations for facility (Treatment, Storage and Disposal) and unit-specific standards to prevent HW release. The Ministry of Environment, Forest and Climate Change (MoEFCC) and Central Pollution Control Board (CPCB) has provided guidelines for selecting suitable TSDF sites, but only a few industries in the country have adequate treatment and disposal facilities. It was not until 1997 that India had proper secured landfill facilities for hazardous waste. (LTD, 2019).

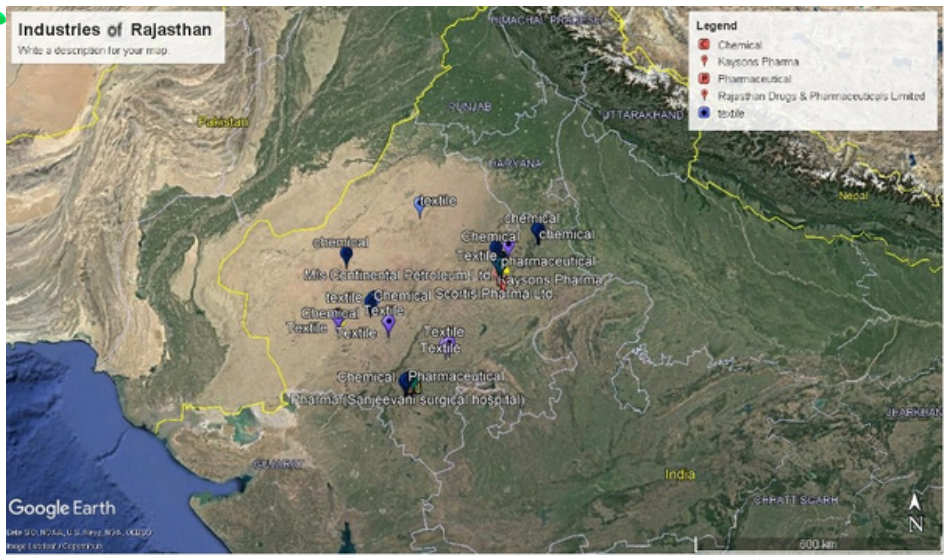
To highlight the requirements of establishing TSDFs in India and an assessment of such sites in Rajasthan and Gujarat. This primary research was undertaken by an intern, Ms. Simran Jatwani, at iCED in September 2021 and was subsequently completed in August 2022.

Study Area and Mythology

The study focused on seven and three common TSDFs sites in Gujarat and Rajasthan, respectively. The criteria was applied to those, who dispose of HW in landfills which should not be located near bodies of water, residential areas, or critical habitats. Distance from habitat area, vegetation, etc. was verified using the Google Earth Pro application (GIS tool) to assess their compliance with CPCB guidelines in terms of location.

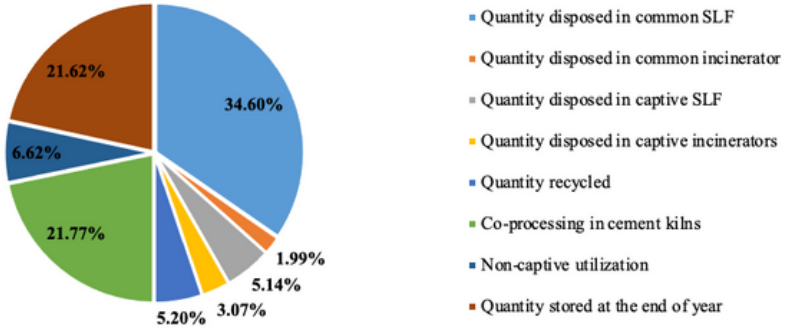


Representation of industrial locations and TSDFs sites of Gujarat



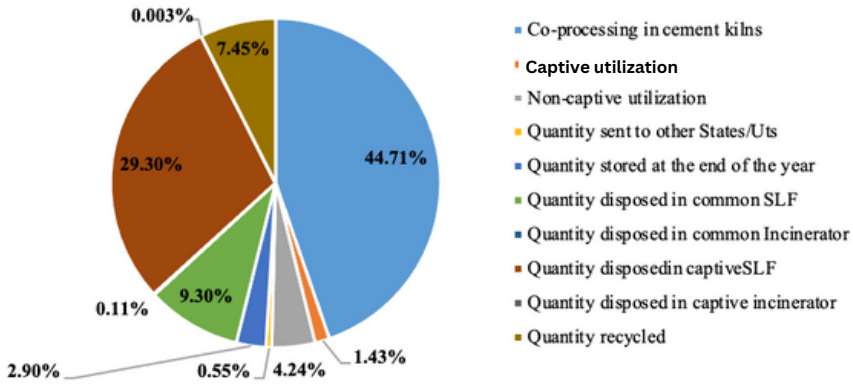
Representation of industrial locations and TSDFs sites of Rajasthan

Hazardous Waste managed in Gujarat



Percentage share of hazardous waste managed in Gujarat Source: Gujarat PCB, 2019-20

Hazardous Waste managed in Rajasthan



Percentage share of hazardous waste managed in Rajasthan Source: Rajasthan PCB, 2019-20

Two sites in Gujarat and one site in Rajasthan appeared to be non-compliant with stipulated guidelines based on Google Earth distance estimations. Such cases need to be examined further in detail to assess their implications and associated risks. This study provided useful toolkit to Audit for risk assessment at the audit planning stage.

Air Pollution in Delhi with a focus on Vehicular Pollution

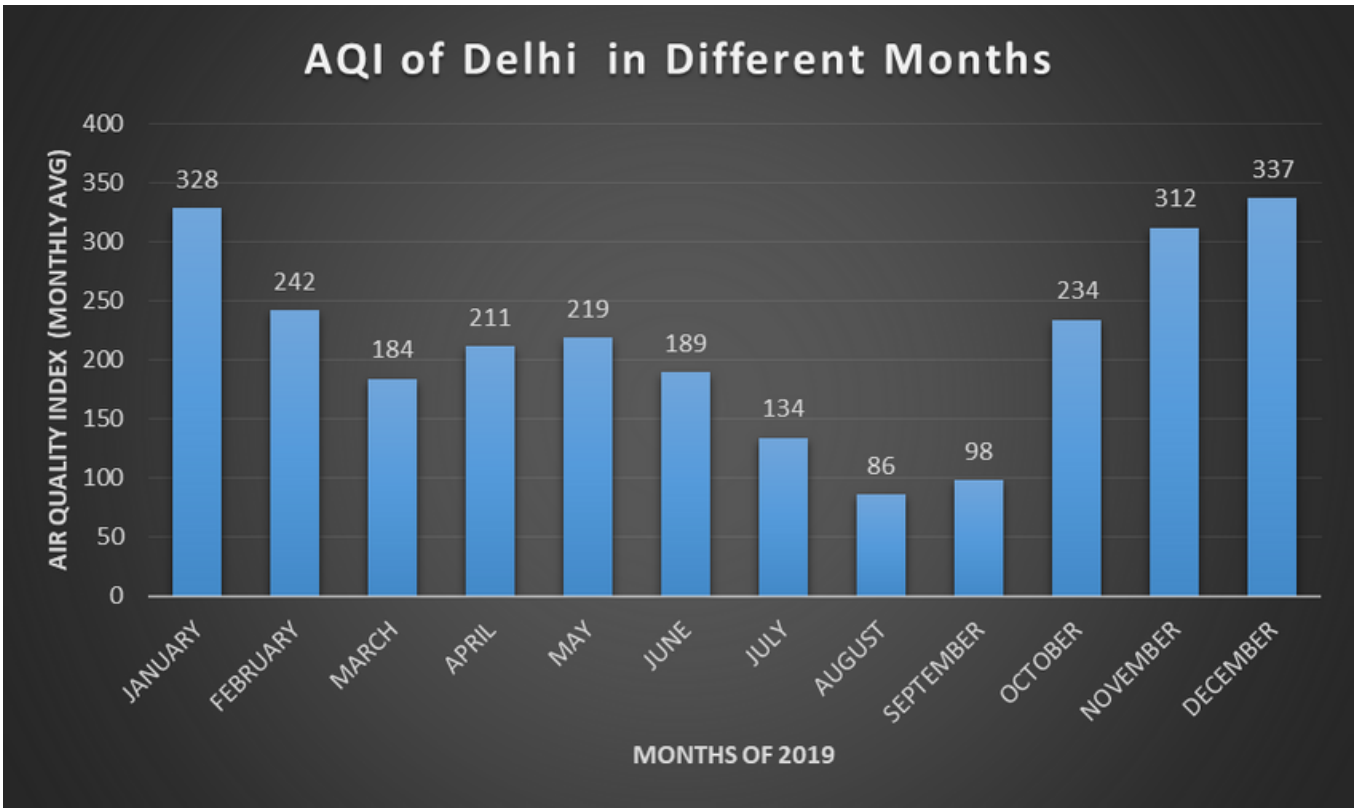
The major sources of air pollution in Delhi include vehicular emissions, industrial activities and construction work as well as the burning of crop residues and waste. Under the National Air Quality Monitoring Programme, four major air pollutants have been identified for regular monitoring: Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2) Suspended Particulate Matter (PM10) and Fine Particulate Matter (PM2.5). The National Air Quality Index, which includes four more pollutants, exhibit seasonal variations in Delhi, with air quality heavily deteriorating in winter months.

Against this backdrop, this primary research on Air Pollution in Delhi with a focus on Vehicular Pollution was undertaken by an erstwhile intern, Shri Swapnil Das at iCED, in September 2020 and was subsequently completed in August 2022.

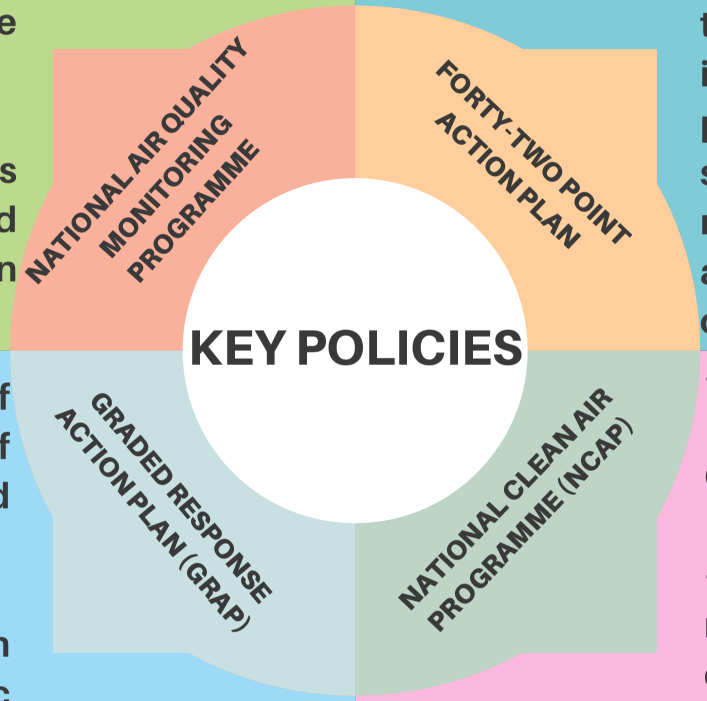
Objectives

- To highlight the trend in the concentration of pollutants due to vehicular emissions in Delhi and NCR with a focus on seasonal variation.

- To study steps taken by the Government of India to reduce Air pollution and implementation of various advanced modes of transportation.



Air Quality Index of Delhi, monthly average for the year 2019
Source: CPCB AQI Dashboard



- The programme is operated by the Central Pollution Control Board (CPCB) in collaboration with state pollution control boards and other agencies.
- SO_2, NO_2, suspended particulate matter (PM10), and fine particulate matter (PM2.5) have been identified for regular monitoring at all the locations.
- The data collected by these stations is used to develop policies and strategies for controlling air pollution and improving air quality.

- The Forty-Two Point Action Plan is a comprehensive set of measures aimed at reducing air pollution in Delhi and the National Capital Region (NCR) and includes measures such as strict enforcement of pollution control norms for industries and construction activities.
- Promotion of cleaner fuels and technologies for transportation including electric vehicles and public transport systems, strengthening of air quality monitoring and reporting systems and public awareness campaigns on air pollution .

- This is in response to high levels of air pollution, and includes a series of measures to be implemented based on the severity of the situation.
- This include restrictions on construction activities, traffic congestion and industrial emissions.
- The Central Government implemented the Graded Response Action Plan for Delhi and NCR region which comprises graded measures corresponding to each source as framed by the AQI categories.

- Launched by the Ministry of Environment, Forest and Climate Change (MoEFCC) in January 2019.
- National level target of 20-30% reduction of PM2.5 and PM10 concentration by 2024.
- The Apex Committee within the ministry will review the progress of these components. Appropriate indicators will be evolved for assessing the emission reduction benefits of actions.

Key Study Highlights

- Growth in the number of vehicles and traffic congestion have led to an increase in vehicular pollution in Delhi, complicated by stubble burning in the neighbouring states.

- The institutional framework for air pollution control in Delhi includes several government agencies at the national, state, and local levels including non-governmental organisations and other stakeholders.

- Faster Adoption & Manufacturing of Electric Vehicles (FAME- INDIA) Scheme to give a push to Electric Vehicles (EVs) in public transport seeking to encourage the adoption of EVs by way of market creation and demand aggregation holds promise for the reduction in vehicular pollution.

- The key policies related to air pollution control in Delhi include the implementation of the National Air Quality Index, National Clean Air Programme (NCAP), Graded Response Action Plan (GRAP), and Air (Prevention and Control of Pollution) Act.

- Sustained and comprehensive efforts from the government, citizens, and other stakeholders are required to mitigate its adverse effects.

- Implementation of the Mass Rapid Transit System, like the Metro, led to a decrease in pollutant concentration, that was emitted through various privately owned vehicles.

- Promotion of clean transportation, enforcement of stricter regulations on industrial emissions, regulation of construction and waste-burning practices, reduction of crop residue burning and increase in public awareness on health impacts of air pollution hold the key to future success.

Pollution caused by Road Dust- A Case Study of Delhi and Mumbai

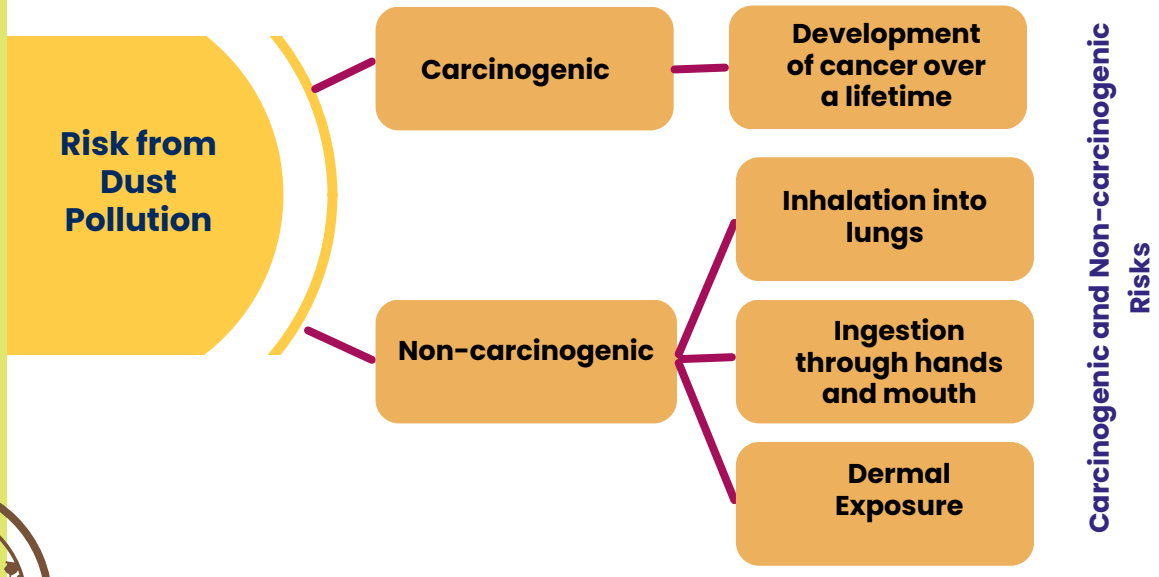
Urban areas are facing a significant problem with dust pollution, as its contribution to air pollution is highly alarming. Dust particles on the road contain various substances like heavy metals, mold spores, and pollen. The movement of vehicles and wind causes these particles to become suspended in the air, leading to poor air quality. In India's growing megacities, people who work or eat food on the roadside are particularly vulnerable to this pollution. In this context, this primary research on pollution caused by road dust in the cities of Delhi and Mumbai was undertaken by an erstwhile intern, Ms. Tannu Mittal, at iCED in September 2021 and was completed in May 2023

Objectives

To analyse the concentration of heavy metals like copper, zinc, lead, chromium etc. present in urban road dust in two cities i.e., Delhi and Mumbai with the help of pollution indices and associated health effects on individuals due to presence of heavy metals in road dust.

Assessment tools

The assessment tools used in this study were Pollution indices (Joanna Beata Kowalska, 2018) such as Contamination Factor, Pollution Load Index, Ecological Risk Index, and Degree of Contamination. The extent and risk of exposure were calculated using the Human Health Assessment Method (United States Environment Protection Agency, n.d.). Further, a potential ecological risk index tool developed by Hakanson in 1980 was also used to calculate the different pollution indices (Hakanson, 1980). The average concentration of heavy metals present in road dust for Delhi (Sayantee Roy, 2019) and Mumbai (Amit Gawade, 2016) were collected from the existing literature.



Key Study Highlights

- In Delhi, the overall average concentration of Iron was on the higher side. In Delhi, ingestion was the main route for the exposure of the local population to road dust, while the least risk was found through inhalation.
- In Mumbai, the overall average concentration of Zinc, Lead, and Copper was on the higher side in comparison to other heavy metals possibly due to motor vehicle emission, wear and tear of the braking system, and use of galvanized steel. In Mumbai, ingestion was the main route for the exposure of the local population to road dust, while the least risk was found through inhalation.

Concentration of Heavy Metals in Road Dust in Delhi and Mumbai

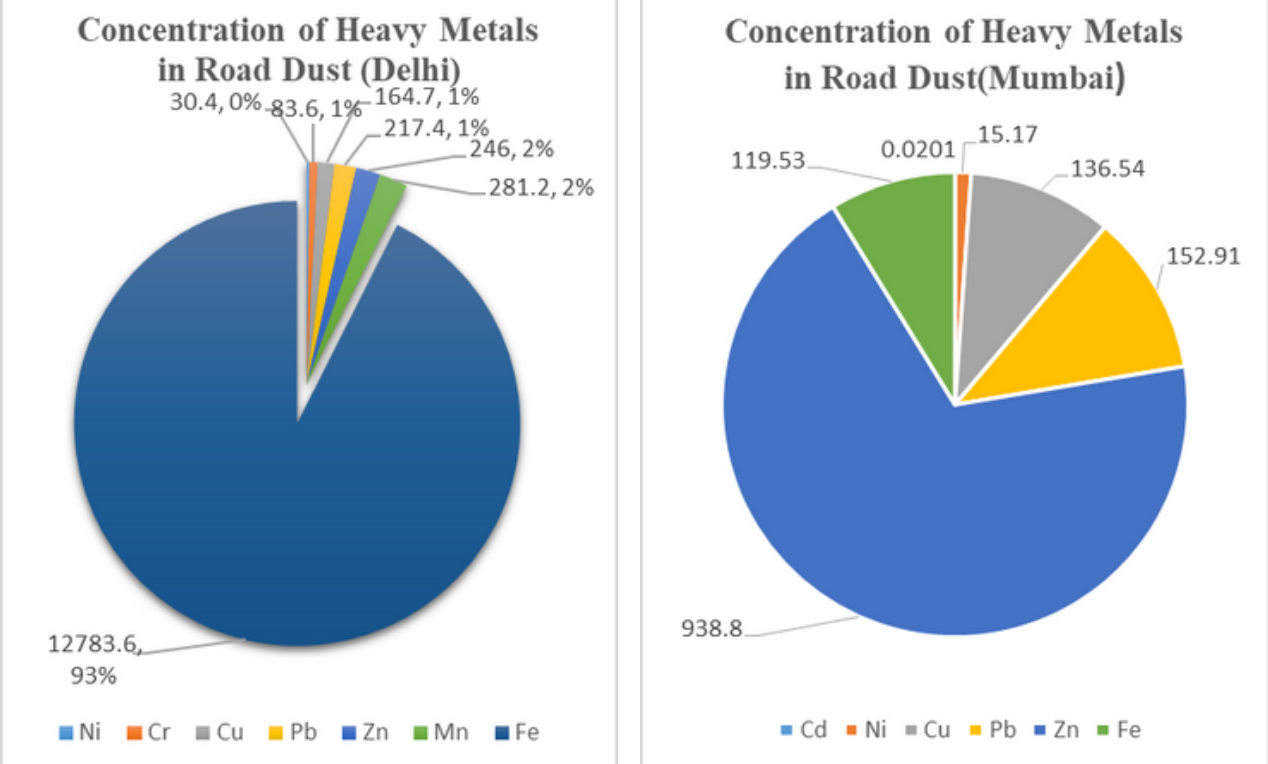


Table: Pollution Indices in Delhi and Mumbai

Parameters	Delhi	Mumbai
Contamination factor (CF)	CF of Lead is on the higher side	CF of Zinc is on the higher side
Degree of Contamination (Cd)	High for both Delhi and Mumbai	
Pollution Load Index (PLI)	PLI>1 [Deteriorating site quality]	PLI<1 [Represents dust pollution within prescribed norms]

Parameters	Delhi	Mumbai
Hazardous Quotient (HQ) ing= ingestion inh= inhalation dermal= dermal exposure	HQing> HQdermal >HQinh for both Delhi and Mumbai. HQing, HQdermal and HQinh is less than 1, which represents that the non-carcinogenic risk of all heavy metals via ingestion, inhalation, and dermal contact is within prescribed limit for both Delhi and Mumbai. HQing and HQdemal for both the cities are more for children in comparison to adults. HQinh for both the cities is more for adults.	
Hazardous Index (HI)	The Hazardous index is less than 1, meaning that the probability of getting non-carcinogenic risk is insignificant for both adults and children.	
Carcinogenic risk (CR)	Risk is insignificant for both Delhi and Mumbai.	

- The study suggested use of proper dust palliative or water sprinkling system to control the road dust, improving the conditions of roads by treating potholes for the free flow of traffic to reduce the emission of road dust, creation of green buffers along the traffic corridors, enhancing building green cover, plantation for green open areas, community places, schools, and housing societies and stringent implementation of Construction & Demolition Rules, 2016 issued by the Government of India for reduction in dust pollution. The indices used in this study provide useful guidance to audit in terms of development of an auditing toolkit for the audit of dust and air pollution in large cities.

Impact of Nature-based Tourism and Shack Policy in Goa



Two Case Studies highlight the use of the method of Regulatory Impact Assessment (RIA) in finding probable solutions to the adverse impacts of tourism and policy violations in the State of Goa, India

Tourism- A Bane or A Boon: A Case Study of the Impact of Marine Nature-based Tourism in Goa

A Performance Audit on the promotion of tourism in Goa was conducted by the Comptroller and Auditor General (C&AG) of India in 2012. The primary research on the impact of marine nature-based tourism on the marine ecosystem, which is a crucial aspect of tourism in Goa, was undertaken by two interns at iCED in June 2018, inspired by the Audit Report. This first study on impact of marine tourism was undertaken by Ms. Trinayani Sen and the second study on impact of Shack Policy was undertaken by Shri Saurabh Suman. These studies were subsequently completed in August 2022

Objectives

- To assess the impact of tourism on the natural resources, the marine ecosystem and to devise necessary regulatory mechanisms for the same.
- To analyse the problem of the negligence of marine life for the promotion of tourism activities, identify the key causal factors for the same and devise relevant regulatory mechanisms.

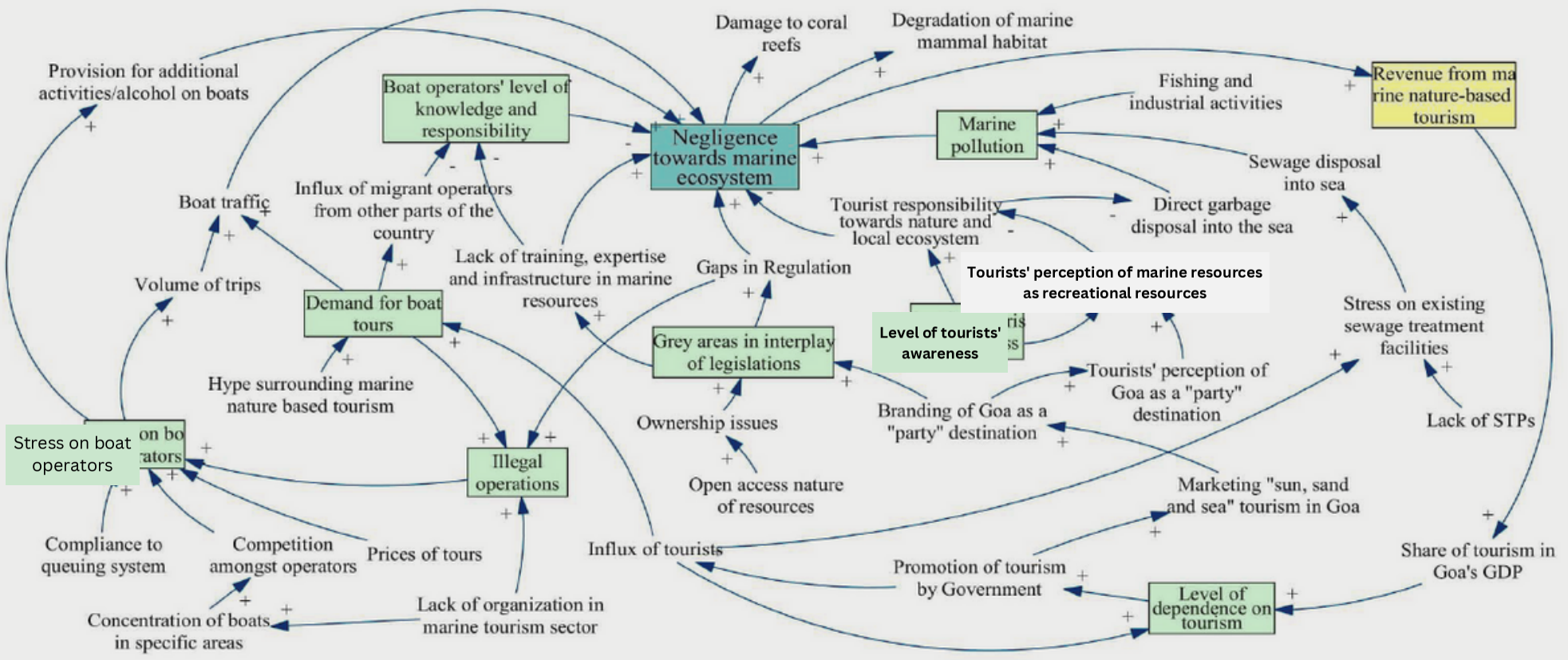
Scope and Assessment Tools

The focus of this study was mainly on marine nature-based tourism activities such as dolphin watching, picnic boat cruises and diving activities. The components of the marine ecosystem considered for this study were the coral reefs and the marine mammals present in that area.

The second study (discussed in the next chapter) probed the question 'Why do the shack owners violate the regulations?' Both the studies demonstrated use of the method of Regulatory Impact Assessment (RIA), which often helps in exploring the causes, establishing a relationship among them, and therefore in helping make precise recommendations and providing their usefulness to the auditors in carrying out a deeper analysis, and in making more informed recommendations.

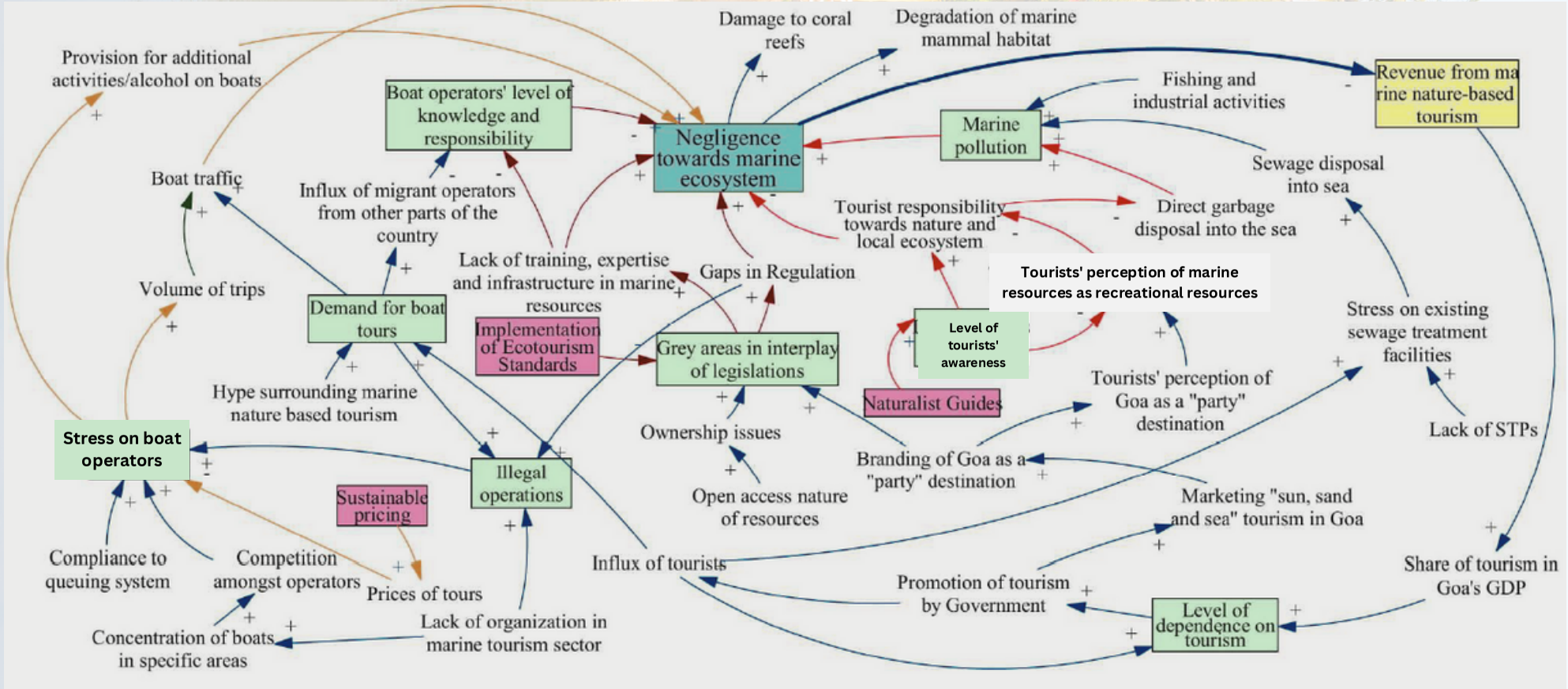


Instrumental Causal Factors



This study identified negligence towards marine ecosystem as the central problem behaviour. To understand the problem behaviour two major marine nature-based tourism activities- Dolphin watching tours and diving tours (Scuba diving and snorkelling) were chosen for the study using RIA.

Causal loop with suggested solutions



An operationalisation procedure for a feasible solution

Regulatory Mix 1
Regulations and penalty + Redistribution of boats using a levy + Mooring Buoys

Regulatory Mix 2
Ecotourism Guidelines + Social Score based incentive system + Naturalist Guides + Capacity building of boat operators + Sustainable tariff system + Mooring Buoys

Out of two identified regulatory solution mixes, the researcher emphasised operationalisation of Mix -2 as it facilitates long-term behavioural change and is a step toward the implementation of sustainable tourism in the State of Goa. The implementation process needs to be sequential.

Impact of Shack Policy of the Department of Tourism, Goa

The shack policy is the tourism policy for erection of temporary seasonal structures, beach shacks, huts and others. This study identified two most relevant regulations which governed the behaviour of the shacks, i.e. the Coastal Regulation Zone (CRZ) Notification, 2011 and the Shack Policy by the Department of Tourism, Goa. Section V of the CRZ Notification, 2011 gave outlines for areas requiring special consideration. Sub-section 3 of the section permits, regulates and restricts certain activities in the coastal region of Goa, highlighting the peculiar circumstances of the State of Goa including its history and other developments. The Shack Policy initially started for a period from 2016-2019 and the shack owners were allotted licenses for the building of shacks for three years. The structures were permitted as temporary and had to be dismantled by the end of the season (10th June). Provisions for imposing penalties and cancelling the license on the offender were the tools to stop the violations.

Objectives

1) To identify the impact of the Coastal Regulation Zone (CRZ) and Shack Policy on the marine tourism and environment in Goa
2) To analyse the reasons for violation of these regulations and identify effective solutions

Assessment Tools

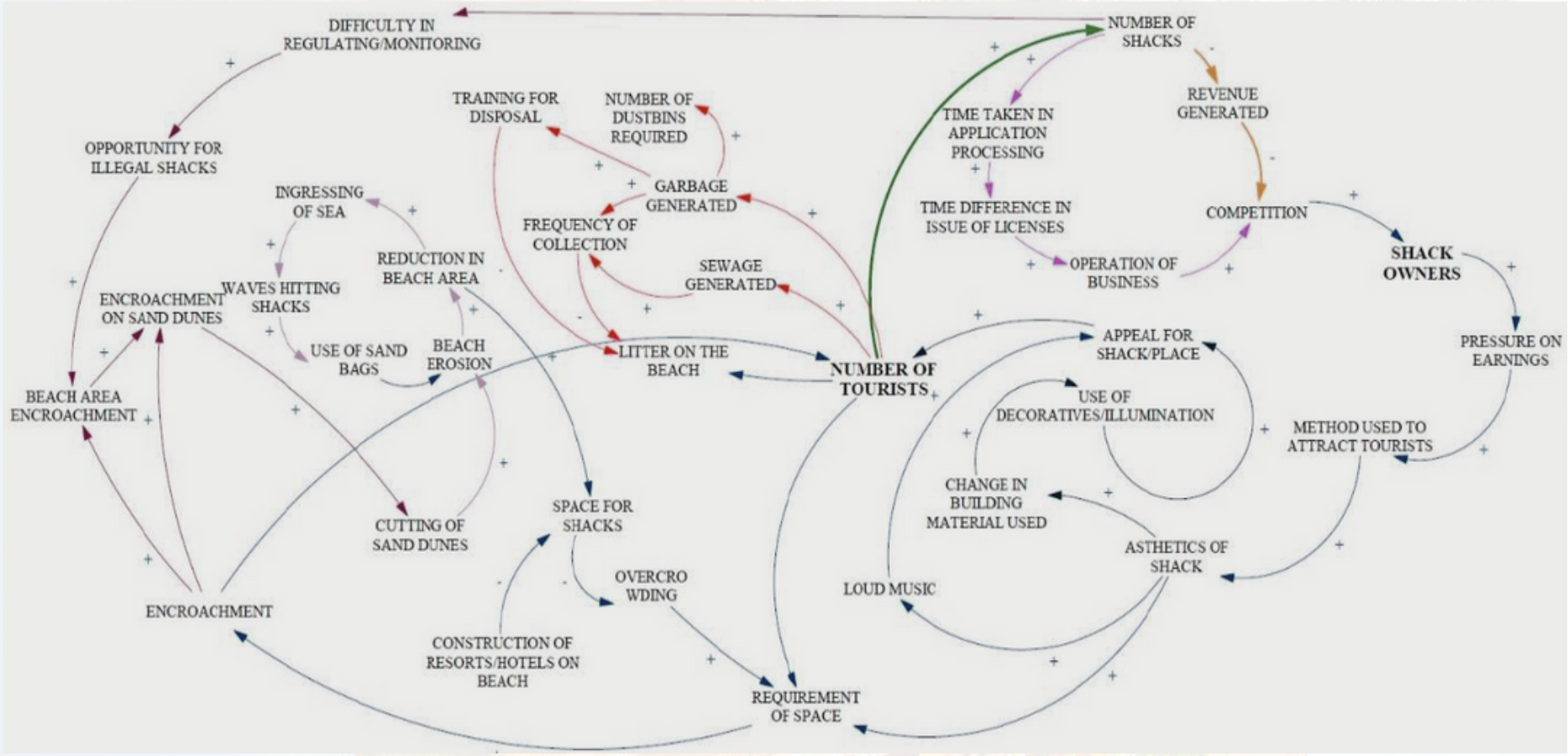
Causes leading to violations were identified and depicted in the Causal Loop Diagram (in next page). To study the impact of the shack policy, various stakeholders, local residents and shack owners were consulted. Tourists and organisations working towards making shacks more compliant with regulations, like the Centre for Responsible Tourism, were also consulted. The economic policy tool which is largely used, is penalty imposed on the shack owners (Diagram in next page).

Audit by the C&AG of India found that there were large number of violations in the implementation of the policy, which indicated the failure of the then solutions and instruments in curbing the problem behaviour. Following broad problem behaviours were identified:

- **Violation of permissible noise limit,**
- **Violation of sewage and garbage disposal norms,**
- **Violation of guidelines for shack construction,**
- **Encroachments and**
- **Initiation of operation without obtaining all licenses.**

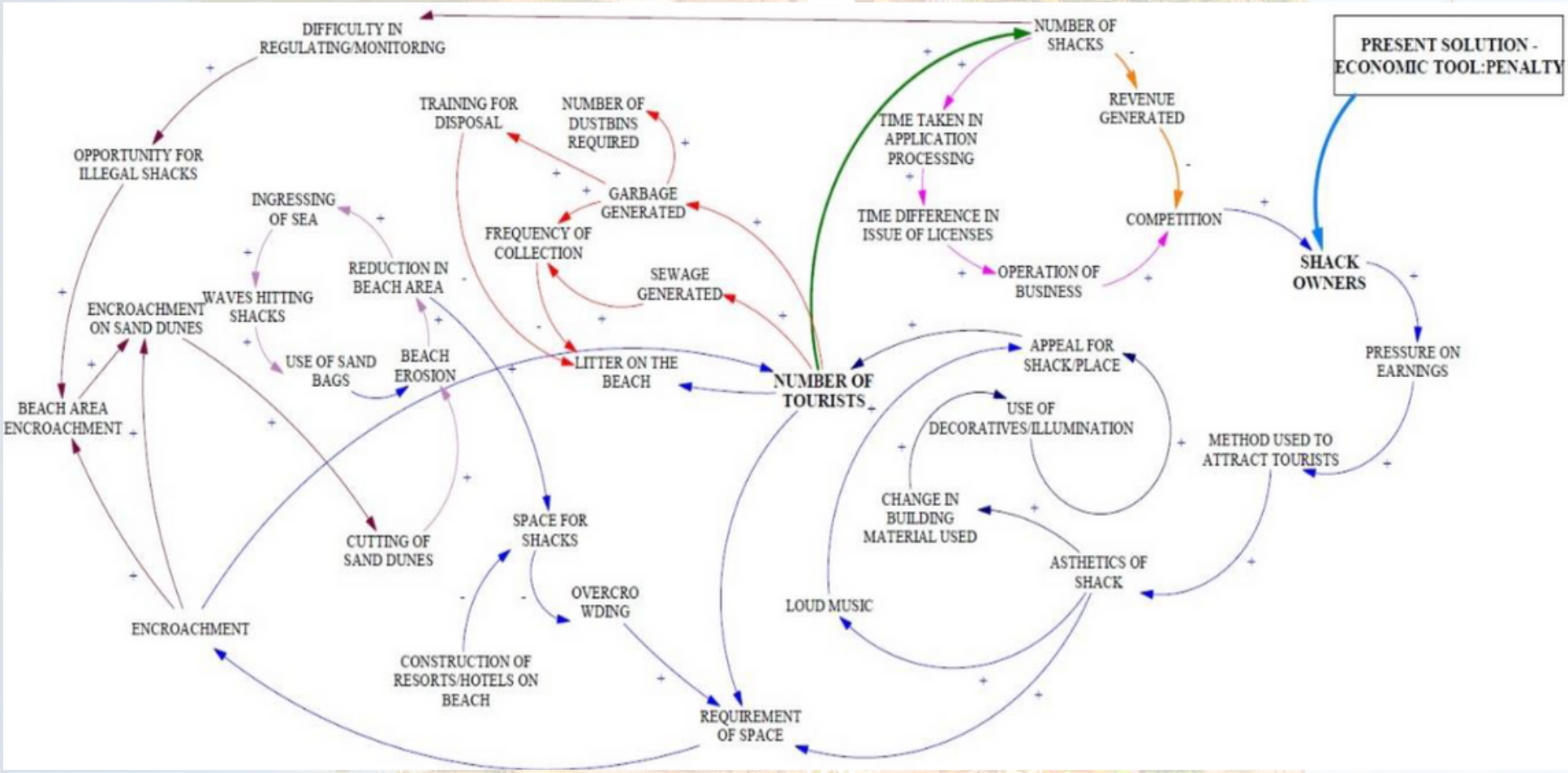
SUPREME AUDIT INSTITUTION OF INDIA
Dedicated to Truth in Public Interest

Instrumental Causal Factors



The whole loop revolves around the number of tourists, which in turn affects a variety of activities. Therefore, the pivot of the loop is not the shack owners, but, the number of tourists. The policy can regulate the shack owners, but the nature of the violations that exist is contingent not on the shack owners but, on the tourists.

Causal Loop with Penalty as an Economic Tool



The study recommends to take steps towards the regulation of the tourists as well as curb the violations on the beaches. The shack policy uses the tool of penalty extensively. In the policy, features of forfeiture of the security deposit, and cancellation of licence have been cited as the control mechanisms.

Penalty as Premium

The issue that arises here is that fixing a penalty for violations at all stages ultimately converts it to a premium. The penalty becomes a fee to perform the prohibited action, thereby reducing its effectiveness. Further, in the presence of regulations, a violator always carries a personal risk, and cost and benefit analysis before committing to the violation. If the benefits of violating the norm are greater than the penalty imposed by the regulation, it becomes an obvious choice to violate. During the field visit, the interaction with the owners revealed that working and maintaining things on sand is difficult.

Stakeholder Analysis

The problem analysis was followed by a stakeholder analysis. The stakeholders were distinctly identified, and interactions with them were carried out on an individual basis. At the end, the study suggests a regulatory mix of Transactional Tools, Economic Tools, Authorisation Tools, and Informational Tools for the formulation of a final tool for regulation. The target of the regulation here is the shack owners, as well as the tourists, and also the party which is directly responsible for beach cleaning and garbage collection.

For Tourists	For Shack-Owners
Sign Boards/Displays (Informational Tool) + Penalty (Economic Tool)	Licensing (Authorisation Tool) + Performance Indicators/Credit Ratings (Informational Tool) + Contract Disqualification (Transactional Tool)

The study highlights that the regulation is focused at a point in the loop which is not causing but responding to the effects of the other causes. Thereby, failure of the tool is evident from the large number of violations that exist. Audit has a role to recommend remedial measures by taking a more diverse approach and by employing a mix of tools, using Instrumentation. Performance indicators for the shack owners can be issued and used as a basis for issue of license and feedback from tourists.

These two studies show how Regulatory Impact Analysis could be integrated with an Audit exercise to enhance scientific and evidence-based recommendations and their effectiveness.

A study on invasive plant species in Bikaner region and Ranthambore National Park, Rajasthan



Prosopis juliflora **and** ***Acacia tortilis*** **were introduced for their economic and environmental benefits, such as sand dune stabilisation, soil quality improvement, and ecosystem-restoration in ecosystems damaged by natural disasters, human activities, or overgrazing. Due to their dominating character, they leave negative impacts on the ecology later on. They compete for resources and habitat with native species, affecting the native species and ecosystem.**

Effects of Invasive Plant Species on Native Animal Species, in Bikaner Region and Ranthambore National Park, Rajasthan

This study has shown how introduction of two invasive plant species, *Prosopis juliflora* and *Acacia tortilis,* in Bikaner region and Ranthambore National Park in Rajasthan impacted the local environment. *Prosopis juliflora* is an exotic weed native to Central and South America that has become an invasive plant species all over the world. It was introduced in India in second half of 19th century in the region of Sindh for stabilising the sand dunes (Ahmed, 2014) and in Rajasthan in the year 1913 for moderating the temperature. It quickly naturalised (got accustomed to local climatic conditions and vegetation) and began competing with native species, affecting biodiversity. A*cacia tortilis* is invasive plant species native to Savanna and Sahel of Africa, which was introduced in Rajasthan by the Central Arid Zone Research Institute (CAZRI), Jodhpur in the year 1958 for stabilising sand dunes and improving soil quality for better crop production, in the Thar Desert and Indian Desert region (Frienvis, n.d.; K,D. Muthana & G.D, Arora). This primary research was undertaken by an erstwhile intern, Ms. Nilisha Sinha, at iCED, in September 2021 and was subsequently completed in August 2022.

Objectives

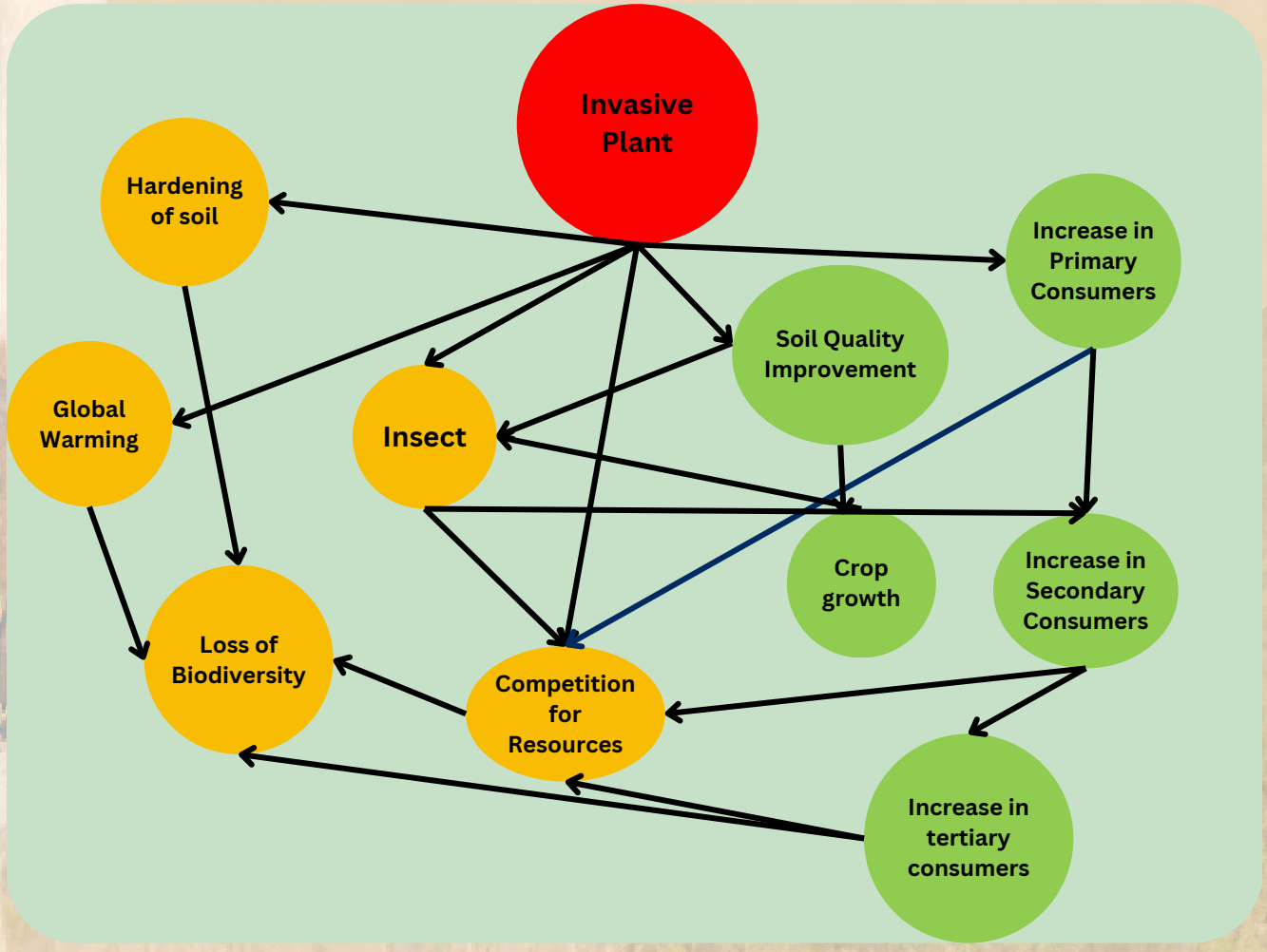
To study the impact of *Prosopis juliflora* and *Acacia tortilis* on the living environment of selected native species, i.e., Spiny-tailed Lizard, Blue Bulls, Bengal Tiger and Great Indian Bustard, in the study area.

Study Area

Bikaner region and Ranthambore National Park are located in two different geographical regions, with Bikaner being a desert region and Ranthambore National Park having dry deciduous forests and open grassy meadow. Biodiversity is abundant in Ranthambore National Park, whereas Bikaner has comparatively less biodiversity. Ranthambore National Park is home to Bengal Tigers and Blue Bulls, whereas Bikaner is home to Spiny-tailed Lizards and Blue Bulls, as well as former home of the Great Indian Bustard (www.wilddweller.com and www.ranthamborenationalpark.com).

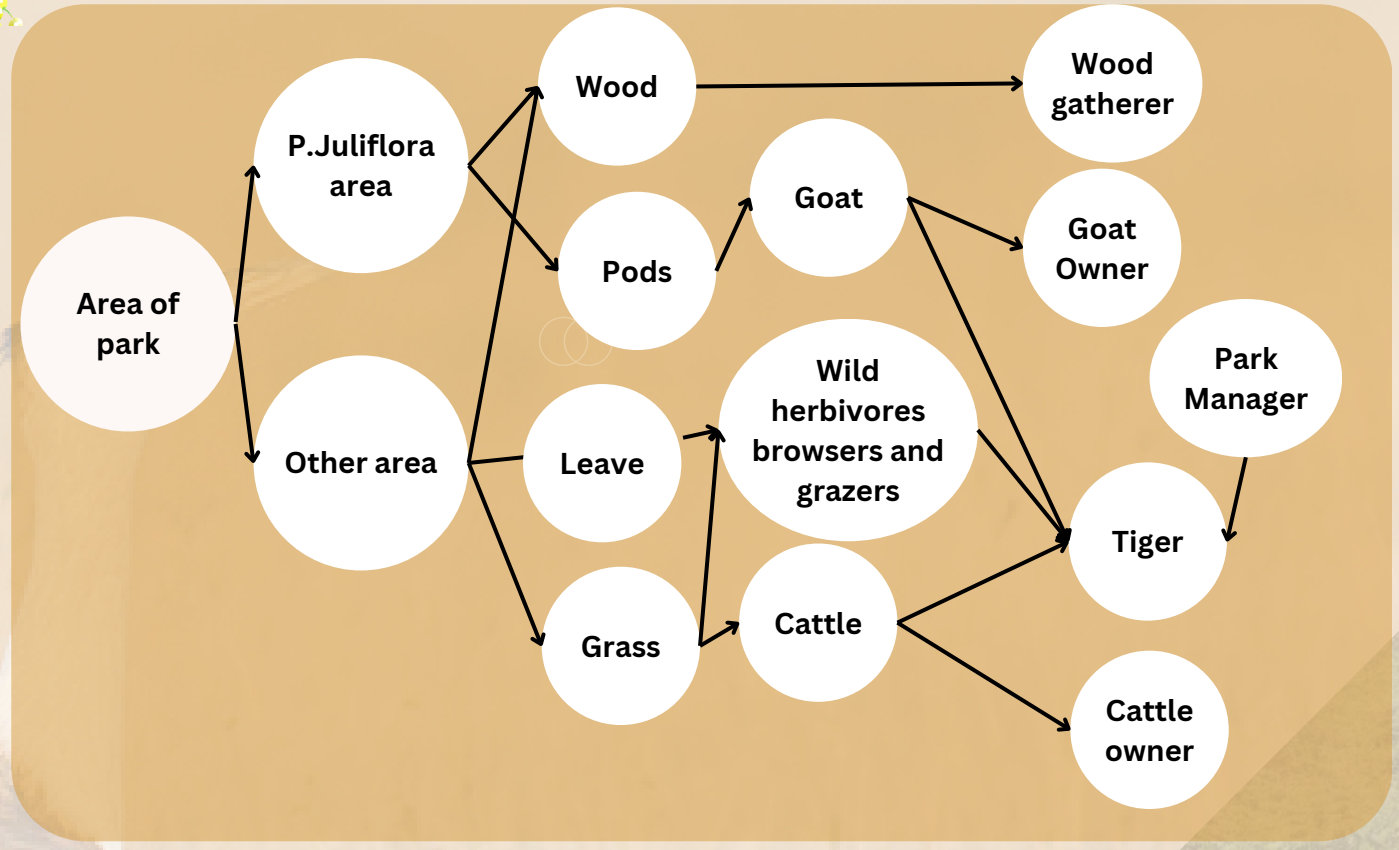
Major Findings

1) *Prosopis juliflora* is affecting the Ranthambore National Park's ecosystem, ecology and economy. It has resulted in an increase in the number of livestock viz. goats, cattle which graze in forest and compete with wild herbivores. As a result, wild herbivores' resources get limited, seeing a decline in their numbers (figure). This, in turn, leads to reduction in the number of tigers in the Park (Dayal, 2007).



(2) Habitat degradation was one of the factors responsible for extinction of the Great Indian Bustard in Bikaner region. Great Indian Bustard is a grassland bird and invasive species have negative impact on grasslands, leading to degradation of habitat of Great Indian Bustard and decrease in their number.

(3) The number of Blue Bulls has increased throughout Rajasthan due to abundance of food. It has been observed that *Prosopis juliflora* and *Acacia tortilis* are beneficial for Blue Bulls as they feed on pods and leaves of these invasive plants.



(4) Spiny Tailed Lizards prefer to burrow in loose sand. Introduction of *Prosopis juliflora* and *Acacia tortilis* causes hardening of soil. In Bikaner region, due to introduction of these species, soil has become harder, making it difficult for Spiny-tailed lizards to dig burrows.



INDIAN SPINY-TAILED LIZARD (SOURCE: PROJECTNOAH.ORG)

5) Although the effects of *Prosopis juliflora* and *Acacia tortilis* on Bengal Tigers are indirect, they do have an impact on their habitat and conservation area. Invasive plant species such as *Prosopis juliflora* alter soil chemistry and herbivore animals, causing ecological changes. The natural food chain and tiger population are disrupted by negative impacts on floral diversity and competition among herbivore species.

The study also highlights how measures have been taken by the Government of Rajasthan for control of these invasive species in the desert regions. The study recommends that instead of planting these invasive plant species, preference should be given to native plants. By replacing invasive plant species with native vegetation in shelter belts, the detrimental impact and spread of invasive plant species can be mitigated. This study provides important inputs to Audit for selection of study area, and audit evidence helping scientific audit analysis.



Understanding the Value Addition of Non-Timber Forest Produce (NTFP) using System Dynamics in Telangana, India

Understanding the Value Addition of Non-Timber Forest Produce (NTFP) using System Dynamics in Telangana, India

Non-Timber Forest Produces (NTFPs) are components of the forest system that exist in nature and are generally not cultivated. Non-timber forest produces are important sources of income and livelihood for many forest-dependent communities in Telangana, India. The NTFPs have a major role in the economy of tribal societies. The primary research was conducted by an erstwhile intern, Shri Hariharan Kannan, at iCED Jaipur in February 2020 and was subsequently completed in August 2022.

Objectives

To study and analyse the role played by the Telangana state government and private co-operative organisations in helping the extraction and use of NTFP products by using system dynamics.

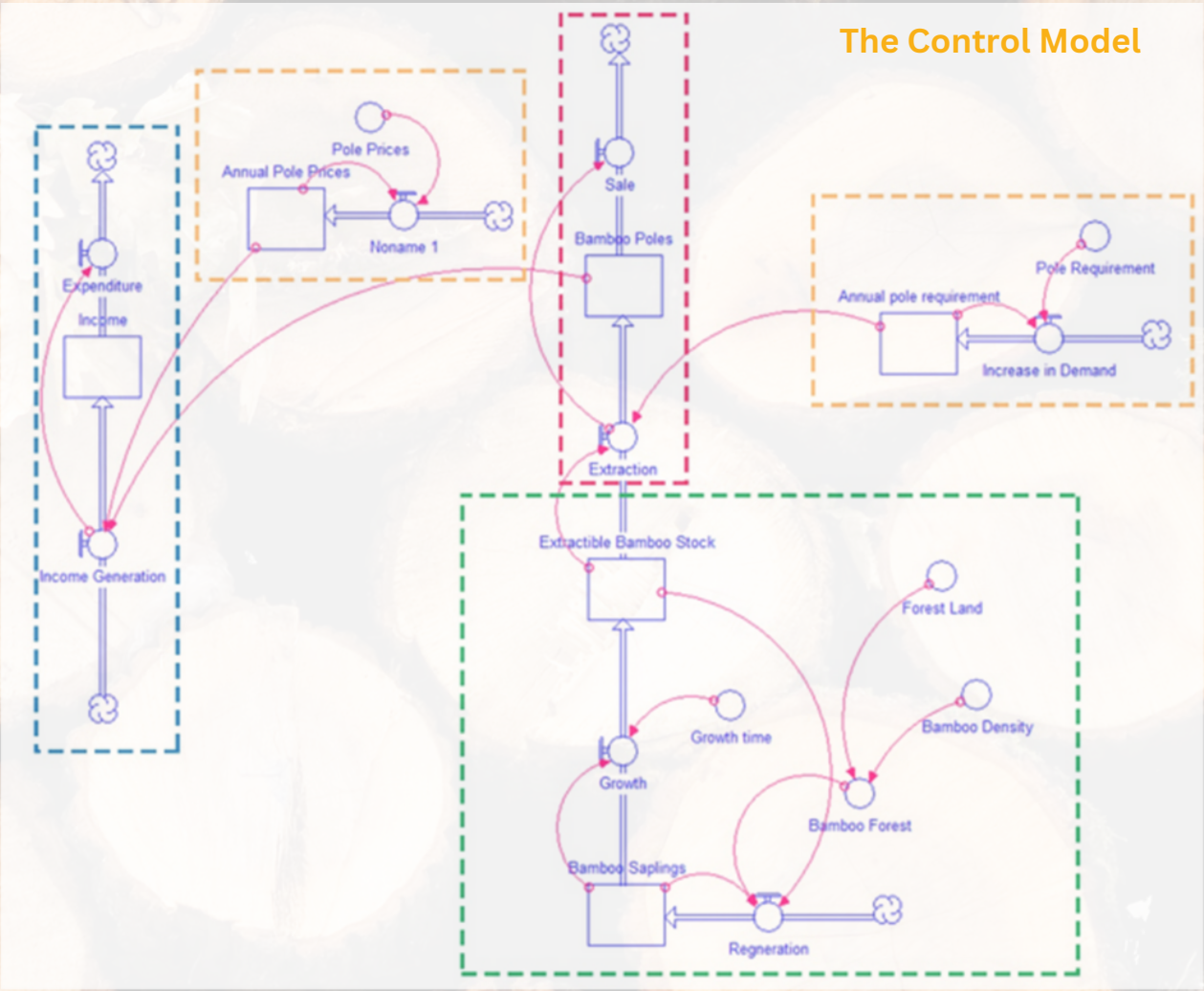


State-wise availability of NTFPs

Source: Ministry of Tribal Affairs, Government of India

Use of system dynamics

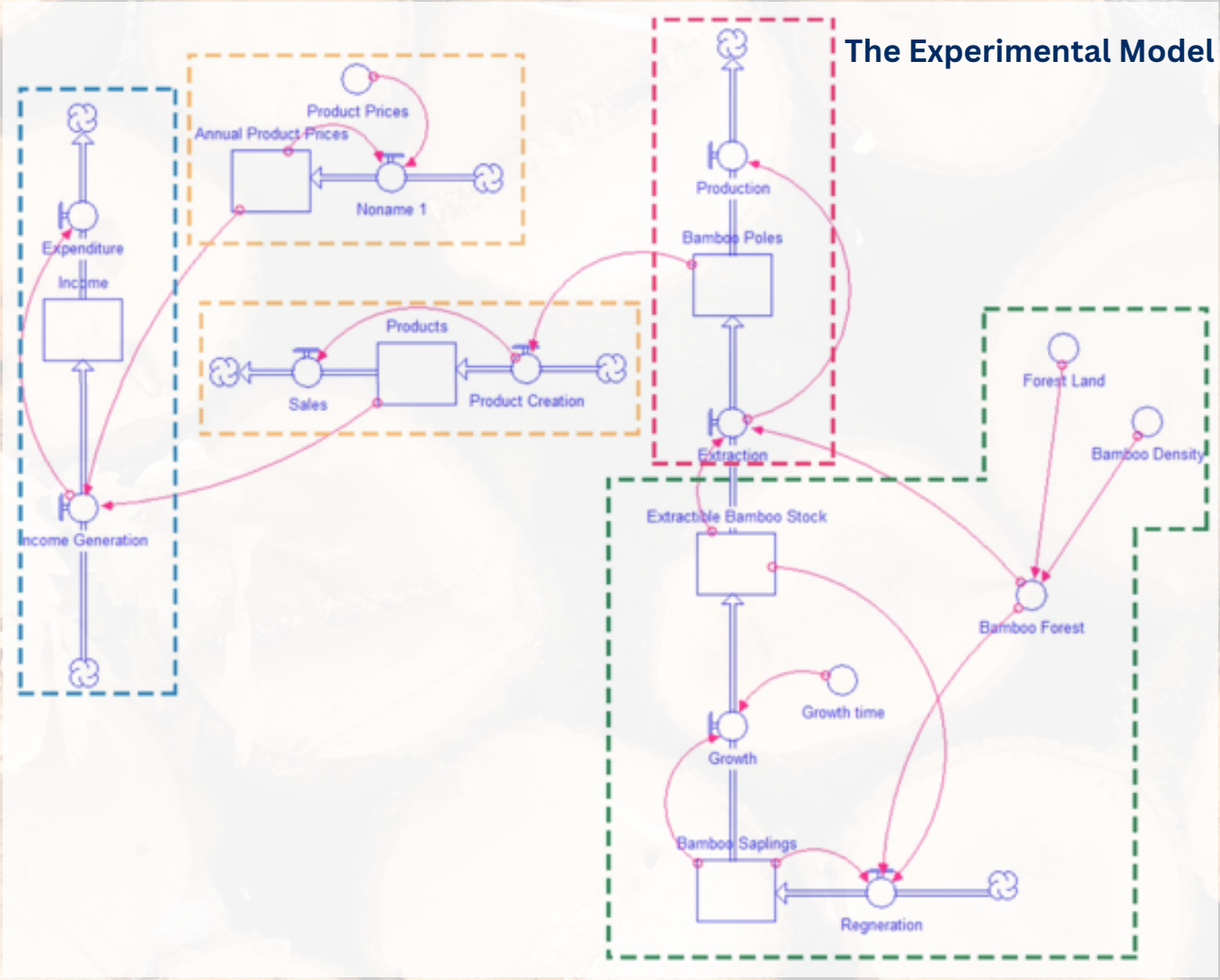
The study uses two models, namely the Control model and the Experimental model to analyse the role played by the state government and private co-operative organisations in helping the extraction and use of NTFPs. The Control model shows a NTFP collection and marketing system where there is no agency or co-operative helping in the manufacturing and marketing of NTFP products. Here, the exploitation of the NTFPs is guided by the demand factor.



The Control model created on the STELLA software, by ISEE Systems. The model was created based on the data received from the Girijan Cooperative Corporation (GCC) and the Telangana State Forest Department. The process exists in three distinct steps; the regeneration and growth of the bamboo forest, the extraction of the bamboo, and the sale of the bamboo.

The Experimental model portrays a system of NTFP extraction and marketing scenario where a co-operative has been introduced and shows how it helps in better income generation through methods of value addition and how it helps in the reduction of extraction rates, making the system more sustainable in nature. In this model, the NTFPs are extracted based on the regenerative capacity of the forest. It also highlights the role played by the co-operative agencies in manufacturing and marketing of the NTFPs ensuring increased income for the forest dwellers.

The Experimental Model



The Experimental model was created on the STELLA software, by ISEE Systems. The model was created based on the data received from the GCC and the Telangana State Forest Department. The process exists in three distinct steps; the regeneration and growth of the bamboo forest, the extraction of the bamboo, and the sale of the bamboo.

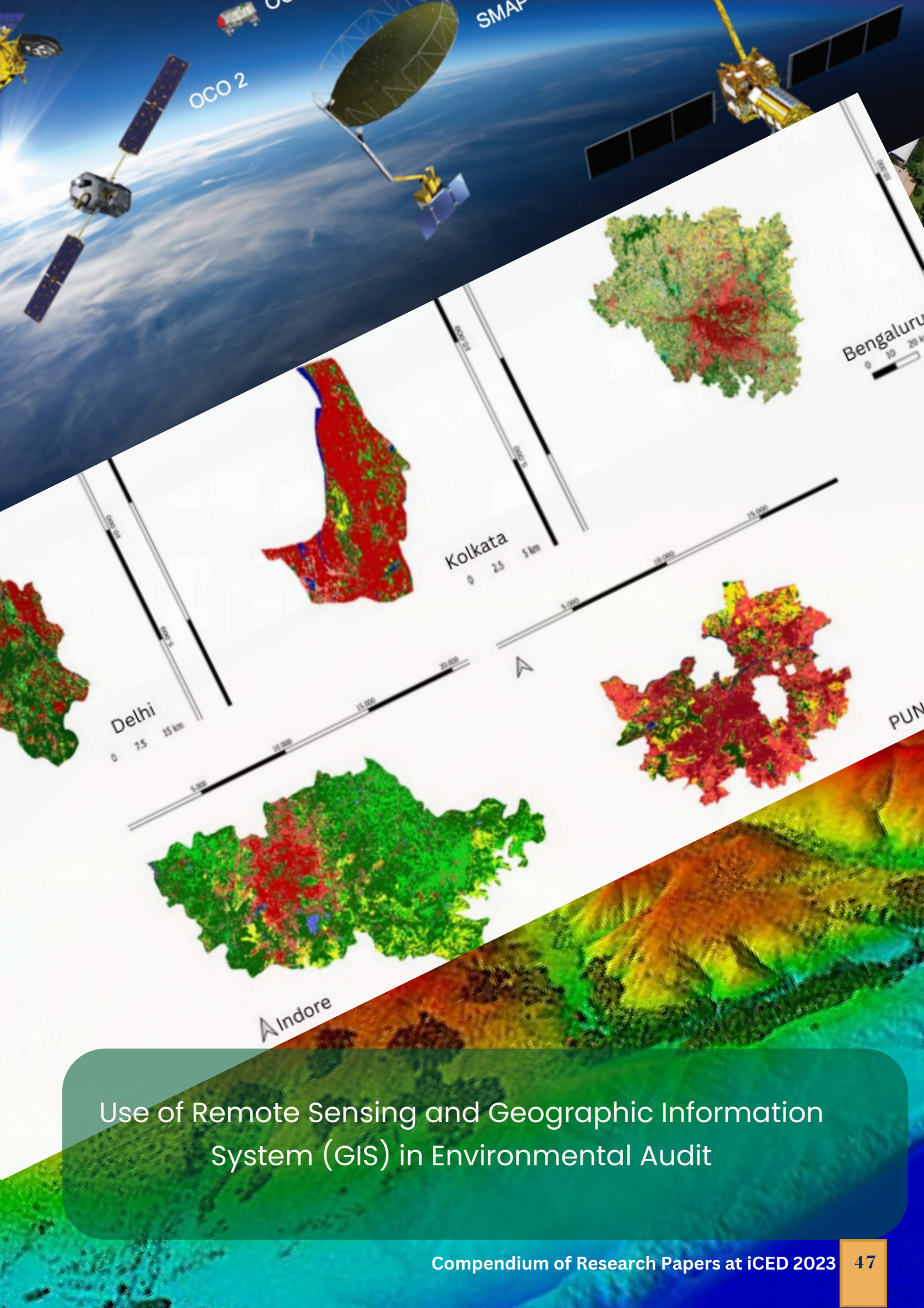
Key Study Highlights

The present study highlights that:

- Income accruing to tribal gatherers in the above business is far below from what would be fair and equitable. That would be possible if fair-trade practices are enforced and the long chain of middlemen is curtailed.
- The trade mechanism of the NTFPs at the "primary haat bazar level remains highly inequitable to the tribals" as a result of which, when the market prices appear impressive, the cash that comes to the tribals' hands remains low and gains are reaped by a long chain of middlemen. The ownership of the tribals is still largely notional and needs to be actualised.

Study highlights the need for

- Implementation of a sound monitoring and evaluation system which involves all the major stakeholders, thus leading to adaptive management.
- Detailed and thorough study of the forest resources in the study area (extraction rates, regeneration rates, etc.).
- Establishment of the evolution of Participatory Resource Monitoring Activities through the initiation of co-operatives and capacity-building exercises.
- The establishment of Tribe Run Enterprises for the processing and value-addition of all available NTFPs.
- Adopting other means under the Participatory Resource Monitoring System including participatory mapping, assessments of fruit production, fruit harvest and regeneration, pre and post- harvest meetings, and adaptive management.



Use of Remote Sensing and Geographic Information System (GIS) in Environmental Audit

A Comparative Study of Changes in Urban Landscapes covering Five Indian Cities (Delhi, Bengaluru, Kolkata, Pune and Indore)

Remote Sensing and Geographic Information System (GIS) have become an integral tool in auditing of natural resources and environment. This primary research was undertaken by an erstwhile intern, Shri Nishant Kumar Upadhyay, in November 2021 at iCED and was subsequently completed in August 2022.

Objectives

A comparative study of the changes that took place in the urban landscape of Delhi, Bengaluru, Kolkata, Indore, and Pune, for the period between 1980/1989/1991 and 2020/2021 using Land Use Land Cover (LULC) classification of satellite imageries.

Tools and Methodology

- Use of Normalised Difference Vegetation Index (NDVI) and QGIS software for analysing satellite images, for highlighting the health of vegetation or green areas in the selected cities.
- Landsat satellite imageries were used to analyse the urban LULC classification in the five cities. The area of the cities has been measured through the municipality boundaries of the given cities and measured in QGIS.
- QGIS was used to prepare the data, analyse the satellite imageries and for mapping the results. City boundary shapefiles were obtained for the year 1980 from DIVA Administrative boundary. Landsat Data was downloaded from USGS Earth Explorer (NASA), which provides data (180*185 KM with 30 m spatial resolution), having multiple bands in visible and infrared spectrum.
- The images were imported into QGIS and pre-processed using the Semi-Automatic Classification plugin. QGIS was used to create a virtual band classification based on reflectance in different bands of raster data. The final map was imported in the QGIS platform by including coordinate values, and other map attributes.
- NDVI was calculated as a ratio between the red (R) and near infrared (NIR) reflectance values.

Comparative Study

- The city of Bengaluru has the highest urbanisation rate. Bengaluru has also lost the highest proportion of areas under water bodies, vegetation, and other agricultural areas during the study period. During the 10 years period between 1990 and 2000, the rate of decrease in dense vegetation in Bengaluru was high, which slowed down during the period from 2000 to 2020.

- In terms of urbanisation, Delhi follows Bengaluru with high rate of urbanisation. The city is also losing its water areas, vegetation and agricultural sources which are converted into urban built-up areas. In Delhi, the green cover has increased, but the dense forest and healthy vegetation has decreased with the decline in NDVI value, from 0.54 in 2000 to 0.4 in 2020. This gives a significant indication of environmental degradation and loss of healthy vegetation due to urban expansion.

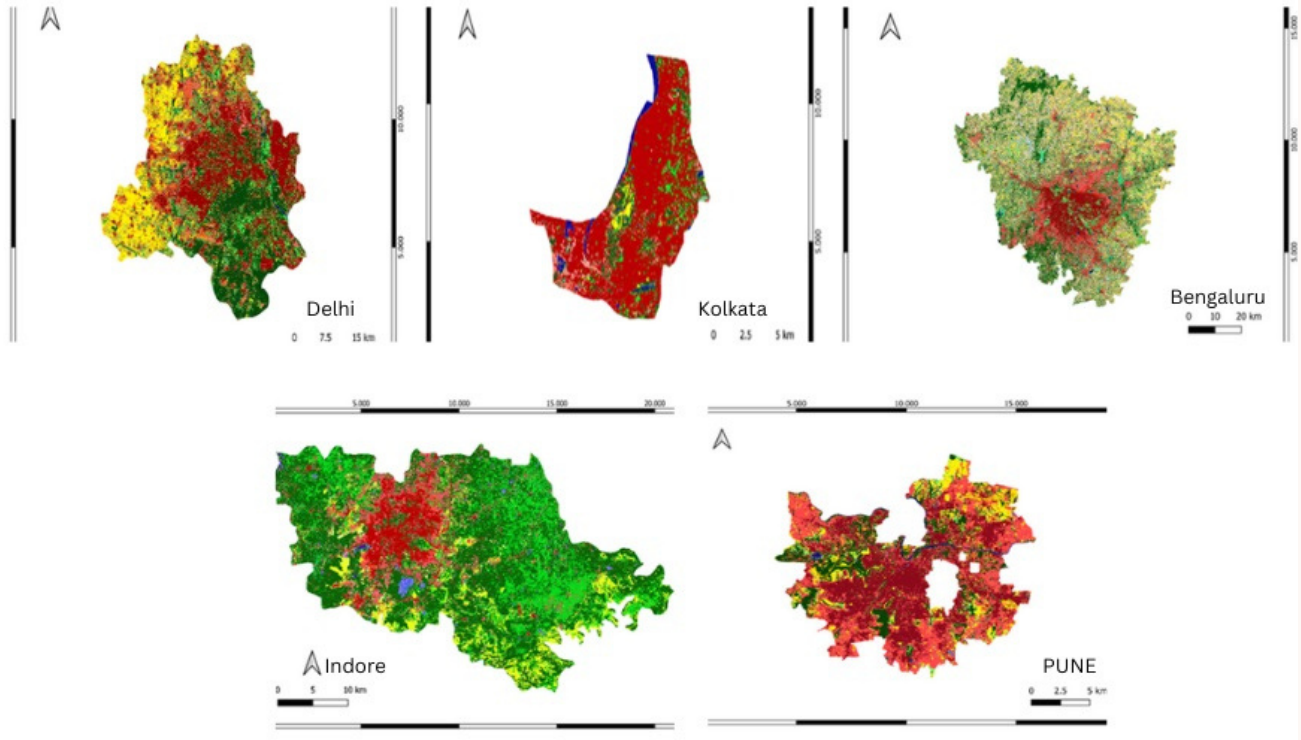
- Indore has the lowest proportion of conversion of land to urban built-up areas, but it has a larger municipal area and conversion of area under water and vegetation areas to urban areas is comparatively higher in Indore, than in Pune and Kolkata. As Indore has a larger proportion of vegetation to the total area, it is better performing in terms of sustainability.

- Pune has a higher proportion of area converted into urban area but the rate is stabilised due to scarcity of land and it is reflected in other parameters also. The rate of urbanisation has doubled in 20 years, between 2000 and 2020, involving a reduction in vegetation area. NDVI results of Pune shows that the vegetation cover in Pune is impacted largely because of increasing urban agglomeration, as more than 41 sq. km of vegetation was directly converted into urban built-up areas.

- Kolkata has the highest urban proportion and lowest urbanisation rate as it was already an urbanised city and has less municipal area (as covered in the study). In all other parameters also, Kolkata shows lower rates of conversion of land to urban built-up areas. Kolkata's minimum NDVI value has reduced from -0.6 in 1990 to -0.17 in 2020, which means that the water bodies have been affected during this period. For vegetation, the maximum NDVI value in 1990 was 0.74, which had reduced to 0.47 in 2000. It indicates that the area under dense vegetation zone in 1990 had reduced in the city during 1990 - 2000. However, a little improvement in NDVI with value increasing to 0.5 can be seen during the period from 2000 to 2020, indicating expansion in area under vegetation.

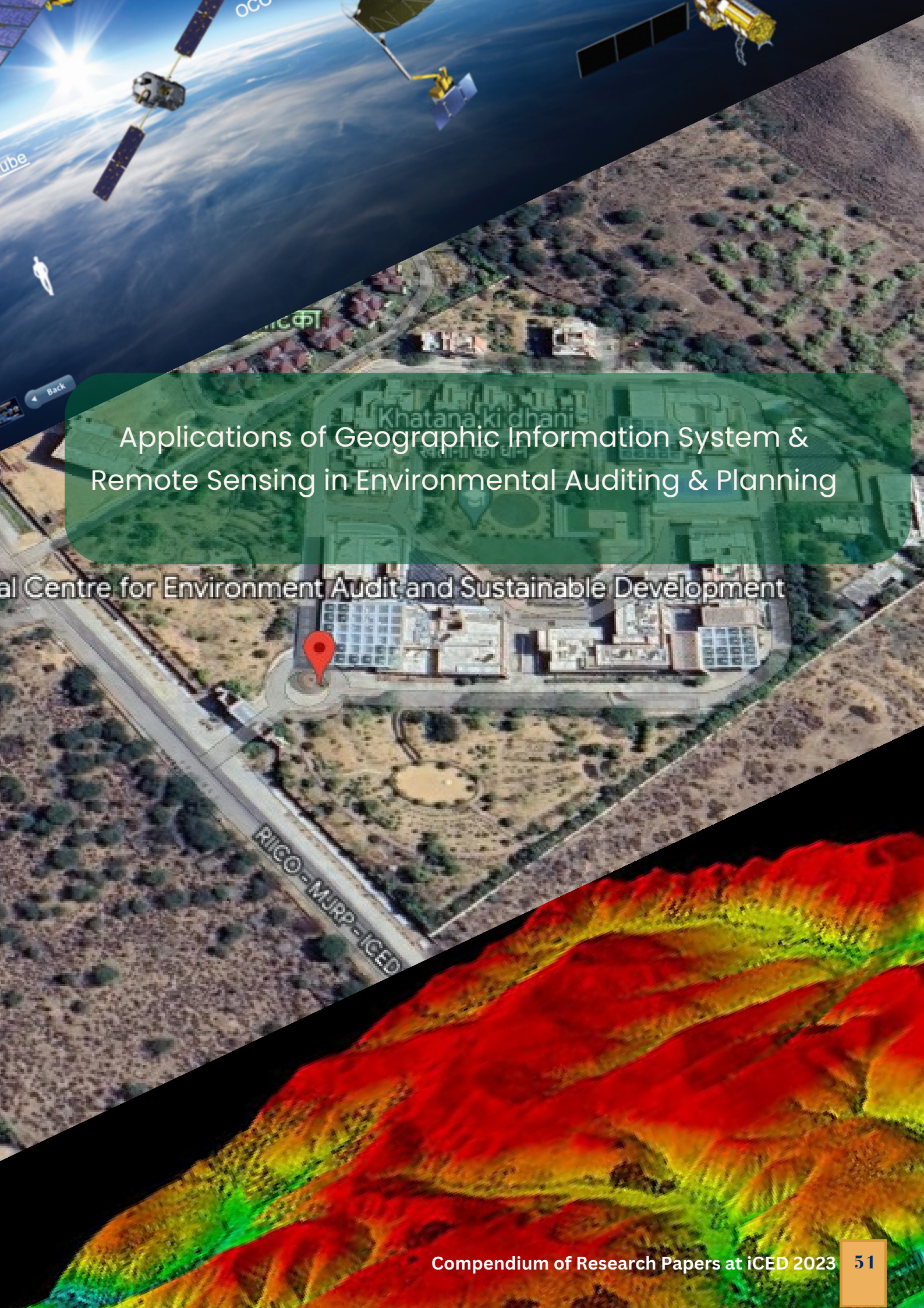
Key Highlights

- In terms of the increase in urban area per sq km per year, Bengaluru has the highest rate of urban expansion rate followed by Delhi, Indore, Pune and Kolkata. Pattern of urbanisation in Pune and Kolkata indicates area- wise large growth in built-ups but at a comparatively slower rate vis-à-vis other three cities.
- As regards the proportion of urban area as a percentage of total area, Kolkata has the highest proportion of urbanised area followed by Pune, Delhi and Bengaluru.
- The areas under vegetation are fast converting into urban areas. A 358 sq km vegetative area has been used directly for urban expansion in Bengaluru. The rate of conversion is almost double of Delhi and significantly higher than the other selected cities.
- Other agricultural lands, barren lands were also converted into urban built-up areas. It is noticed that a total of 262 sq km of such area, was converted into urban built-up area in Bengaluru, followed by Delhi.



Study Highlights the need to:

- Encourage Green-field urban development with appropriate land-use and zonation planning. Use of Geographical Information System mapping with the help of modern technology would be essential for such plans to become successful.
- Undertake brown-field urbanisation projects too for the mega and old cities, which already existed for several decades or even centuries, and would require planned redevelopment and retrofitting.
- Conduct regular Environmental Impact Assessment (EIA) study to determine adverse impacts on the urban environment due to change in unscientific land-conversions.


Applications of Geographic Information System &
Remote Sensing in Environmental Auditing & Planning
al Centre for Environment Audit and Sustainable Development
RICO - MJRP - ICED

Applications of Geographic Information System & Remote Sensing in Environmental Auditing & Planning

This study has shown how the tools and techniques of Remote Sensing and Geographic Information System (GIS) can be used for mapping and monitoring of water quality; monitoring of air pollution; mapping of degraded lands; forest management and forest monitoring; climate change analysis; and land-use and land-cover change. This primary research was undertaken by an erstwhile intern, Shri Sangam Yadav, at iCED in July 2018 and was subsequently completed in August 2022.

Objectives

To study temporal change in land-use and land-cover in iCED between 2013 and 2018.

Tools and Methodology

- Temporal datasets from the years 2013, 2014, 2016 and 2018 of ResourceSat-1, Landsat-8 and Sentinel-2 satellites to identify different changes in Land cover over iCED campus.
- Normalised Difference Vegetation Index (NDVI), which reflects ratio of reflectance between Near Infra-Red (NIR) and red bands, is used as an effective indicator to monitor vegetation health and density.
- ArcGIS, MS-Excel and platforms like Bhuvan and EOS Land Viewer.

Highlights of Study

- The study highlighted that during 2009, the land-parcel, where the present day iCED campus is located, was barren land and no vegetation was found, but over the study-period, vegetation covers had improved to a significant extent (Imageries below).









- The study found that vegetation density in the iCED campus had greatly improved in 2018, from a hitherto barren land in 2013 (Classified Imageries below; emergence of red color signifies increase in vegetation cover in a False Colour Composite).

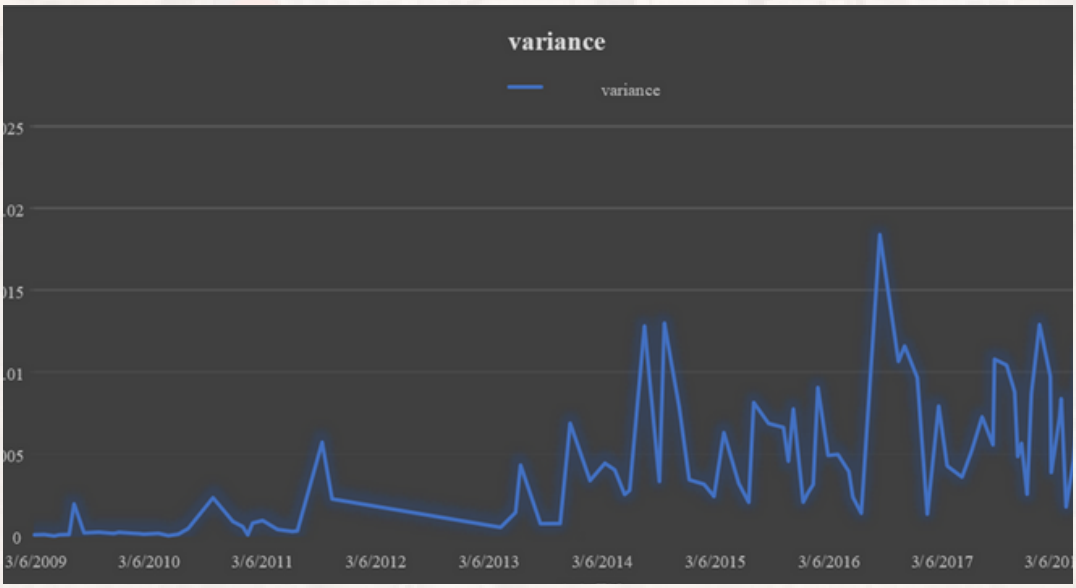








- Statistical analysis showed significant improvement in vegetation growth after 2015 and a healthy existence of vegetation in 2018 (Figure below).

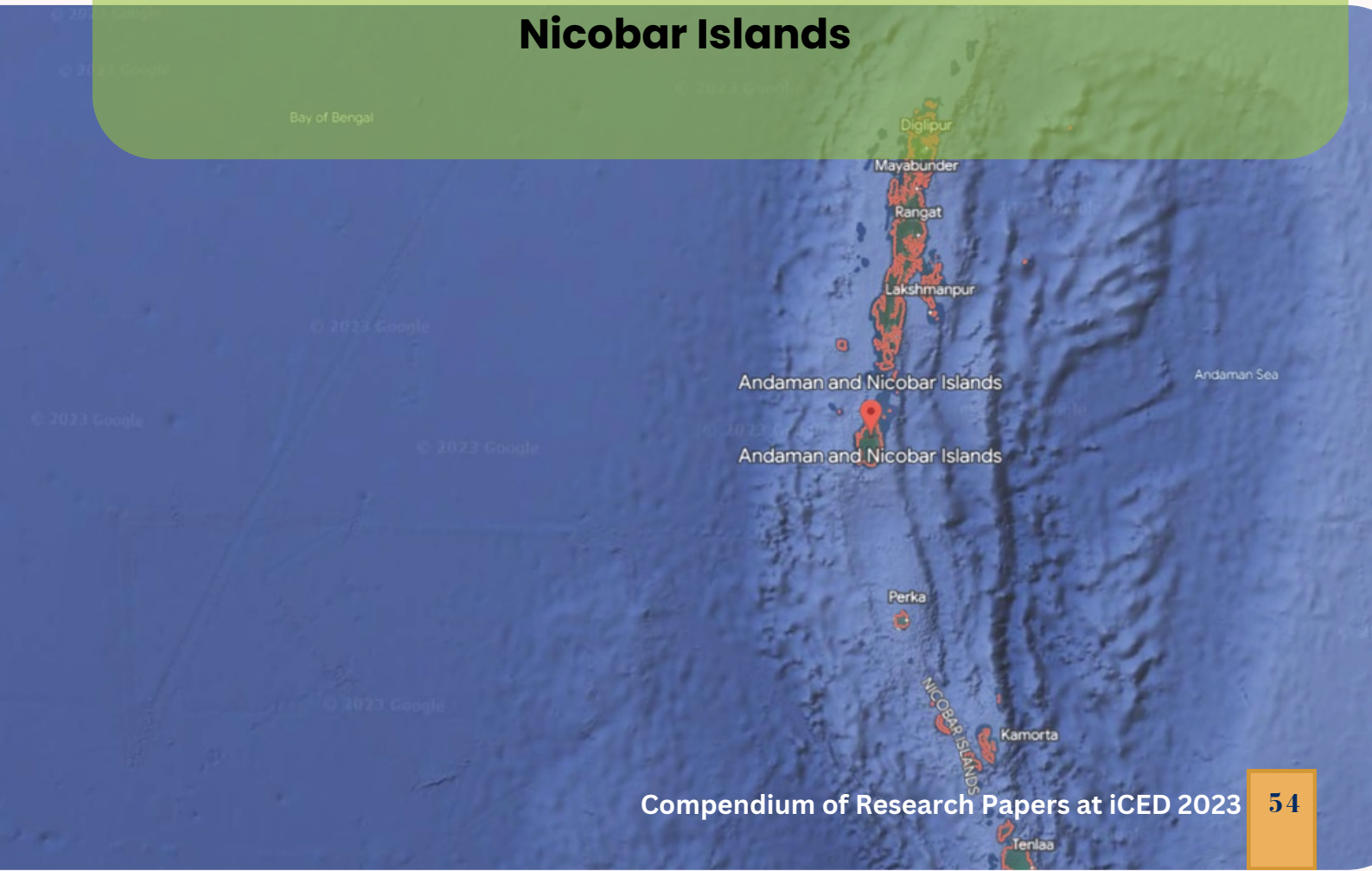


Conclusion

The NDVI variance shows that between the years 2014 and 2018, the vegetation cover in iCED improved significantly. However, there remain seasonal variations in vegetation health between the dry and moist seasons.



Tsunami Disaster Preparedness in Andaman and Nicobar Islands

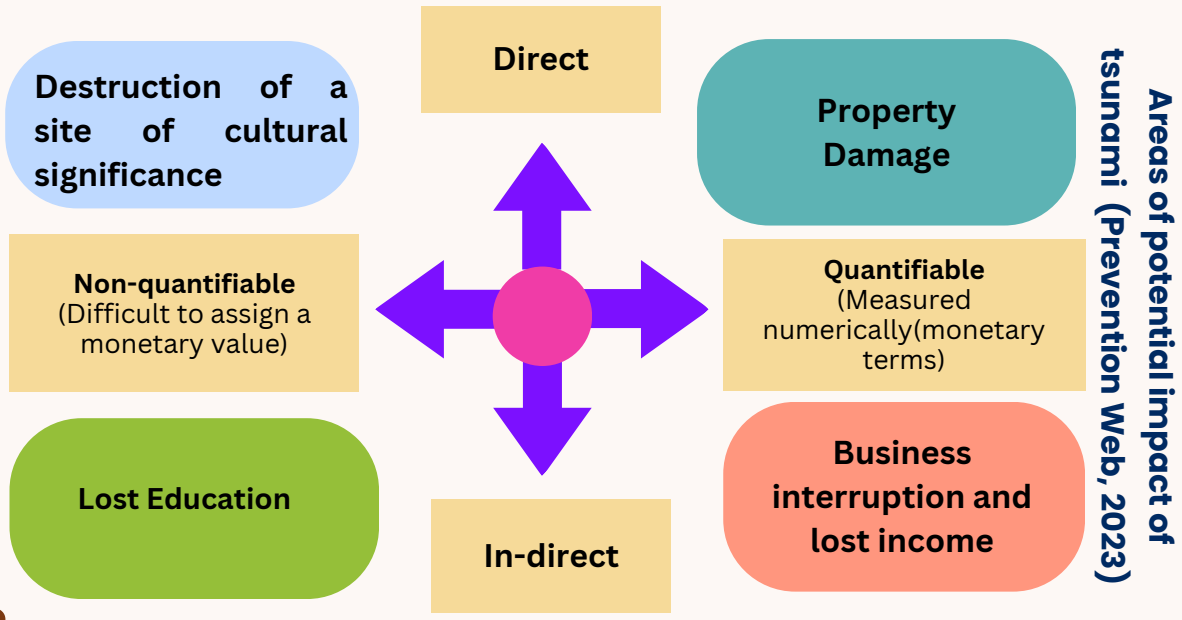


Tsunami Disaster Preparedness in Andaman and Nicobar Islands

The 2004 tsunami had hit the Andaman and Nicobar Islands, causing widespread devastation. The official death toll was 1,310, with about 5,600 people missing and monetary loss exceeding INR 10,000 million. Prior to this disaster, India's vulnerability to tsunami was believed to be low, and there was little study on tsunami vulnerability. Following the disaster, efforts were made to establish an advance warning and international networking system (Usha, 2009). This primary research was undertaken by an erstwhile intern Ms. Ankita Singh, at iCED in September 2020 and was subsequently completed in August 2022.

Focus of the Study

The study highlights the impact of 2004 tsunami, on the Andaman and Nicobar Islands, focusing on mapping vulnerabilities, using GIS techniques and other vulnerability frameworks for disaster mitigation and adaptation. The study identified various aspects of risk, hazard, exposure and vulnerability; and identified potential impacts of tsunami in four-dimensions as direct, indirect, quantifiable and non-quantifiable impacts.



Approach and Methodology

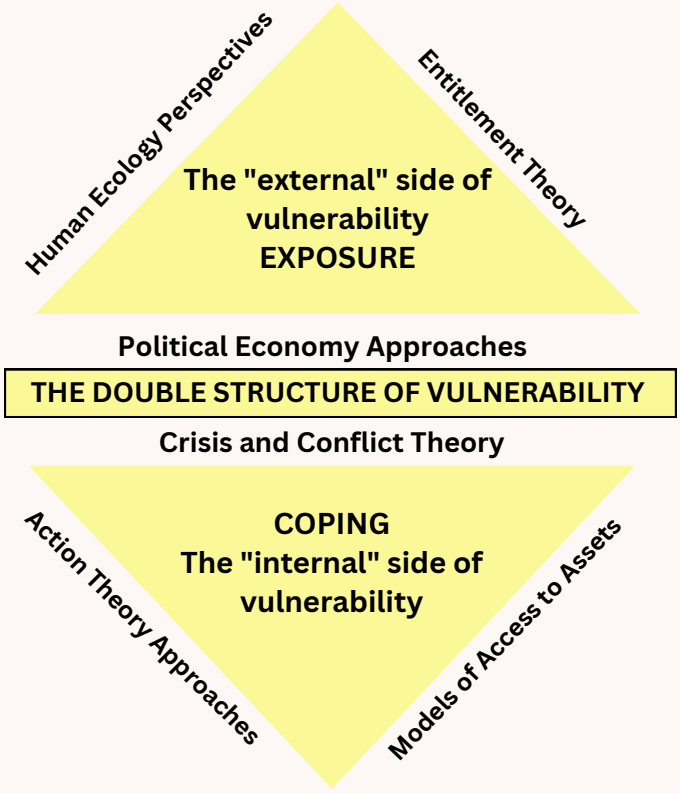
STHA (Scenario-based Tsunami Hazard Analysis)

- Involves creating hypothetical scenarios based on different earthquake sources and magnitudes
- Focuses on specific scenarios to assess potential risks and impacts
- Useful for emergency planning and risk mitigation strategies

PTHA (Probabilistic Tsunami Hazard Analysis)

- Evaluates the likelihood of a tsunami occurring
- Based on the historical and geological record
- Estimates hazard levels based on the probability of different scenarios
- Useful for long-term coastal development and land-use planning

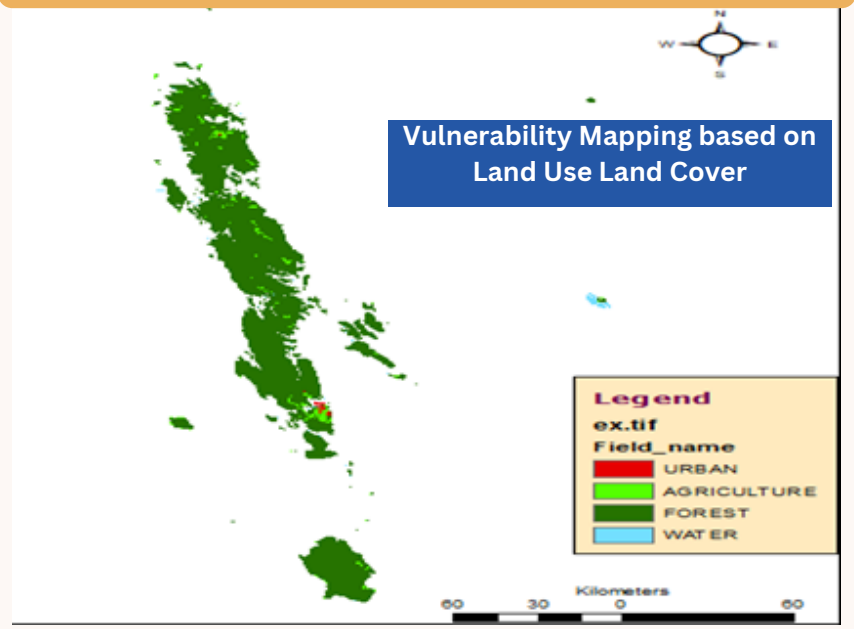
The study also highlighted two vulnerability frameworks, i.e., Bohle's framework which perceives vulnerability from the lens of internal and external side (Figure) (Bohle, Hans-Georg, 2001) and framework for vulnerability proposed by Pelling (2003) which is based on exposure, resistance and resilience (Pelling, Mark, 2003).



Double structure of vulnerability (Bohle, Hans-Georg, 2001)

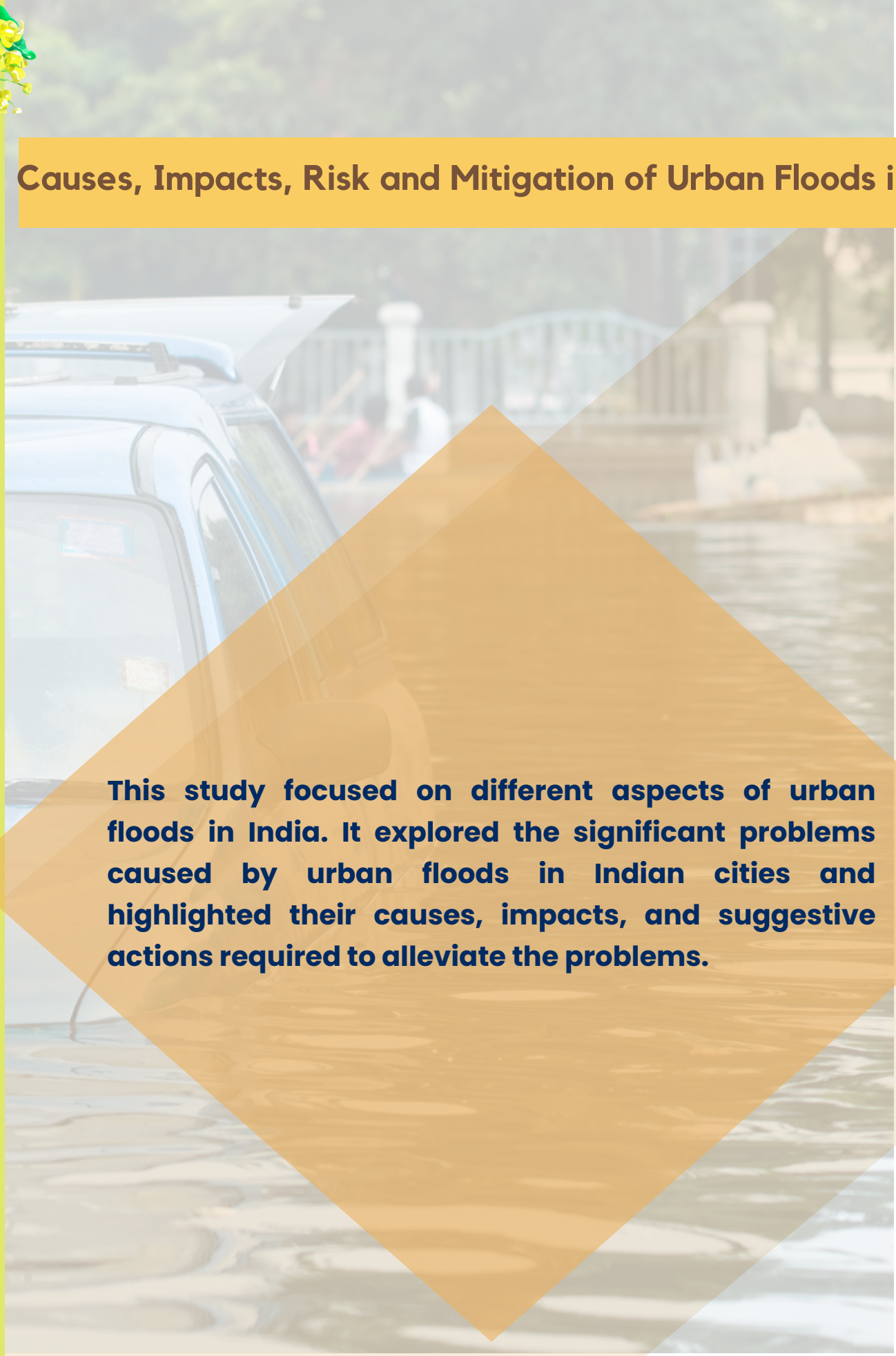
A simplified approach highlighting crucial parameters of interest, were identified in the study for the Andaman and Nicobar Islands, comprising land-use/land-cover, exposure to the hazard, distance from the sea, elevation, capacity to evacuate and impact on livelihood. The study also suggests measures for reduction of exposure and vulnerability to tsunami through plantation of mangroves, enforcing techno-legal measures for construction of buildings and improving Early Tsunami Warning System.

Land-Use Mapping of Andaman and Nicobar Islands



The paper, therefore, utilised a multi-criteria analysis of tsunami vulnerability at a regional scale using geospatial variables, within a GIS platform, and vulnerability mapping was done using land use and elevation data for Andaman and Nicobar Islands. However, such analysis can be limited by the availability of data necessary for estimating the risk of natural hazards.

Causes, Impacts, Risk and Mitigation of Urban Floods in India



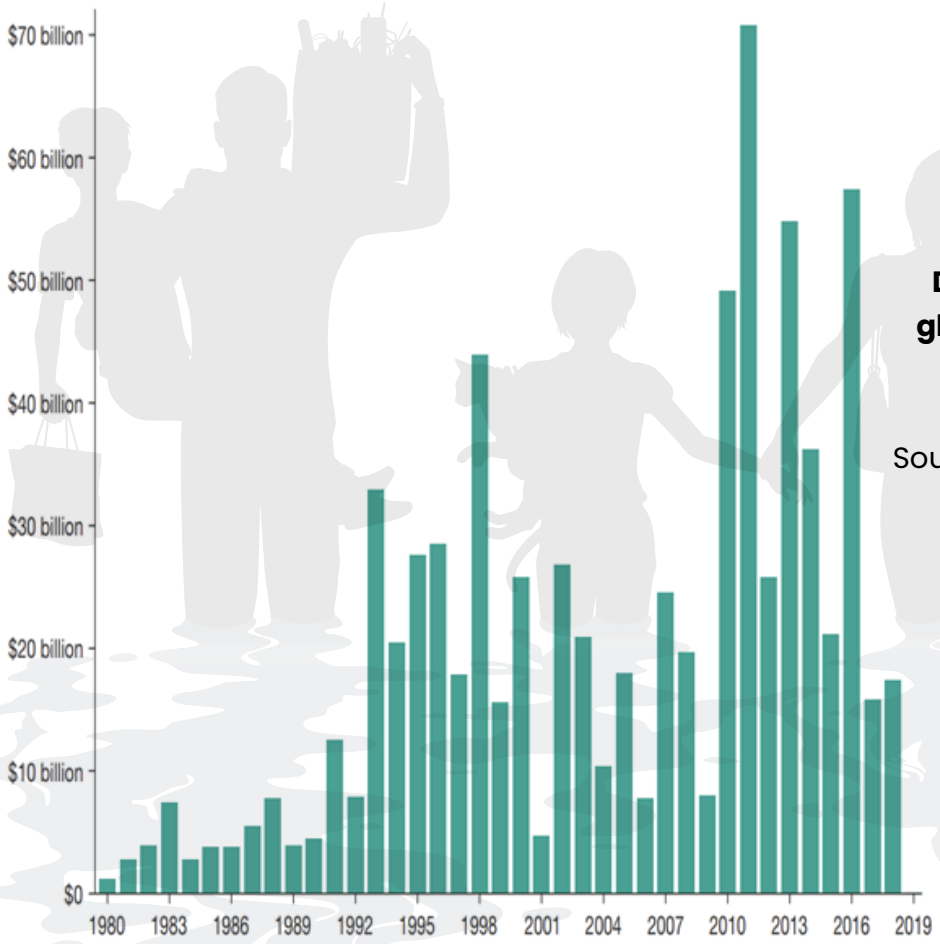
This study focused on different aspects of urban floods in India. It explored the significant problems caused by urban floods in Indian cities and highlighted their causes, impacts, and suggestive actions required to alleviate the problems.

Causes, Impacts, Risk and Mitigation of Urban Flood Management in India

Flood is the most frequent type of natural disaster and occurs when an overflow of water submerges land that is usually dry. Floods are often caused by heavy rainfall, rapid snowmelt, or a storm surge from a tropical cyclone or tsunami in coastal areas (World Health Organization, n.d.). The urban floods have caused severe loss of life and substantial economic damage in numerous countries including India. In this context Ms. Divya Singh, a former Research Associate at iCED, conducted a study in 2021-22, which focused on different aspects of urban floods in India.

Objectives

- To explore the significant problems caused by urban floods in Indian cities and highlight their causes, impacts, and suggestive actions required in this area.

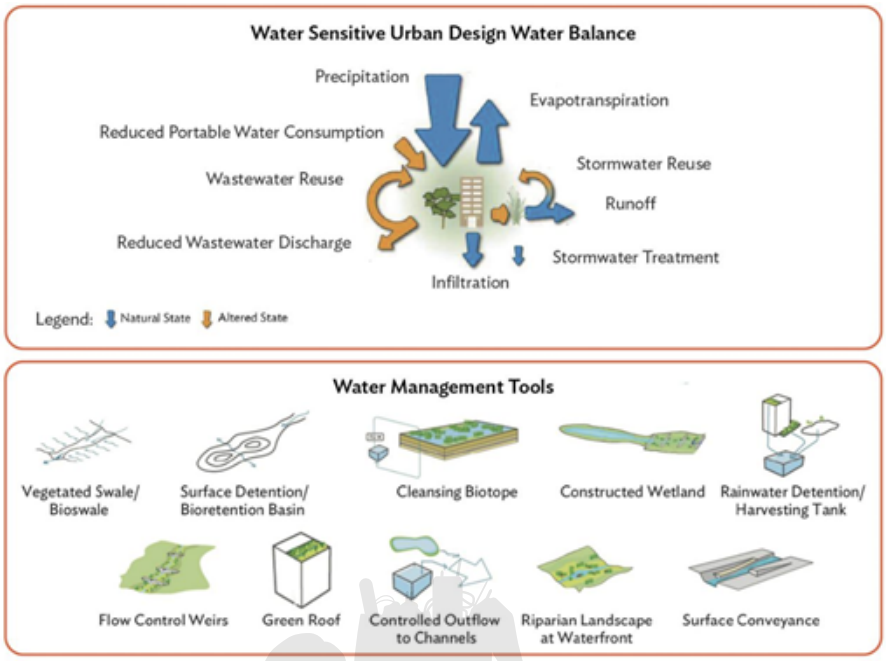


Damage as a result of global flood disasters in USD(1980-2019)

Source : (Marcus Wishart et. al. 2021)

The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) was the first major agreement of the post-2015 development agenda and provided the Member States with concrete actions to protect development gains from the risk of disaster (United Nations Office for Disaster Risk Reduction, n.d.).

Good Practices

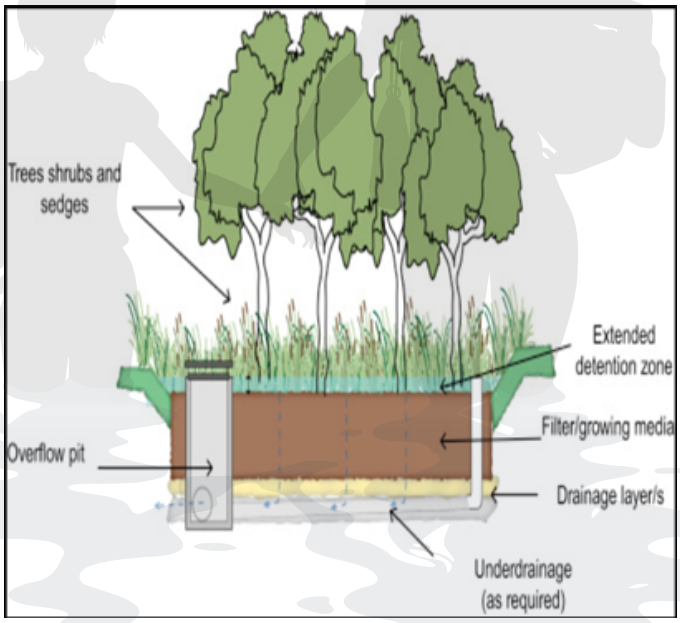


Water-sensitive Urban Design and Water Management Tools

Source: (Development Asia, 2020)

- The Water Sensitive Urban Design (WSUD) approach integrates the management of the urban water cycle with the built environment in Australia (Nash, 2020).
- It aims to enhance the natural water cycle and reduce the impact of urbanisation on water resources by promoting the use of green infrastructure and low-impact development techniques.

- Rain Garden System is used to capture and treat rainwater by allowing it to infiltrate into the ground, where it can recharge groundwater resources or be used for irrigation (Centre for Science and Environment, 2017).



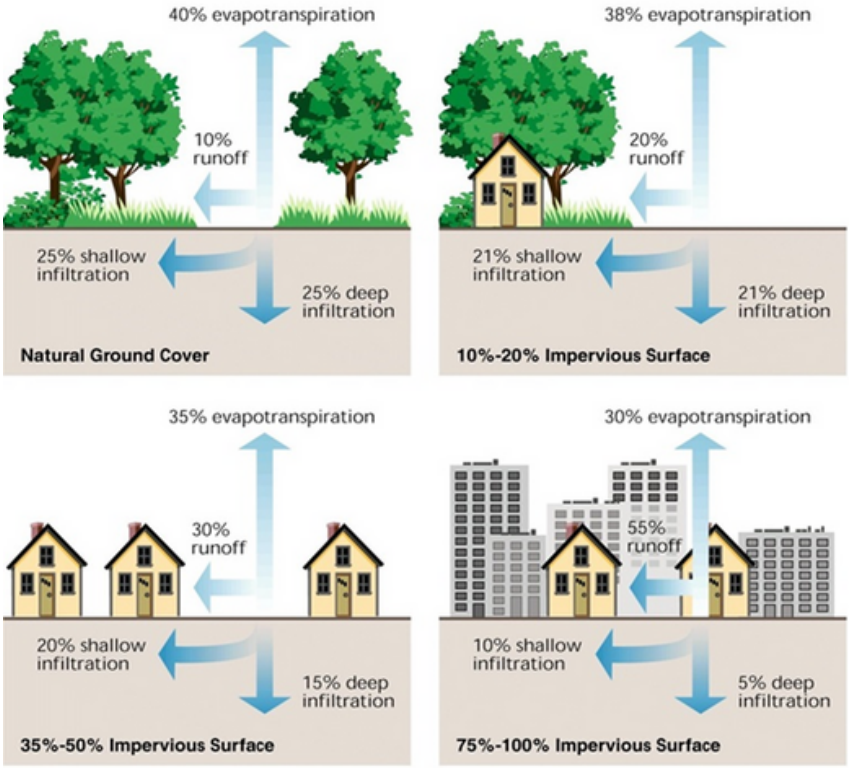
Schematic cross-sectional diagram of a typical rain-garden system

Source: (Alan Hoban, 2019)

- IFLOWS-Mumbai early warning system developed by the Ministry of Earth Sciences (MoES) in coordination with the Brihanmumbai Municipal Corporation (BMC) (Ministry of Earth Science, 2020), can provide all information regarding possible flood-prone areas, likely height the floodwater could attain, location-wise problem areas across all wards and calculate the vulnerability and risk of elements exposed to flood.
- The Chennai Flood Warning System (CFLOWS), is India's first integrated coastal flood warning system.

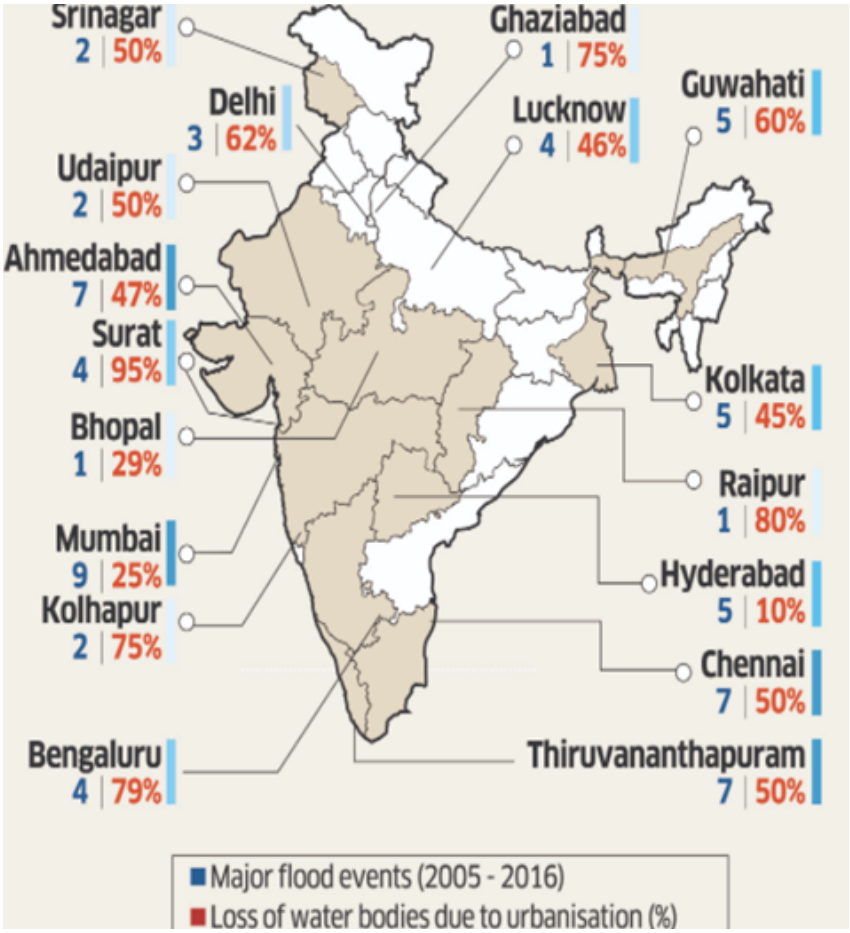
Key Study Highlights

- The study identified increased intensity of rainfall due to climate change and urbanisation as direct factors to urban flood, while improper drainage system and solid waste management as the indirect contributors to urban flood.



- Increasing urbanisation and built-up areas leave less open space for natural infiltration and percolation to take place. This increases the proportion of water being run-off, causing flash floods and waterlogging in the cities.

How increasing built-up area causes urban flooding
Source: (RANA, 2021)



- Encroachment of water bodies and wetlands by concrete structures leaves little space for water columns to go downward or sideward.

Flood incidences due to encroachments and loss of water bodies

Source: (Niranjan Kaggere, 2020)

- The study highlighted the impacts of urban floods on different sectors of the economy and on the life of people and property.
- The study also focused on the actions taken at the national level including the National Disaster Management Authority (NDMA) guidelines on urban flood management, while highlighting international good practices which may help policy-makers identify further strategies and approaches that can be implemented according to local requirements.

Recommendations

- The complexity of the flood risk evolution process requires a clear understanding of the typology of various flood risks and the factors that mitigate or abate them.
- A multiple mitigation approach should consider measures such as preventing or restricting new or inappropriate development or activities in the flood plain; removal of certain structures from the floodway; flood proofing of structures in the flood plain; introduction of structural measures such as levees, dams, and constructed channels; controlling land use practices within the basin; and applying flood forecasting and warning systems linked with response mechanisms.
- Mitigation and rehabilitation measures should be the main focal area in solving the problem of recurrent floods.

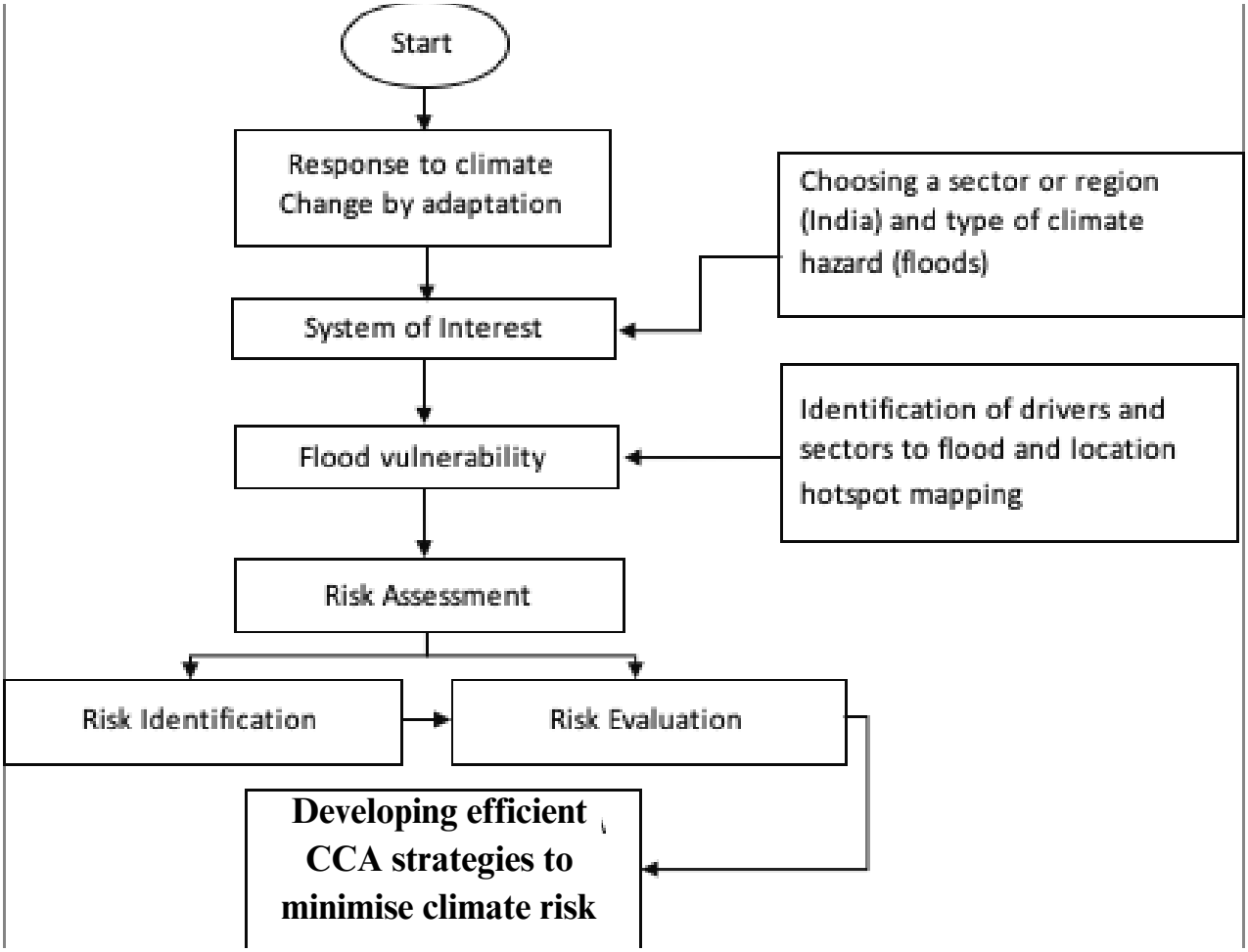
Climate Change Adaptation in India in the context of Urban Flooding

Climate risk poses a threat to the sustainable development of communities and countries. To develop effective adaptation strategies, it is crucial to have a climate risk assessment and management framework that can help in developing effective adaptation strategies to prevent and minimise losses and damages. Recognising the importance of Climate Change a study was done by an erstwhile Research Associate, Dr. Harsha V., at iCED in 2022.

Objectives

- To highlight the linkage between non-climatic factors and vulnerability to urban flood
- To create a macro framework for adapting to urban flood

This study developed a robust macro framework to create evidence-based Climate Change Adaptation (CCA) strategies for urban flooding as shown in figure below.



India is one of the world's most vulnerable countries to climate change (IPCC, 2014). With 1354 deaths from floods in the first half of 2022, India is first among the top ten countries for natural disaster deaths (CRED, USAID, 2022).

Key Study Highlights

- A blend of non-climatic indicators, such as the economy, social development, governance, and environmental sustainability, plays a significant role in shaping India's susceptibility to climate variability and change.
- The susceptibility of a society, such as India's, to climate risks can be exacerbated by crucial socio-economic factors, namely poverty and inequality.

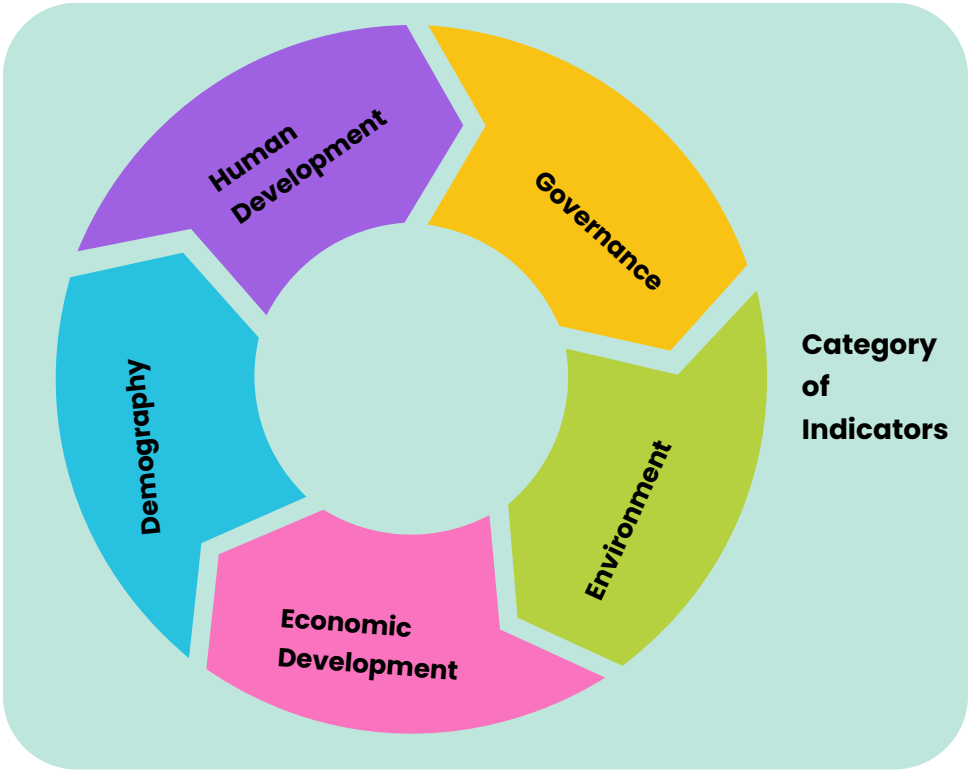
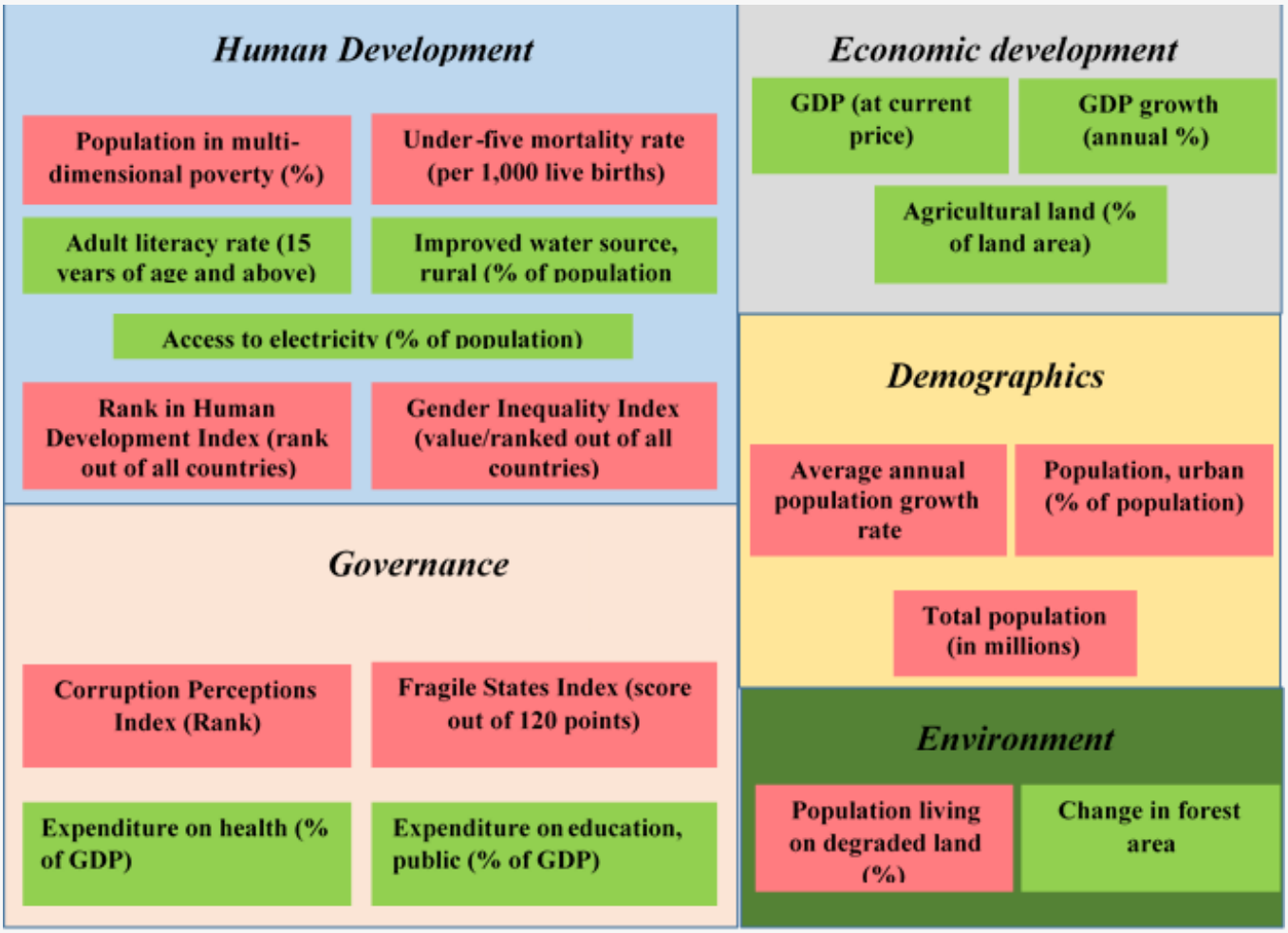
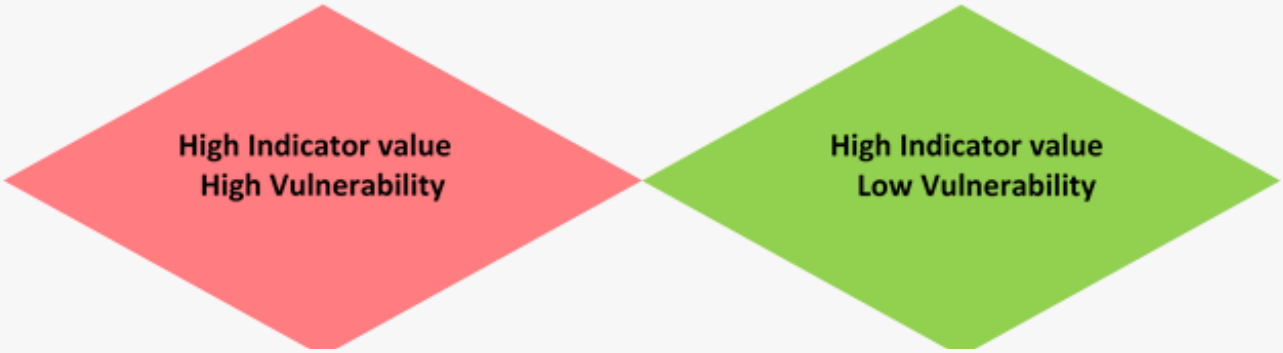


Table below provides Indicators to assess urban flood vulnerability on the basis of social, economic and Hydrogeological/ Environmental Dimensions (Vajjarapu, H., & Verma, A, 2021; Salazar, Carlos & Ruiz Gibert, Jose Mizael & Lomeli, Marcelo & Mungaray-Moctezuma, Alejandro, 2020; Balica, S. F., Wright, N. G., & Van der Meulen, F, 2012; Moghadas, M., Asadzadeh, A., Vafeidis, A., Fekete, A., & Kötter, T, 2019)

	Impact on Vulnerability	
Indicators	**If the rank/indicator value is**	**Vulnerability will be**
Population density, Population under poverty, Under and elderly population, Population with special needs, Unemployment rate, Commercial infrastructure in flood hot spots, Urbanisation.	High	High
Access to medical facilities, Access to transportation and other communication means, Homeownership, Female labour force, Urban green spaces, Water bodies, Storm water drains, Drainage length and connectivity.	High	Low

- Integrating the five dimensions of non-climatic factors which impact flood vulnerability of India at greater degree, the study has done a relationship study between value of following indicators and extent of vulnerability.

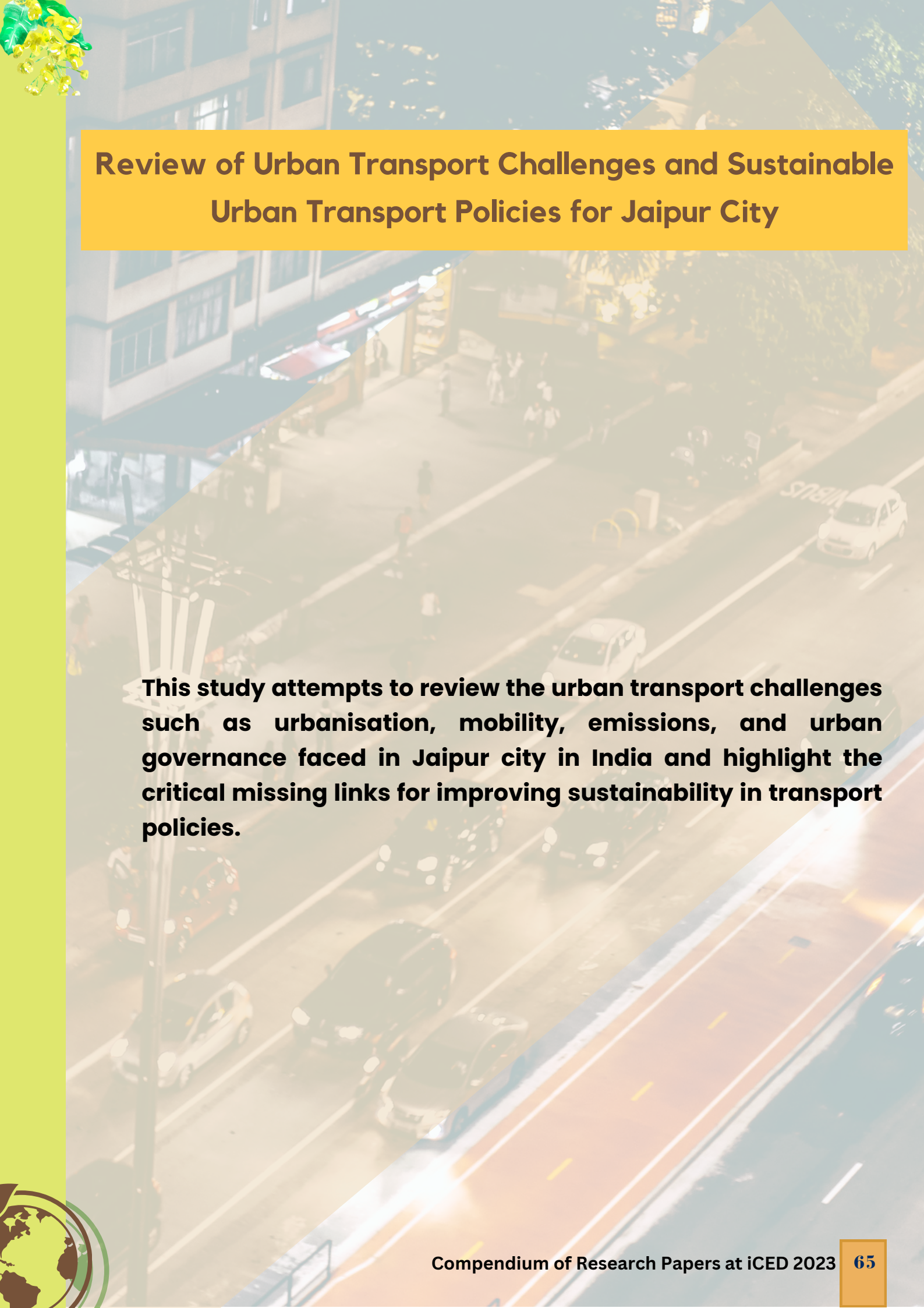




The study also highlighted efforts taken by the Government of India towards climate change adaptation under the National Action Plan on Climate Change (NAPCC) (Ministry of Environment, Forest and Climate Change, 2021). National Mission on Sustainable Habitat (NMSH), National Water Mission (NWM), National Mission for Sustaining Himalayan Ecosystem (NMSHE) focuses on the flood aspect, while NMSH specifically focuses on urban flooding.

The study recommended the need for an integrated and unifying policy framework incorporating mitigation and adaptation initiatives.

Review of Urban Transport Challenges and Sustainable Urban Transport Policies for Jaipur City



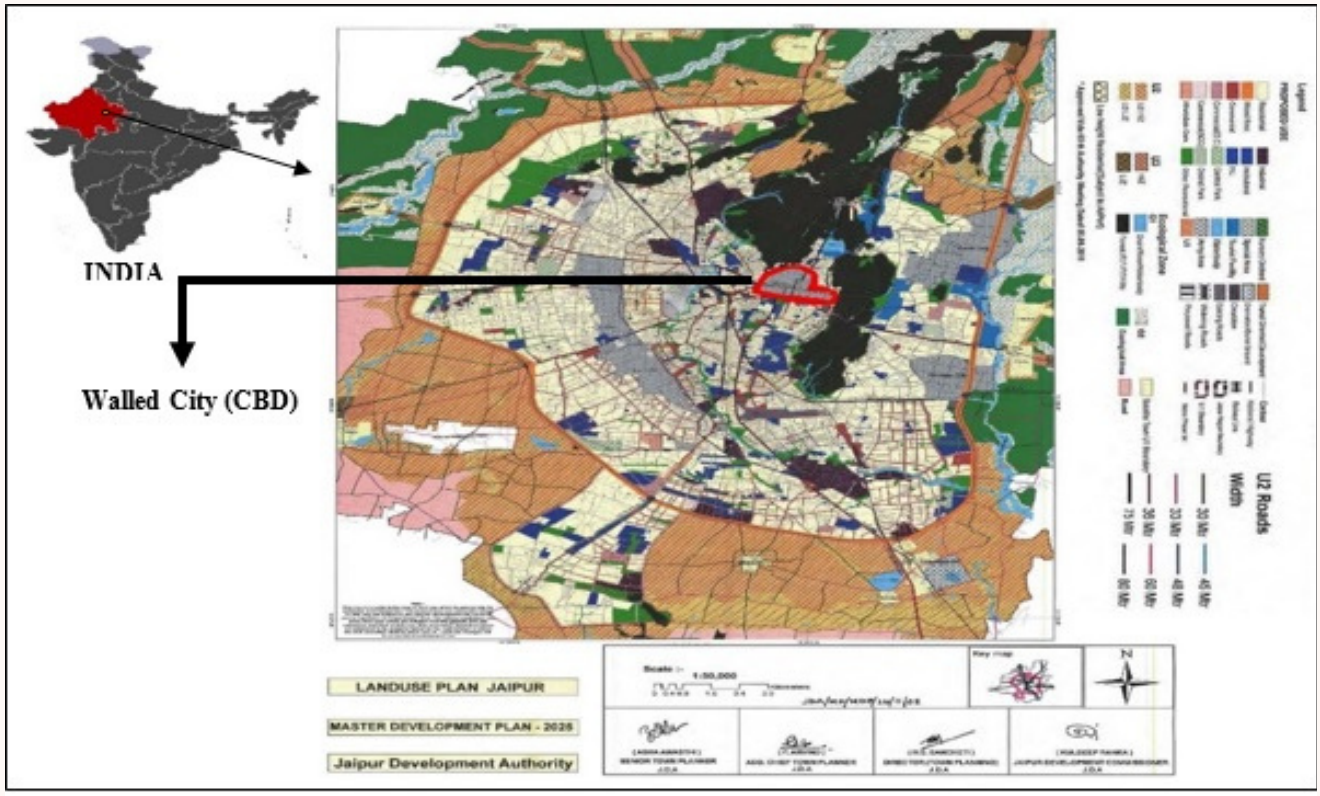
This study attempts to review the urban transport challenges such as urbanisation, mobility, emissions, and urban governance faced in Jaipur city in India and highlight the critical missing links for improving sustainability in transport policies.

Review of Urban Transport Challenges and Sustainable Urban Transport Policies for Jaipur City

This study was conducted by an erstwhile research associate, Shri Harsha V. and former Director (Training & Research), Shri Pushkar Kumar, at iCED in 2022 and attempted to review the urban transport challenges such as urbanisation, mobility, emissions and urban governance faced in Jaipur city in India.

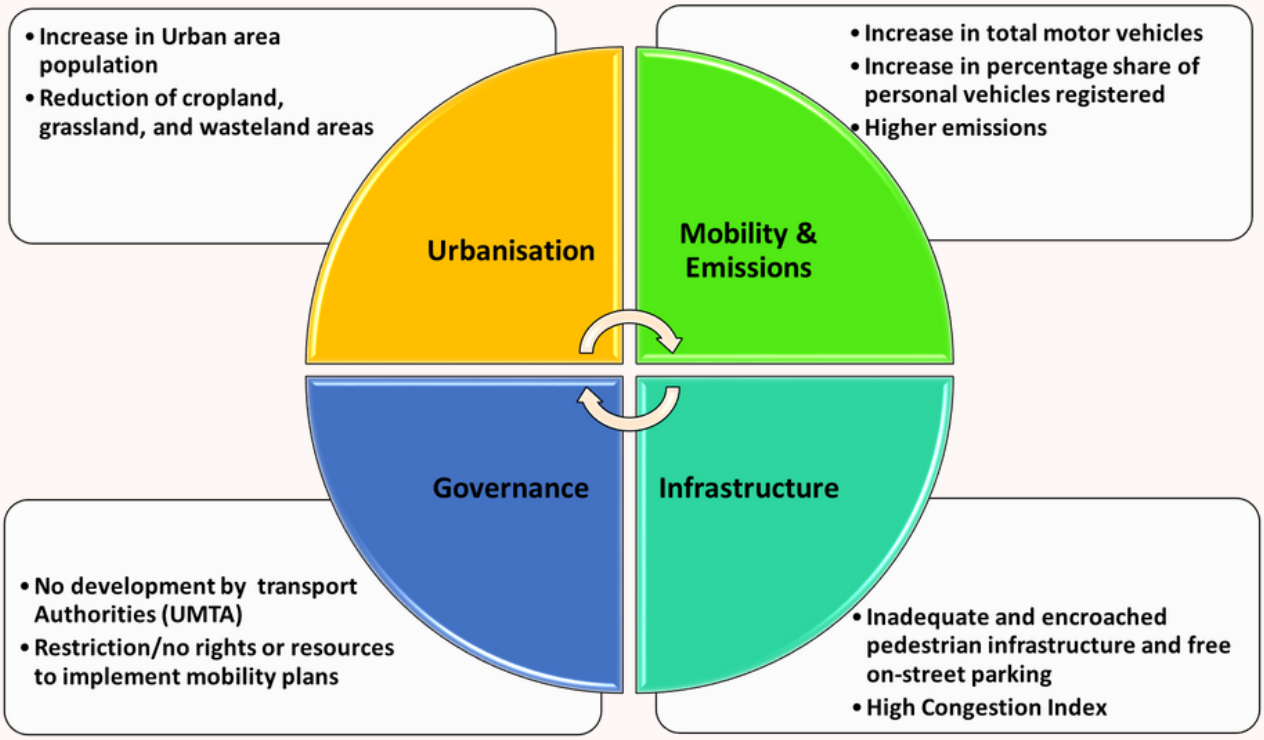
Focus of the Study

The national and state-level transport policies focused on reducing the transportation problems in the city have been highlighted, and their impact on the Jaipur transportation system discussed. Critical missing links for improving sustainability in transport policies have also been identified.



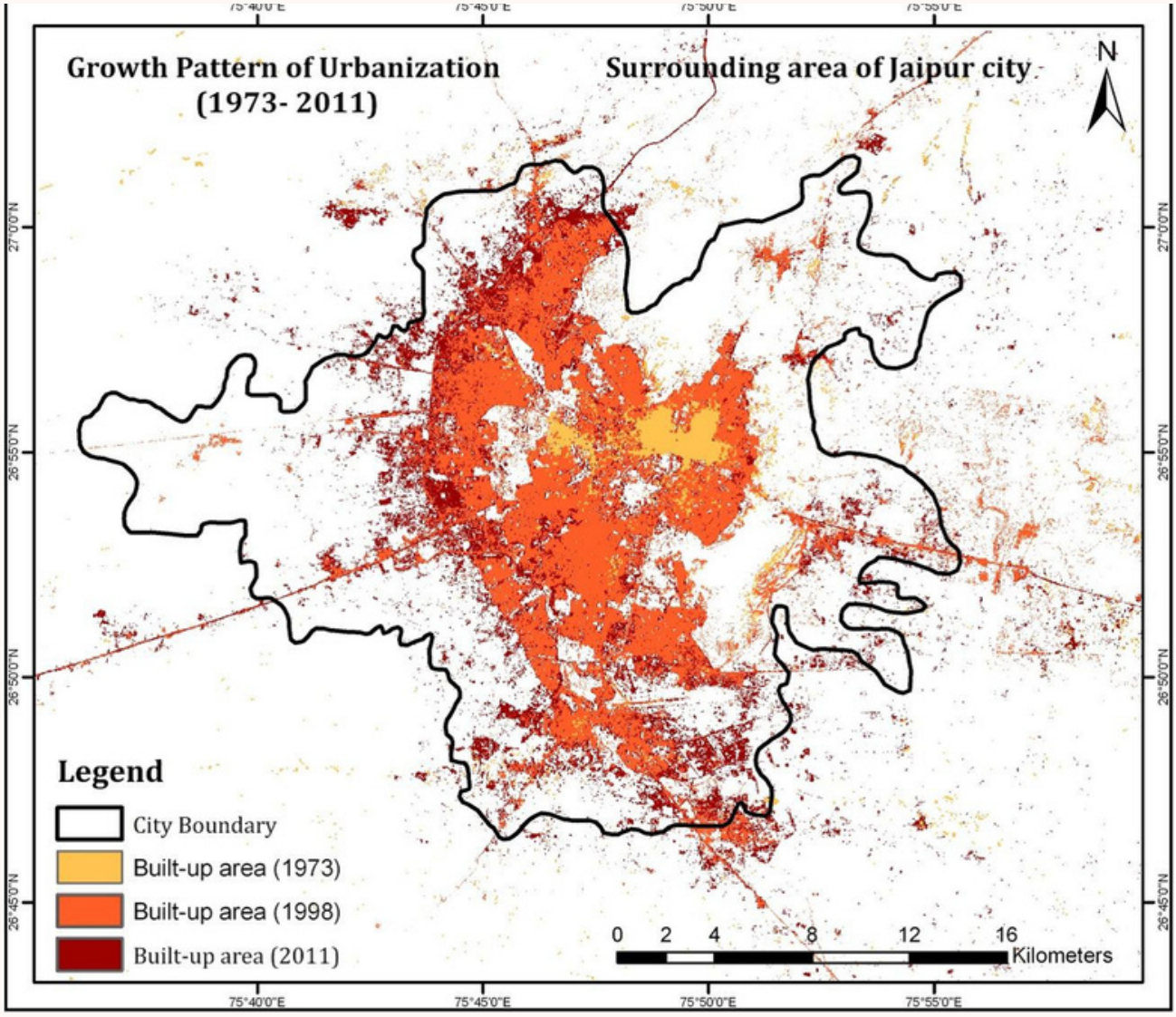
Land-use Map of Jaipur Urban Area
Source: JDA (2011)

Urban Transportation Challenges in Jaipur



Urbanisation

The Jaipur urban area population has risen from 0.31 million in 1951 to 4.01 million in 2021 (World Population Review, 2022), and in the last decade alone, a 30 per cent rise in the population has been observed. Consequently, to accommodate the increasing population, Jaipur city is sprawling outwards. The urban sprawl of Jaipur city has increased significantly in recent years all the while reducing the cropland, grassland, and wasteland areas



Jaipur city urban sprawl from 1973 to 2011

Source: Singh, et. al. 2014

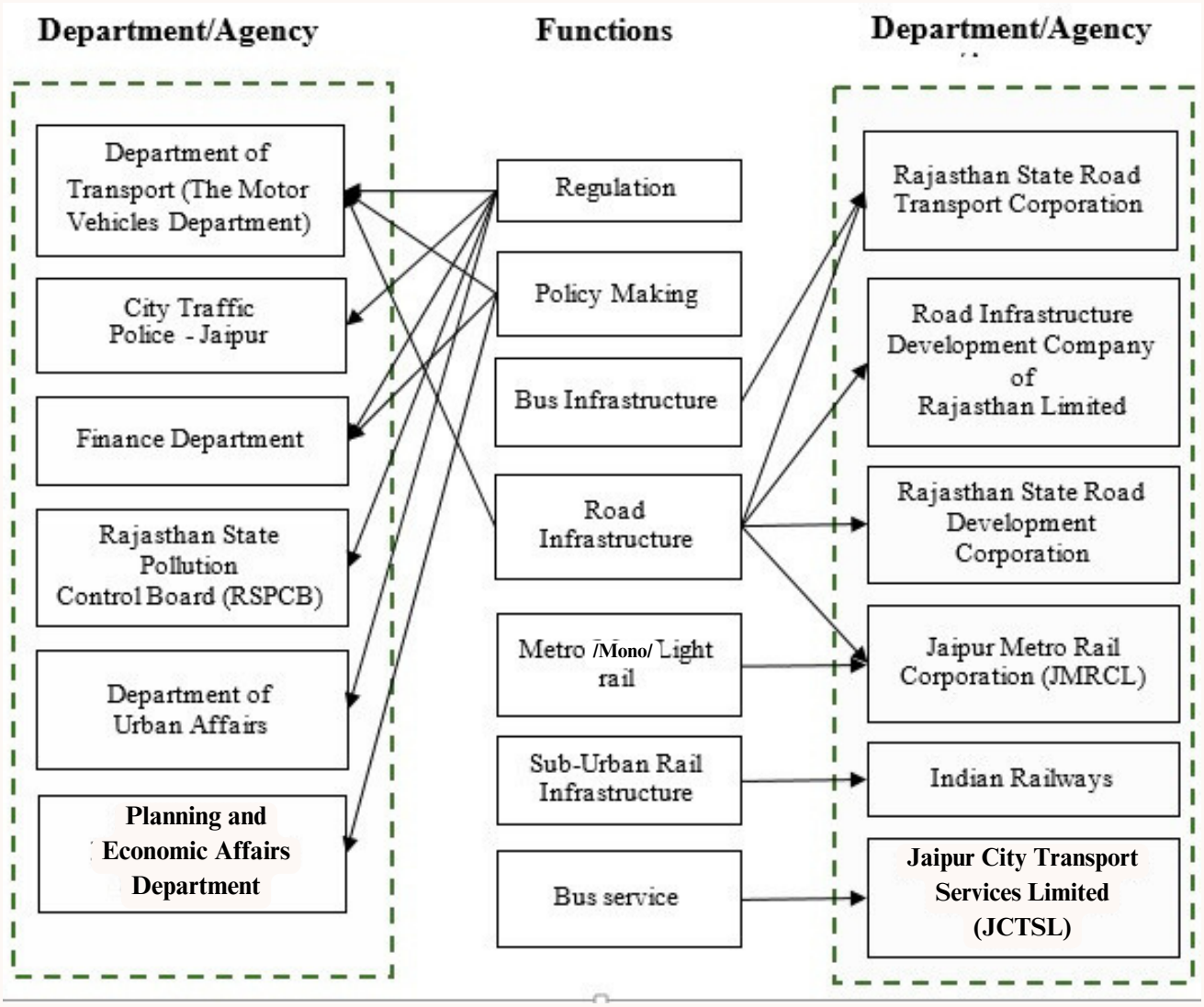
Mobility and Emissions

The per capita income levels in Jaipur are relatively higher than in many cities in India, making private vehicles a common household item (UNESCAP, 2019). The growing population and income levels have resulted in vehicular growth. Although Jaipur is a Tier-2 city in India, the total motor vehicles registered in Jaipur are at par with some Tier-1 cities such as Mumbai and Hyderabad.

The increased vehicular growth has put pressure on the road infrastructure. For 2019, the total number of motor vehicles per kilometre of road length in Jaipur was estimated to be 1192 vehicles/km, higher than some big metropolitan cities such as Bengaluru (794 vehicles/km) and Delhi (501 vehicles/km). Beside vehicular growth, inadequate and encroached pedestrian infrastructure and free on-street parking are primary reasons for high congestion in the city.

Urban Transport Governance

The urban transport governance in Jaipur involves various agencies and authorities across the centre, state, and city levels to oversee the planning, implementation, infrastructure development, etc.



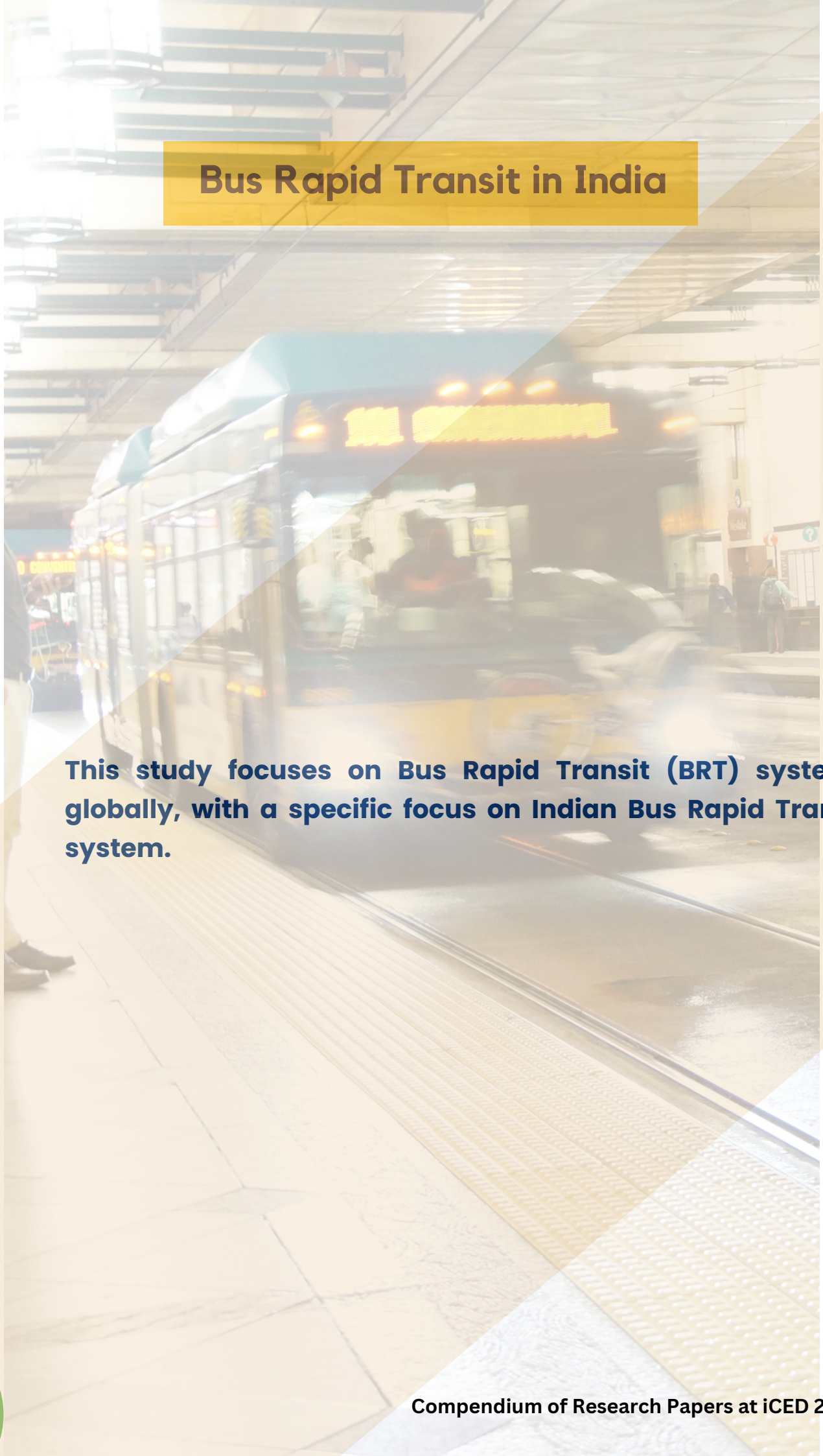
State/City level agencies and their functions

Source: CUTS, 2020

The study suggests to focus on

- Improving sustainable transport modes such as public transportation (public buses, BRT, and Metro) aided by alternate fuels and Electric Vehicles.
- Ensuring funding required to develop sustainable transportation, based on their performance.
- Further, an appropriate institutional framework with fewer overlapping functions and strong communication, for a sustainable transportation system and better liveability in Jaipur city.

Bus Rapid Transit in India



This study focuses on Bus Rapid Transit (BRT) systems globally, with a specific focus on Indian Bus Rapid Transit system.

Bus Rapid Transit in India

Bus Rapid Transit (BRT) is a vital component of a comprehensive public transportation system and provides significant benefits to cities, saving time and resources, when compared to other alternatives. This study was carried out by an erstwhile research associate, Dr. Harsha, V. at iCED in 2022.

Objectives

- To study and analyse the global and Indian Bus Rapid Transit system policies, guidelines and performance, for identifying performance issues and prospects for improvement with respect to some Indian cities.



Smart fare collection



Dedicated median bus lanes



A dedicated fleet of high-quality buses and stations

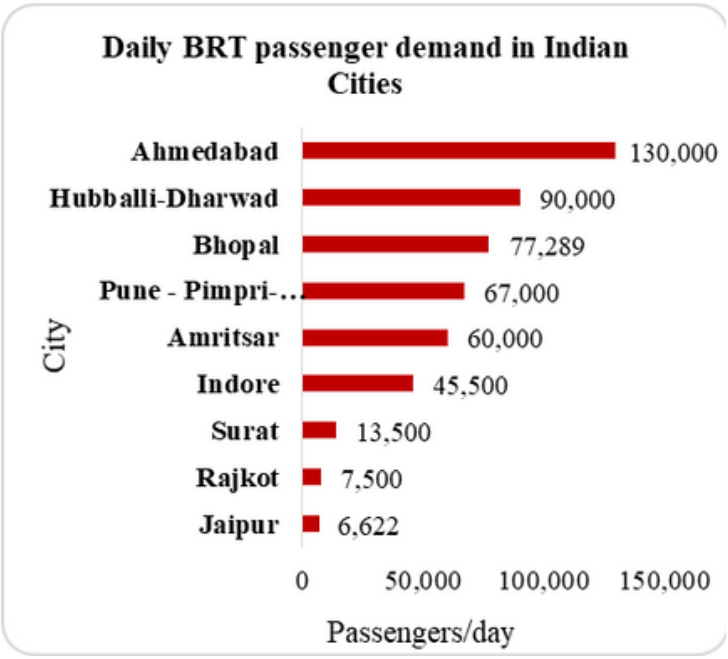


Levelled platforms to reduce boarding delays

Well-designed intersections that restrict mixed traffic

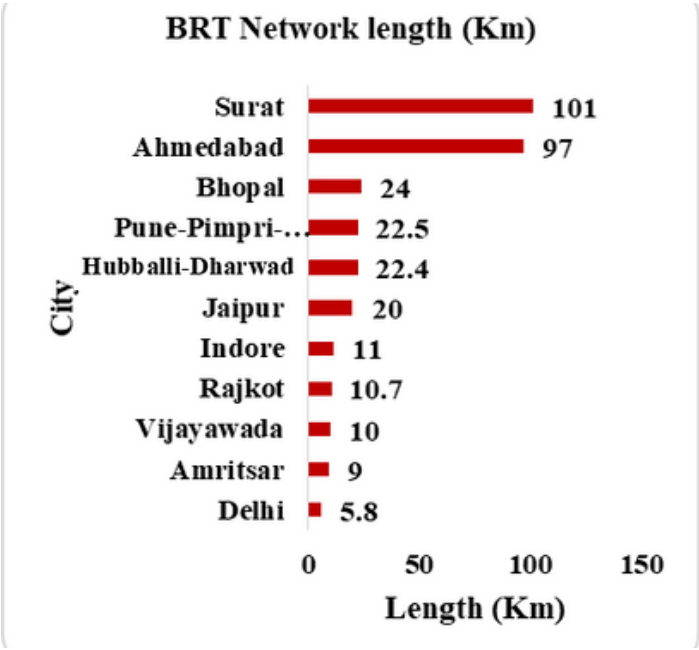


Vital elements of a BRT System

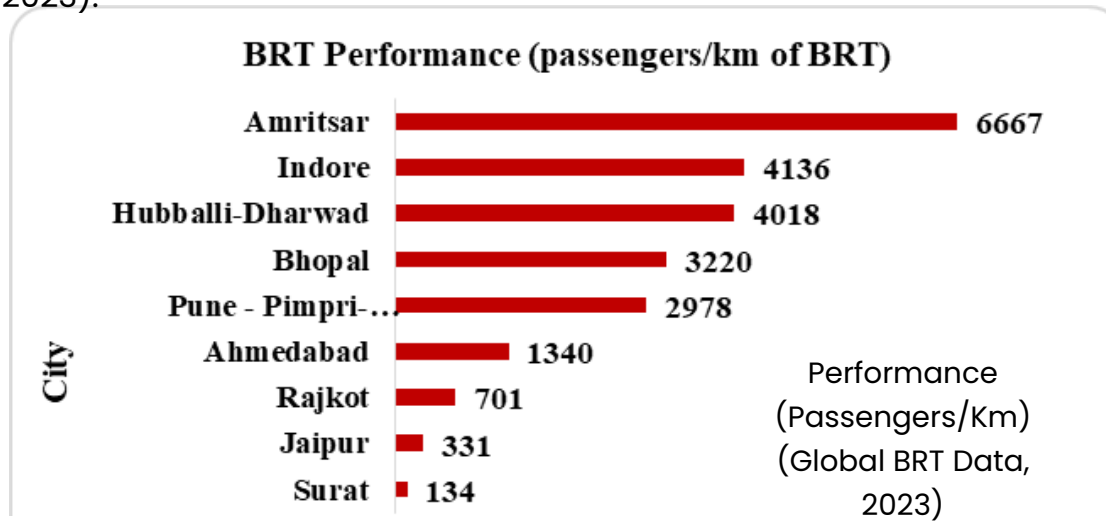


- Ahmedabad BRT carries the highest number of passengers in India with 130,000 passengers per day, while Jaipur records the lowest.

- Surat has the largest BRT network in India, followed by Ahmedabad, but Surat has one of the lowest daily passenger demands.
- Surat has the lowest performance due to its recent construction and the city plans to connect it with other systems soon.
- Amritsar has the fifth-largest passenger demand and the lowest running BRT network, making it the best performing BRT in terms of passengers transported per kilometre (Global BRT Data, 2023).



Critical Indicators and Status of Cities
(Global BRT Data, 2023)



Performance (Passengers/Km) (Global BRT Data, 2023)

Study Highlights

- The study highlights that Bus Rapid Transit (BRT) ridership in India is significantly lower than in Latin America and other developed nations.
- The development of BRT networks in India, apart from Pune, has primarily focused on easy-to-construct corridors and less on peak-hour demand or connectivity to low-income neighbourhoods. Consequently, Metro services have received more funding than BRT, leading to pressure on local urban bodies managing BRT to increase fleet and network size with limited funds.
- The study emphasises the need for an extensive network with high-frequency bus stops and multi-modal connectivity, to increase ridership.
- To encourage usage, a combination of policies should be implemented, including regulatory policies that reduce the usage of private vehicles and incentivisation policies for promoting use of BRT.
- Separated BRT lanes with barriers and strict enforcement of penalties for lane violations can help reduce travel delays and accidents.
- The study highlights the need to utilise riders' feedback to upgrade the operations and network.

Successful Case Studies on BRT



Istanbul's Metrobüs System

- Develop benchmarking and measure the impacts of BRT
- Low cost, reduced travel time and GHG emissions
- Improved road safety and physical activity



Buenos Aires Metrobus System

- Focus on strong stakeholder engagement and communications
- 49,000 tonnes of CO2 emissions reduction per year
- Cut travel times by 20 - 40% on average for 1.2 Million people across the city



Curitiba's BRT System

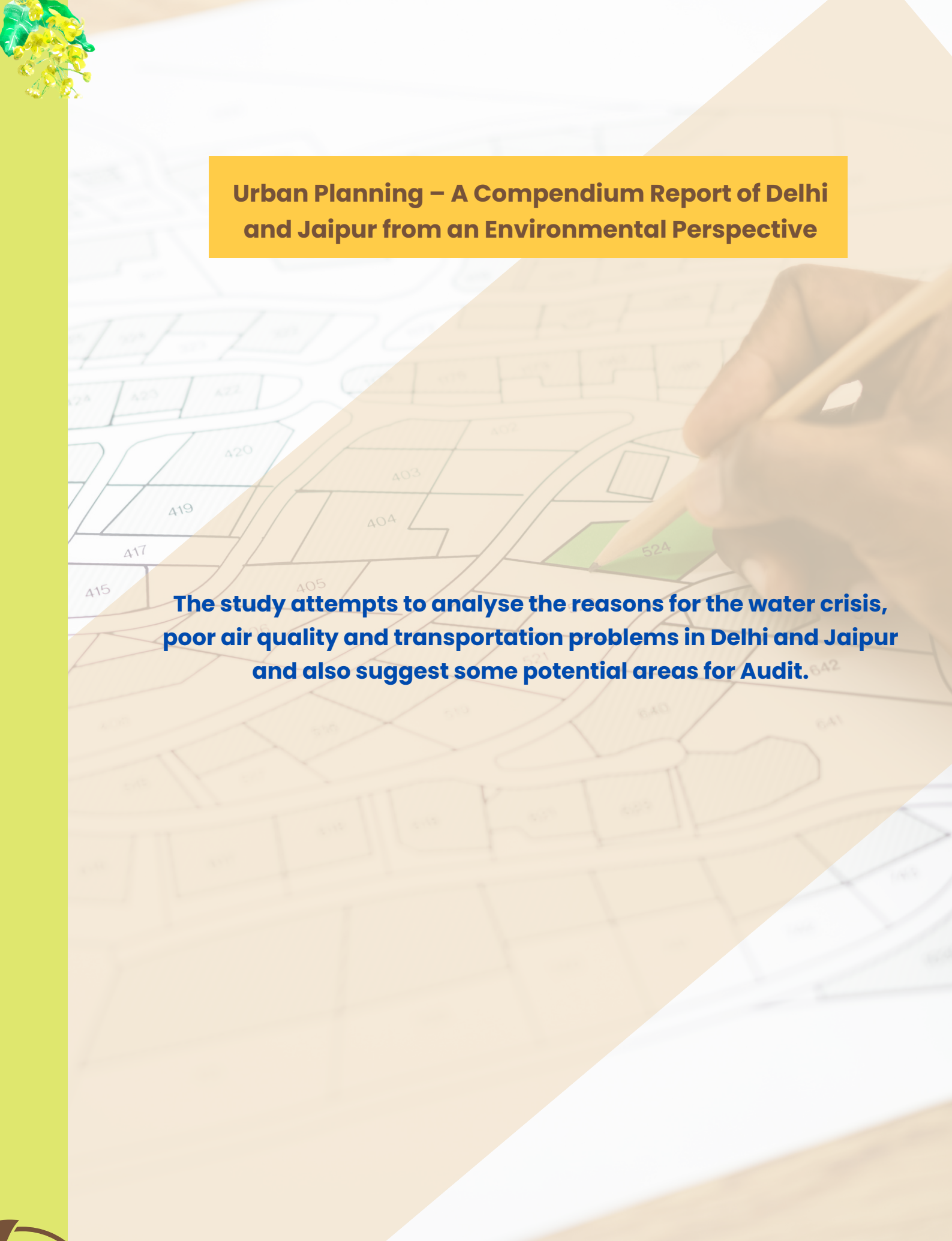
- Integrate BRT with other means of public transport and urban planning
- First city to develop Bus Rapid Transit in 1974. Around 2 million passengers use the BRT system, accounting for approximately 80% of the travellers
- With 30 hybrid buses, the overall fuel requirement reduced to 35%, limiting pollutant emissions



Guangzhou's BRT system

- Adopted holistic planning for a high-capacity BRT corridor
- Reduced traffic congestion and increased speed of buses and mixed traffic by 29% and 20%, respectively
- Saved 52 million commute hours of worth US$ 24 million, in 2010

Urban Planning – A Compendium Report of Delhi and Jaipur from an Environmental Perspective



The study attempts to analyse the reasons for the water crisis, poor air quality and transportation problems in Delhi and Jaipur and also suggest some potential areas for Audit.

Urban Planning – A Compendium Report of Delhi and Jaipur from an Environmental Perspective

India's urban population has surged from 17.92 per cent in 1960 to 33.6 per cent in 2017, making sustainable development a formidable challenge (Macrotrends, n.d.). Urban planning is crucial to optimise land use, rejuvenate cities, and manage resources for liveability, affordability, and infrastructure. In this context, this study was done by Dr. V. Harsha, Research Associate, and Ms. Sucheta Deb, former Young Professional at iCED in 2021-22.

Objectives

- To analyse the reasons for the water crisis, poor air quality and transportation problems in Delhi and Jaipur and also suggest some potential areas for Audit.

Risk Analysis

QUALITATIVE ASSESSMENT OF WATER RESOURCES OF DELHI

•East and north-east districts of Delhi are undergoing arsenic contamination of groundwater; furthermore, other districts have recorded nitrate and fluoride pollution.

QUALITATIVE ASSESSMENT OF WATER RESOURCES OF JAIPUR

•Rajasthan has a significant portion of habitations in India that face multiple water quality issues, with 74% of such areas located in the state. This includes 51% of all areas affected by fluoride and 42% of all areas affected by salinity.

WATER SUPPLY STATUS OF DELHI

•1. As per Central Ground Water Board (CGWB) Delhi faces a shortage of 180 MGD of portable water, and this gap is currently being filled by excessive groundwater extraction.
•2. The Master Plan of Delhi suggested the rainwater harvesting method to meet this demand.

•1. Jaipur has prohibited water-intensive industries due to declining water tables, negatively affecting industries such as beverages and textiles.
•2. According to the Jaipur Master Plan 2025, out of the total demand for 1170 MLD, 820 MLD will be met through the Bisalpur Project and tube wells, while the remaining demand will be met by the Isarda and Chambal dams.

WATER SUPPLY STATUS OF JAIPUR

LIMITATIONS OF THE WATER POLICY OF DELHI

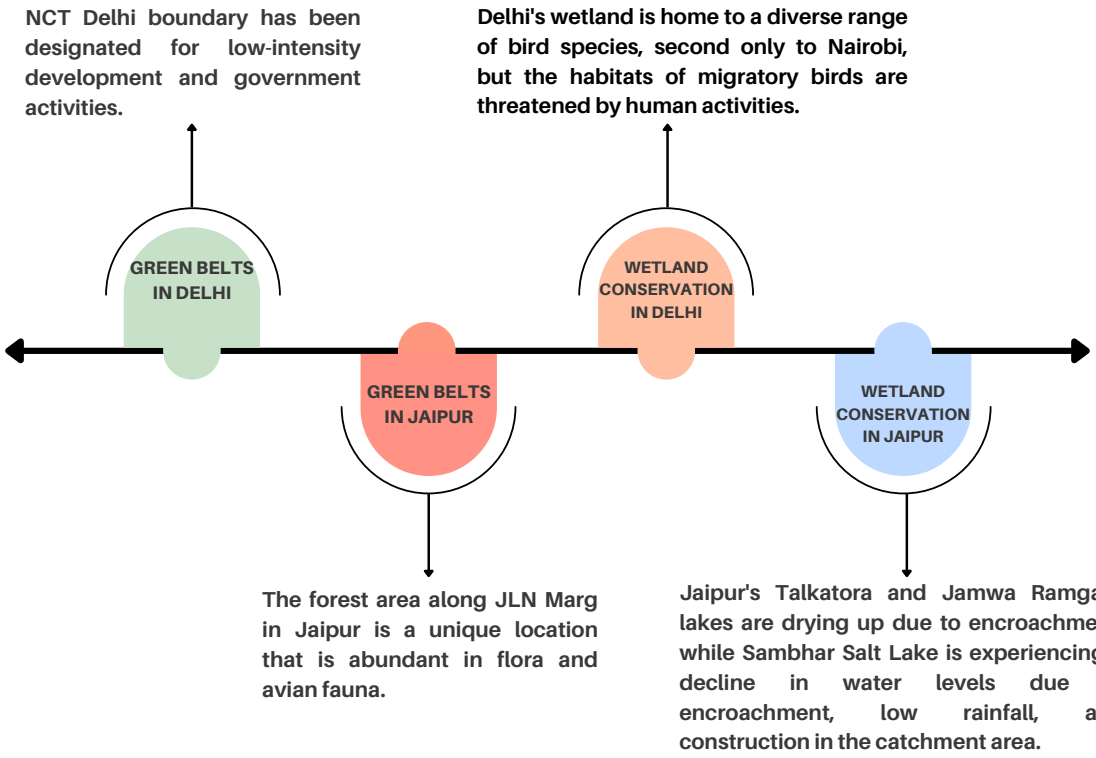
1. Lack of coordination exists between DDA and the Government of NCT Delhi
2. Lack of regional approach, emphasis on planning and developing ground water sources.
3. There are high losses of water at various stages of the supply system.

LIMITATIONS OF WATER POLICY OF JAIPUR

1. The absence of a groundwater regulation act in the State has resulted in the growth of the private water tanker business in the capital city.
2. The State departments have not been able to control the commercial exploitation of groundwater by private bore wells.

Comparison of status of water availability status in Delhi and Jaipur

The cities of Delhi and Jaipur are facing increasing demand in infrastructure requirements (water, sewerage, housing, etc.) due to the growing population.



Risk assessment of Green Belts & Wetlands

The transportation sector in Delhi and Jaipur is also facing significant risks, including increasing traffic congestion, inadequate public transportation infrastructure, air pollution, and road safety issues. These risks have adverse impacts on the environment, public health, and overall quality of life. Therefore, effective policies and strategies are needed to address these challenges and ensure sustainable transportation development in these cities.

Focus areas for auditing

1

Water

•Local authorities are required to implement strict rules against wastage of water

•Improper monitoring in water management as well as sewage treatment

•Absence of effective groundwater regulation act

2

Green Belts & Wetlands

•Deterioration of Green belts and Wetlands and Instances of Project approval in water stressed locations.

•Industries over-exploiting the groundwater need to implement artificial recharge measures.

•Non-achievement of forest cover target of 33% and potential for increasing India's forested area.

3

Transportation

•Comprehensive Mobility Plans (CMPs) in India lack comprehensive policy frameworks and data, resulting in an inefficient transportation system.

•Lack of regulatory framework is the reason for ignoring the indicators such as fleet utilisation, bus stop spacing, etc.

•National Policy on Biofuels and National Electric Mobility Mission Plan (NEMMP) need monitoring to keep emissions under control.

SELECTED CONTENTS FROM ICED'S CONTRIBUTION TO THE ASIAN JOURNAL OF GOVERNMENT AUDIT



Knowledge and experience sharing are the hallmarks of iCED's business or functional processes. We strive to collaborate proactively with the regional SAI organisations by sharing SAI India's audit experiences on various environmental themes, in the form of Country Papers, Articles, Presentations etc.

In this section, we showcase some of our earlier contributions of articles to the journal of ASOSAI.

Auditing Climate Change- An Overview and Experience from SAI India

By Team iCED (April 2022)

Climate change refers to long-term shifts in temperatures and weather patterns. Since the 1800s, human activities have been the main driver of climate change. It has been reported that the earth is now about 1.1°C warmer than it was in the late 1800s with the last decade (2011-2020) being the warmest on record (United Nations, n.d.). Climate change poses serious consequences to human society and many of the physical and ecological systems upon which it depends. Other externalities of climate change include reduced water and food security; increased damage to infrastructure; additional mortality and morbidity; human migration and displacement; damaged livelihoods; increased mental health issues; and increased inequality (Intergovernmental Panel on Climate Change (IPCC), 2022).

In bi-annual edition of the Asian Journal of Government Audit (April 2022), team iCED contributed an article on the topic "Auditing Climate Change- An Overview and Experience from SAI India". This article highlights the dedicated efforts of C&AG of India, INTOSAI and global Supreme Audit Institutions (SAIs) to combat the impact of climate change.

Climate Change and Sustainable Development Goals (SDGs)

SDG 13, also known as Climate Action, aims to inspire nations to work together towards fighting climate change. However, climate change is associated with many other Sustainable Development Goals (SDGs). Achieving SDG 7 on affordable and clean energy and SDG 12 on responsible consumption and production is crucial for making significant progress on climate action (INTOSAI Working Group on Environmental Auditing(WGEA), 2010).

Global and National Climate Change Commitments

The first effort towards Climate Change was in the form of the 1st United Nation's Conference on Environment held in 1972 (also known as the Stockholm Conference). Subsequently, a series of international summits were convened to establish a plan for addressing climate.

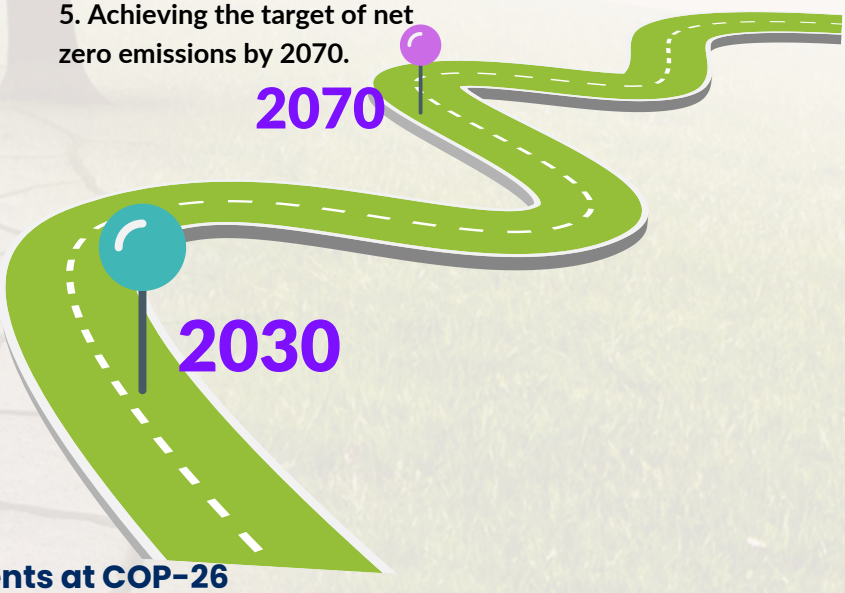


The Paris Agreement, aimed to prevent the global average temperature from rising more than 2°C above pre-industrial levels, with the goal of limiting the increase to 1.5°C above pre-industrial levels. (United Nations Framework Convention on Climate Change, n.d.). India is a party to the United Nations Framework Convention on Climate Change (UNFCCC). India presented the five nectar elements (Panchamrit) at COP-26 held at Glasgow.

In August 2022, India updated its Nationally Determined Contributions (NDCs) and revised its emissions intensity targets in line with deliberations made at COP-26.

Five Nectar Elements (Panchamrit) of India's Climate Action

1. Reach 500GW Non-fossil fuels based energy capacity by 2030.
2. 50 per cent of its energy requirements from renewable energy by 2030.
3. Reduction of total projected carbon emissions by one billion tonnes from now to 2030.
4. Reduction of the carbon intensity of the economy by 45 per cent by 2030, over 2005 levels.
5. Achieving the target of net zero emissions by 2070.



India's commitments at COP-26

(Source:- Ministry of External Affairs, Government of India, 2021)

Need of auditing Climate Change: Global Initiatives

Climate change is a field of urgent importance and SAIs can play an important role in helping governments improve their performance and management.
INTOSAI Working Group on Environmental Auditing (WGEA) has worked increasingly with climate related topics to support the economic, efficient and effective implementation of climate policies. SAIs across the globe have audited climate mitigation/adaptation policies and found ineffective measures, poorly planned taxation systems, lack of data and monitoring systems, and inadequate risk management. Similarly, in adaptation policies, they found missing innovations for new technologies, insufficient concrete measures, and inefficient measures.

Audits by Global SAIs on Mitigation Adaptation and finance related issues Mitigation related global audits

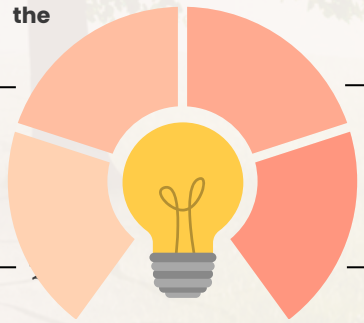
Mitigation Audits

•According to the European Court of Auditors in 2021, it was reported that the €100 billion of funds from the common agricultural policy, which were allocated towards climate action during the period of 2014-2020, did not lead to a reduction in greenhouse gas emissions from farming.
•In 2017 and again in 2019, Canada's SAI audited progress towards fulfilling the G20 commitment to phase out inefficient fossil fuel subsidies. Overall, the audits found that there was no clear definition of what could be considered an inefficient fossil fuel subsidy, and that there was no consideration of economic, social, and environmental sustainability in subsidizing the fossil fuel sector over the long term.

Co-operative Audits

•As per WGEA Work Plan, SAI Indonesia is developing a training package on auditing climate action and finance in the context of the SDGs. SAI India hosts an International Training Centre (iCED) and provides training and knowledge-building networks on various environmental topics, including the climate and sustainable development.
•In 2019, SAI Egypt conducted an audit on desertification and pointed out the importance to assess the performance of national environmental programmes and the environmental impacts of other national programmes, which may have direct or indirect impact on desertification.







Adaptation Audits

•In 2019, SAI USA found that the federal government does not strategically identify and prioritise projects to ensure they address the nation's most significant climate risks.

Financial Audits

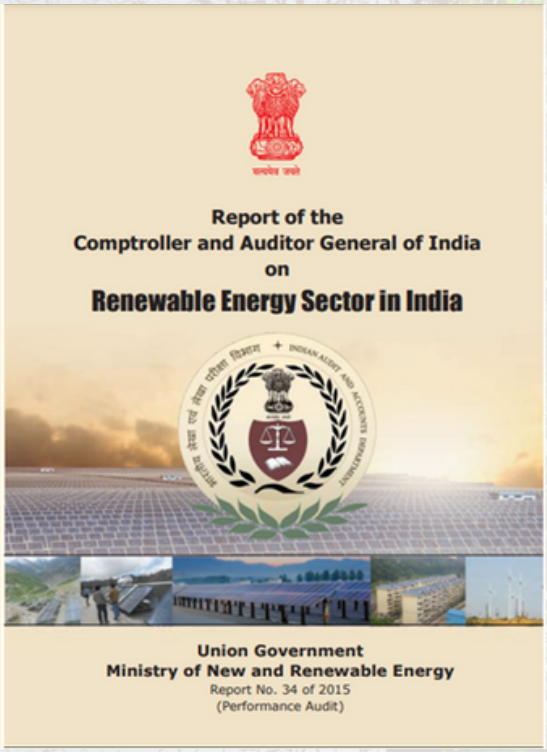
•In 2021, SAI Finland reported that despite the government's intention to scale up climate finance and direct half of it to climate change adaptation, there was no published plan for how these policies will be implemented nor strategic objectives for climate finance. The audit recommended that the Ministry for Foreign Affairs should draw up a public plan as to how it will increase and allocate Finland's international climate finance, justifying the choices and priorities.

Source: (INTOSAI WGEA, 2021)

SAI India's efforts on audit of climate change issues

The Comptroller and Auditor General (CAG) of India is actively engaged in conducting climate change audits to ensure that government funds allocated for climate change policies are being used effectively and efficiently.

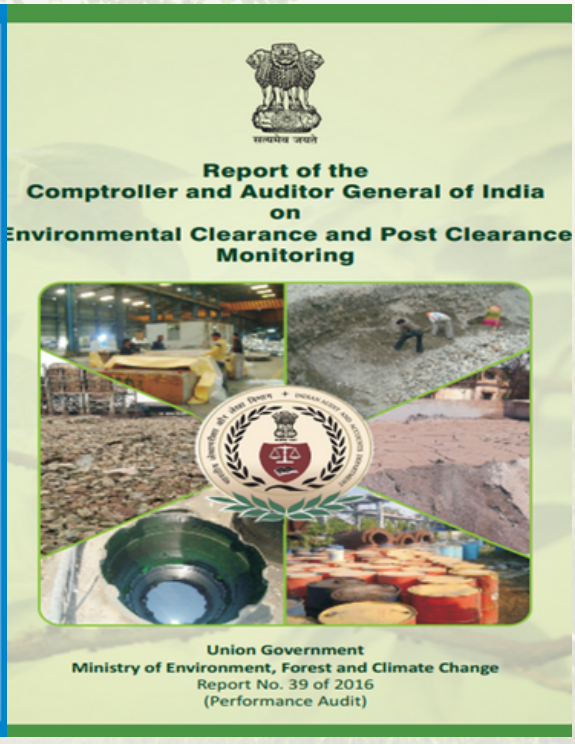
Audits on Mitigation by SAI India





Audits on Adaptation by SAI India





Challenges and way forward

Auditing climate change initiatives is a challenging task due to the dynamic and cross-cutting nature of the subject, involving multiple agencies and initiatives. Lack of clear criteria and information on greenhouse gas emissions sources and sinks is an immense challenge for the audit fraternity. In a global environment of pandemic related risks leading to economic crises, a persistent increase in public awareness is the only way to mitigate the dangers of climate action.

Auditing Plastic Waste - An Overview and Experience from SAI India

By Team iCED (October 2022)

iCED extensively contributes research inputs on key environment issues as representative of SAI India at global forum, ASOSAI including its Journals and other SAIs. The Asian Journal of Government Audit is a popular resource for the SAI community. It has provided a forum to ASOSAI members for discussion and dissemination of good practices. The theme for the October 2022 edition was "Plastic Waste" and team iCED shared its experience by contributing the article for the journal. The article provided an overview of the various international conventions regarding plastic waste. Regulatory and Institutional framework in India, roles and responsibilities of local agencies in plastic waste management and listed some important audit reports by other SAIs and SAI India featuring plastic waste management issues.



Various efforts have been made at International level for curbing Plastic Waste. These initiatives can be traced back from 1972 (London Convention) to 2020 (European Plastics Pact).

In 2022, a resolution was adopted by the United Nations Environment Assembly held in Nairobi to end plastic pollution, and forge an international legally binding agreement by the end of 2024.

There is only one indicator (14.1.1b) under Goal 14 which is specifically related to reducing impacts of plastic in the marine environment.

The article provided a snapshot of existing Regulatory and Institutional framework in India indicating important legislations and its timelines, role of apex bodies for framing rules and guidelines and role of local bodies responsible for effective implementation of plastic waste management.

The article apart from providing overview, shared experiences by illustrating few important audit reports of SAI India and other SAIs highlighting audit concerns on the issue of plastic waste

Important issues highlighted in the reports were:

- Need for circular economy approach which includes recycling targets and targets for the prevention and reuse of plastics
- Insufficiency of existing legislations and organisational arrangements to reduce the generation of Plastic Waste
- Indicator related to plastic debris density to be included in relevant frameworks
- Absence of mechanisms for assessment of quantum of Plastic Waste generated leading to non-availability of data for any future projections, composition required for planning
- Ineffective mechanism for collection, handling, segregation, storage, transportation and disposal of Plastic Waste
- Non-utilisation of plastic waste for constructive purposes such as construction of roads

Challenges faced during these audits were:

- Non-availability of authentic and reliable data on generation, collection, segregation and treatment of Plastic Waste
- Stakeholders not mapped in National Indicators Frameworks
- Incomplete Records
- Lack of awareness
- Ineffective implementation of Extended Producer Responsibility measures

Conclusion and Way Forward

The conduct of such audits in the area of Plastic Waste and pollution would thus help in red-flagging crisis areas of environmental degradation, which would then assist the executive authorities to take suitable remedial action in the sphere. Plastic Pollution is not only a "severe anthropogenic issue in the coastal and marine ecosystems across the world", it is also a crucial component of the overall paradigm of degenerative climate change with its destructive effects on manifold ecosystems and consumption patterns. The need of the entire global community is to thereby acknowledge this fact; and successful auditing of plastic waste is thus of immense necessity.

SELECTED CONTENTS FROM ICED'S QUARTERLY NEWSLETTER "GREEN FILES"

The quarterly newsletter of "Green Files", is a cornucopia of diverse environmental themes which features glimpses of recent environmental news, key events, print media, environmental news items and emerging trends, which can act as a corpus of information for environment audits in particular.

In this section, we showcase a few articles on various environmental themes from previous editions of the "Green Files".



Sustainable Development Goal 11.6 – A Gap Analysis and Roadmap for Solid Waste Management in Urban India

Dr. Amitha A.J., IA&AS
Greenfiles Vol. 24, 2017

The article highlighted the need for efficient Solid Waste Management (SWM) systems to achieve the Sustainable Development Goal for making cities inclusive, safe, resilient, and sustainable. The Comptroller and Auditor General of India's audit reports highlighted the lack of planning, poor enforcement, resource constraints, plastic waste burden, irregular collection of biomedical waste, inadequate monitoring and unscientific disposal of solid waste etc. These inadequacies must be addressed to achieve the Agenda 2030.

Issues needed to be addressed

- **Silos approach and misaligned priorities** among different tiers of government which are interdependent led to severe delays and poor progress in creating SWM infrastructure.

- **Lack of effective planning and strategies** for solid waste management (SWM), resulting in poor implementation and negative externalities such as unauthorised dumping.

- Urban Local Bodies (ULBs) outsource the implementation of SWM to contractors, and effective monitoring and enforcement of such contracts are crucial. Contract **agreements for delivery of services have lacunae** that were exploited by service providers and ULBs are not enforcing contract provisions strictly. As a result, service delivery is poor.

- **Limited financial** resources for ULBs for SWM.

- Plastic waste disrupts effective SWM by causing **mixed waste** which is difficult to process. **Poor monitoring** of management of bio-medical waste generated in clinical establishments outsourced to private service providers. Simplifying the reporting mechanism into an online format can increase compliance rates.

- **The improper maintenance** of landfills and dumpsites in ULBs leads to severe groundwater contamination, fire hazards, release of dioxins, and unauthorised dumping outside. Existing rules must be enforced strictly and penalties for substandard maintenance should be high. ULBs must coordinate with Pollution Control Boards to develop a round the clock surveillance system to ensure adherence to quality standards.

Challenges in effective SWM

The challenges faced by ULBs in effective solid waste management are due to:

- shortage of resources,
- lack of decision-making power,
- administrative bottlenecks, and
- mismatch between fiscal and functional devolution to ULBs, with meagre funds at their disposal, compared to the demands for rapid urbanisation.

Road ahead

To address these challenges, state and central governments need to play a proactive role in empowering ULBs with adequate funds, functions, and functionaries to achieve the goal of reducing the adverse per capita impact of Indian cities by 2030.

Using Data Analytics in Audit of State Pollution Control Boards

Ms. R. Monica, IA&AS
Greenfiles Vol. 21, 2017

This paper aims to explore the potential for data analytics using data of State Pollution Control Board (SPCB). It provides a data collection template and outlines potential outcomes and use for audit planning and conduct.

Functioning of SPCBs

SPCBs are nodal agencies responsible for preventing and controlling air and water pollution. Objectives of SPCBs are derived from Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981. Activities of SPCBs further widened with enactment of Environment (Protection) Act, 1986. SPCBs plan comprehensive programmes for pollution prevention, control and abatement.

Primary objective of SPCBs is to plan comprehensive programme for prevention, control and abatement of water and air pollution. SPCBs lay down and review standards for sewage effluents and emission of air pollutants. They are responsible for collection and dissemination of information related to pollution control and have authority to inspect industries and evaluate working of effluent/emission treatment plants and provide guidance for corrective measures. SPCBs periodically collect samples of sewage effluents and emissions of air pollutants and analyse for specific parameters. They collaborate with Central Pollution Control Board to organise training and mass education programme to improve sensitisation.

Following sections provide a data template for each SPCB's activity and discuss results, using data analytics for audit planning and outcomes.

Templates for Data Collection

SPCBs maintain data on various polluting sources which can be used for risk analysis. Completeness of this inventory data can be verified using third-party sources like Central Excise Department's database. This study proposes seven templates for collection of data relating to inventory of industries, SPCB's consent to establish and consent to operate, monitoring of air and water quality, emission from industries, data on inspection of industries by SPCB, data relating to monitoring of small scale industries etc. which were used for risk-profiling of different district offices of SPCB.

Risk-profiling of SPCB Offices

The study proposes a method for determining the inherent risk score of district offices of SPCBs, based on the nature of industries handled by them. The risk score is calculated based on the categorisation of industries as Red, Orange, or Green and Large, Medium, or Small, based on turnover. This approach helps in efficient utilisation of audit resources by identifying the inherent risk of non-compliance. In order to calculate the inherent risk score of offices of Tamil Nadu SPCB, a risk score was attached to each of the industry under the district offices obtained from one of the seven templates discussed above.

Calculation of Inherent Risks for District Offices of SPCB

	Large (50)	Medium (30)	Small (10)
Red (50)	100	80	60
Orange (30)	80	60	40
Green (10)	60	40	20

The risk scores of industries in each district are mapped geographically to identify high-risk district offices of Tamil Nadu SPCB for prioritising audits.

Data Visualisation

Illustration of data analysis and visualisation for audit planning



The darker shades in each category indicate a higher number of highly polluting industries. Data analysis and visualisation assist in predicting high-risk district offices, which can be further modified to include additional parameters such as arrears in inspection and previous audit observations.

Conclusion

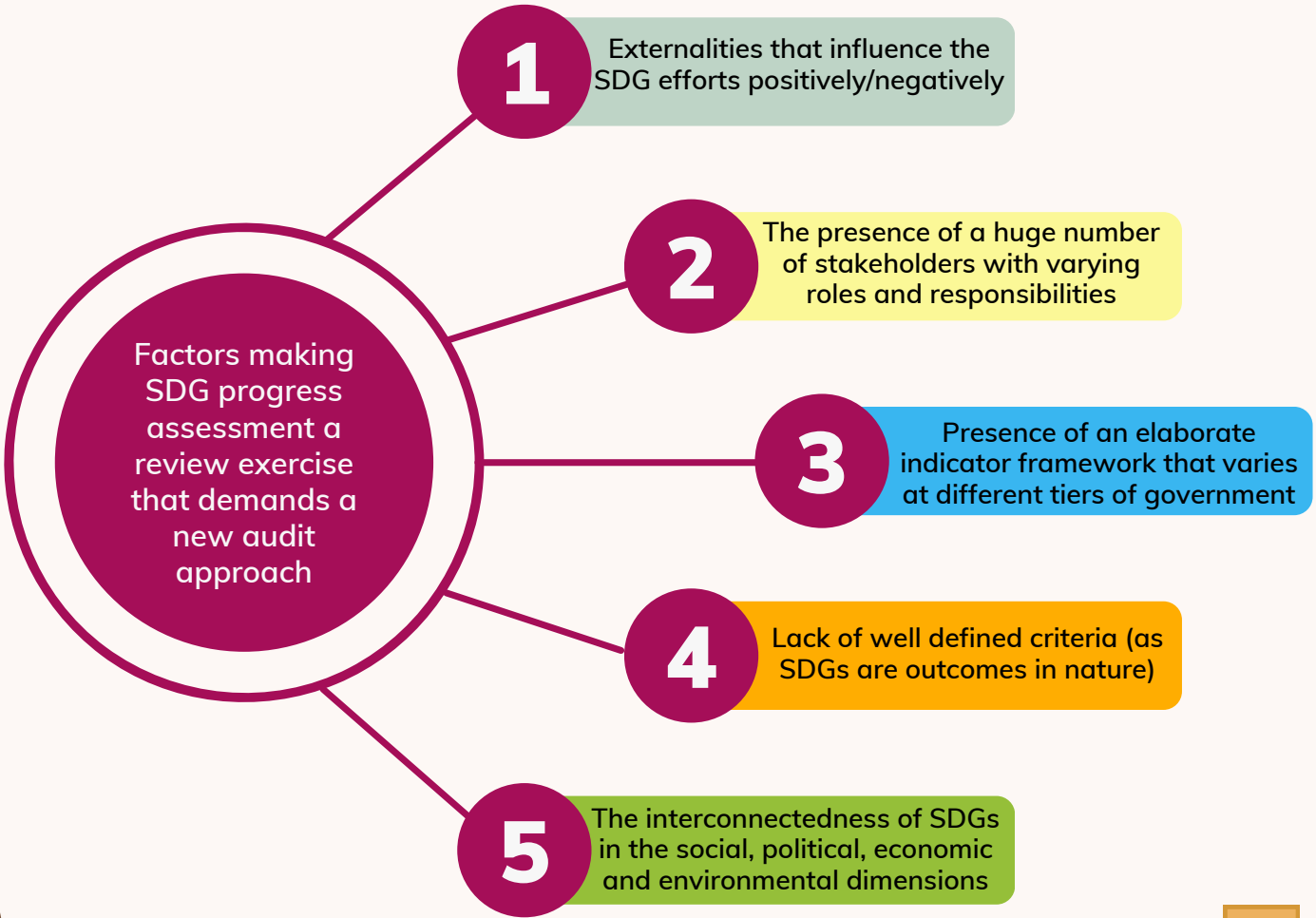
The paper shows how data analytics can be used for planning and conducting audits of SPCBs, but it is important to note that the reliability of the results depends on the reliability of the collected data.

Evaluation of efforts towards Sustainable Development Goals

Ms Stefi Sofi, IA&AS
Greenfiles Vol. 41, 2022

The Sustainable Development Goals (SDGs) aim to achieve social and economic progress without exhausting Earth's resources. India has a demographic dividend, with a significant proportion of young and economically viable population, but this could lead to increased exploitation of non-renewable resources. Therefore, there is a need for sustainable development to ensure intergenerational equity. Evaluating SDG efforts is a priority for SAI India, and the United Nations has recognised the role of SAIs and INTOSAI in SDG evaluation. The 2030 Agenda for Sustainable Development emphasises the primary responsibility of governments in follow-up and review of progress towards the SDGs at national, regional, and global levels.

SDG evaluation is a new and evolving domain without a template, and SAIs can adopt different approaches and methodologies based on the scope and purpose of the review. SDG evaluation needs to be integrated into policymaking and requires innovation and active engagement of SAIs.



Defining the boundaries of SDG evaluation

In order to assess SDG efforts, auditors must identify and prioritise stakeholders based on their roles and responsibilities, as all SDGs are interconnected and influenced by a broad spectrum of actors within and outside the government. Stakeholder analysis can be used to identify key actors and organizations that influence SDG implementation, but this requires thorough knowledge of the subject matter, including expertise across multiple government sectors. Auditors need to interact with stakeholders and consult experts to gain a deeper understanding.

Review of SDG Indicators

The main challenge in SDG implementation is developing measurable output metrics. The global indicator framework has 232 indicators as benchmarks, but member countries must create their own frameworks at different levels of implementation. The auditor should review indicators for qualities like comprehensiveness, reliability, and accessibility of data, and only evaluate output indicators that are attributable to SDG targets. The indicators should be coherent horizontally and vertically in SDG implementation.

Countering the challenges of SDG related Data

SDG evaluation requires analysis of complex, voluminous data at various levels, with reliability and accessibility of data being a major concern. India's socio-economic and environmental inequalities may require spatial and temporal progress monitoring of SDG efforts. Remote Sensing and Geospatial Information Systems can be useful in tracking and evaluating progress towards SDG indicators. The auditor must integrate data from different stakeholders and use tools to extract relevant information from available data. Spatio-temporal analysis of data can help identify regional disparities in SDG implementation and provide feedback to the government to streamline the overall SDG strategy.

Deviating from pure Result Oriented Approach

An audit approach that assesses systemic gaps and evaluates the SDG implementation process would be more appropriate than focusing solely on outcomes and failures. The auditor should identify and prioritise stakeholders and may need to collect and integrate data using remote sensing and geospatial information systems. A phased audit approach with periodic follow-ups and revisions of stakeholder analysis is necessary for effective SDG evaluation.

Environmental Challenges with Rooftop Solar Scheme

Dr. Divya Singh, Research Associate
Greenfiles Vol. 44, 2022

Solar photovoltaic rooftop systems have emerged as a promising green technology to address climate change issues by decreasing reliance on traditional fossil fuel-based electricity sources. India has pledged to increase its capacity of renewable source-based electricity to 175 GW by 2022, with a goal of adding 100 GW of solar energy capacity.

Grid Connected Rooftop Solar Scheme

The Grid-connected Rooftop Solar Scheme implemented by the Ministry of New and Renewable Energy uses solar panels on the rooftops of buildings to generate electricity. Compared to ground-mounted solar power plants, rooftop systems are smaller and can boost renewable electricity production while preserving open spaces and enhancing community resilience to power system interruptions caused by global warming. In areas like Rajasthan where water is scarce, large solar farms can require a lot of water for maintenance, negatively impacting sustainability. Additionally, the strong beam of concentrated solar light may harm birds and insects, posing a threat to biodiversity.

Recycling Photo Voltaic Modules

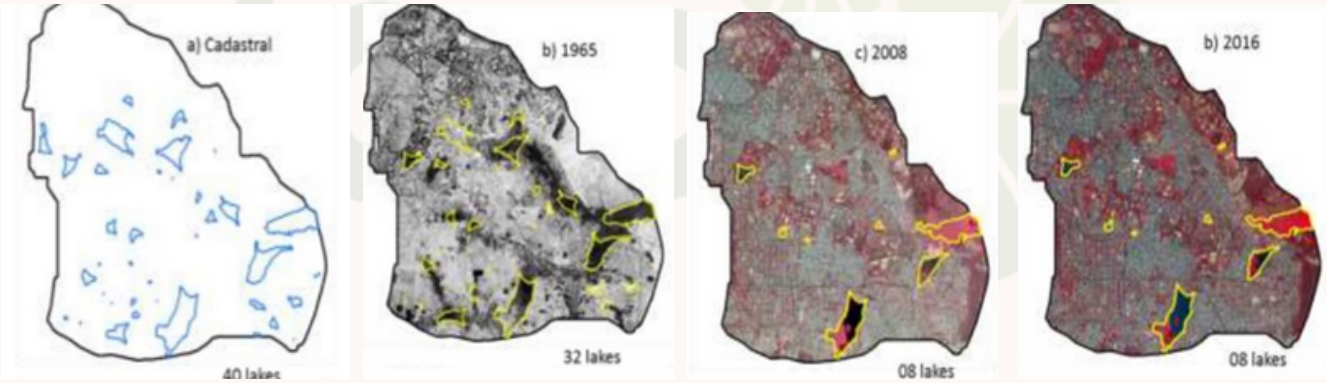
The management of end-of-life solar photovoltaic (PV) modules in India is a growing challenge. While there is a high potential for recycling solar PVs, there is also a risk of producing hazardous waste. Solar PV cells may contain toxic metals such as lead, selenium, tellurium, and cadmium, which can pose a threat to food safety and biodiversity. In addition, solar PV panels generate greenhouse gases like carbon dioxide during certain stages of their life cycle, and the constituents of solar PV cells have potential cancerous and non-cancerous effects on water, soil, and ecological systems. More research is needed to maximise resource recovery and reduce the environmental burden of e-waste.

Performance Audit of the Management of Stormwater in Bengaluru Urban Area

Ravikumar U, Sr. AO
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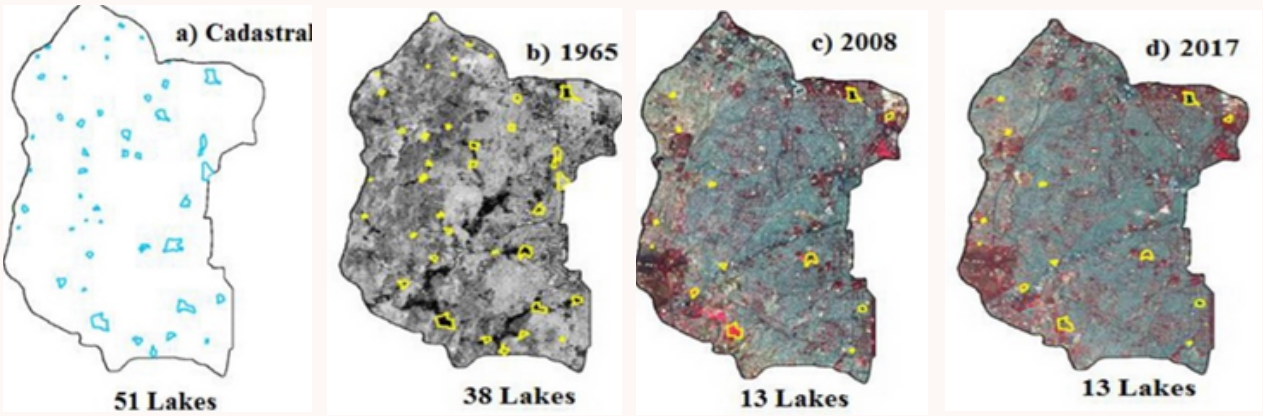
The Performance Audit conducted in Bengaluru aimed to address the paradoxical situation of urban flooding and water scarcity in the city. The focus was on exploring whether improved storm water management could be a solution to both challenges. To study and analyse the storm water infrastructure over time, the absence of complete maps from various authorities necessitated the use of satellite imagery. Collaboration with the Regional Remote Sensing Centre, ISRO allowed for a study of long-term changes in land-use patterns using geospatial inputs. This study helped identify the impact of these changes on groundwater recharge and highlighted weaknesses in the management and monitoring of the storm water drainage (SWD) infrastructure.

Time series maps showing changes in lakes / tanks



Koramangala valley

Cadastral maps pertains to 1900s



Vrishabhavathi valley

Large scale encroachment of lakes/drains, reduction in number of water bodies and depletion of natural drainage systems









Google Earth images showing the realignment of drains

Important findings:

- Encroachment, reduction in water bodies, and changes in land-use have disrupted natural drainage systems, leading to a loss of inter-connectivity between water bodies, reduced groundwater recharge, and increased stormwater runoff.
- Neglecting the potential of urban surface runoff as a valuable water resource.
- The absence of a comprehensive inventory of drains, unclear guidelines to mark buffer zones and inadequate action on identified encroachments.
- Mixing of sewage with storm water.
- Lack of periodic inspections, maintenance, and failure to install Sewage Treatment Plants.

Important recommendations:

- **A comprehensive policy** to be formulated for recognising urban runoff as a potential water source and develop a plan for its conservation.
- **A comprehensive database** of stormwater drains for effective planning and management.
- **A joint plan** to prevent sewage flow into stormwater drains and monitor its implementation.
- **A revised master plan** for addressing omissions regarding stormwater drains and managing encroachments.
- Incorporate relevant parameters in road and drain design to enhance groundwater recharge and prevent flooding.
- **Prioritise** the prevention of sewage discharge into stormwater drains and develop strategies for sewage treatment plant installation.
- **Periodic surveys** to identify and remove all encroachments on stormwater drains and maintain buffer zones.

Acknowledgements

Citations

1) Design and Templates, using www.canva.com

2) Details of authors, articles and books are provided in the main Occasional Research Papers, which can be accessed at www.iced.cag.gov.in

3) The selections here-in are summarised and adapted versions of the original products which can be accessed at www.iced.cag.gov.in



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