Risk and Vulnerability Assessment: Key Findings on the potential impact of Climate Change on the on-going WASH inclusion program in Informal Settlements - Bhubaneswar and Jaipur

Australian AID

Water For Women

Centre for Advocacy and Research

Risk and Vulnerability Assessment: Key Findings on the Potential Impact of Climate Change on the On-going WASH Inclusion Programme in Informal Settlements-Bhubaneswar and Jaipur

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AHP	Analytical Hierarchy Process
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BMC	Bhubaneswar Municipal Corporation
CCA	Climate Change Adaptation
CGWB	Central Ground Water Board
CMC	Community Management Committee
CSO	Civil Society Organisation
CTC	Community Toilet Complex
DRR	Disaster Risk Reduction
FGD	Focus Group Discussion
HRVA	Hazard Risk and Vulnerability Analysis
IHHL	Individual Household Latrine
IMD	Indian Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
JMC	Jaipur Municipal Corporation
JMP	Joint Monitoring Programme
NIDM	National Institute of Disaster Management
OBC	Other Backward Classes
OD	Open Defecation
PHED	Public Health and Engineering Department
PHEO	Public Health and Engineering Organization
PwD	Persons with Disabilities
SBM	Swachh Bharat Mission
SC	Scheduled Castes
SDA	Slum Development Association
SDGs	Sustainable Development Goals
SeVI	Socio-economic Vulnerability Index
SSC	Sanitation Sub-Committee
ST	Scheduled Tribes
SWF	Single Window Forum
WASH	Water, Sanitation and Hygiene
WATCO	Water Corporation of Odisha

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GLOSSARY

Adaptation: Climate change adaptation refers to actions that help reduce vulnerability to the current or expected impacts of climate change like weather extremes and natural disasters, sea-level rise, biodiversity loss, or food and water insecurity (UNDP Climate Dictionary, 2023; p.7).

Capacity: The combination of all the strengths, attributes, and resources available to an individual, community, society, or organization, which can be used to achieve established goals (IPCC, 2012; p.556).

Climate: Climate is the average of weather patterns in a specific area over a longer period of time, usually 30 or more years, that represents the overall state of the climate system (UNDP Climate Dictionary, 2023; p.85).

Climate Change: Climate change refers to the long-term changes in the Earth's climate that are warming the atmosphere, ocean and land. Climate change is affecting the balance of ecosystems that support life and biodiversity, and impacting health. It also causes more extreme weather events, such as more intense and/or frequent hurricanes, floods, heat waves, and droughts, and leads to sea level rise and coastal erosion as a result of ocean warming, melting of glaciers, ad loss of ice sheets (UNDP Climate Dictionary, 2023; p.37).

Exposure: The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected (IPCC, 2012; p.559).

Flood: The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods (IPCC, 2012; p.559).

Hazard: The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPCC, 2012; p.560).

Heatwave: A period of abnormally hot weather. Heat waves and warm spells have various and in some cases overlapping definitions. See also Warm spell (IPCC, 2012; p.560).

Impacts: Effects on natural and human systems. In this report, the term 'impacts' is used to refer to the effects on natural and human systems of physical events, of disasters, and of climate change (IPCC, 2012; p.561).

Mitigation: Climate change mitigation refers to any action taken by governments, businesses, or people to reduce or prevent greenhouse gas emissions, or to enhance carbon sinks that remove these gases from the atmosphere (UNDP Climate Dictionary, 2023; p.55).

Resilience: Climate resilience is the capacity of a community or environment to anticipate and manage climate impacts, minimize their damage, and recover and transform as needed after the initial shock (UNDP Climate Dictionary, 2023; p.75).

Risk: The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species (IPCC, https://apps.ipcc.ch/glossary/).

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, https://apps.ipcc.ch/glossary/).

Weather: Weather refers to atmospheric conditions at a particular time in a particular location, including temperature, humidity, precipitation, cloudiness, wind, and visibility. Weather conditions do not happen in isolation, they have a ripple effect. The weather in one region will eventually affect the weather hundreds or thousands of kilometers away (UNDP Climate Dictionary, 2023; p.85).

INTRODUCTION

With almost 68 percent of the global population, expected to reside in cities by 2050, urban areas find themselves on the frontline of climate risks. Soaring temperatures, devastating droughts, raging forest fires, and encroaching sea levels pose a grave threat to city infrastructure, livelihoods, and economies. Moreover, the heavy reliance of cities on fossil fuels intensifies greenhouse gas emissions, exacerbating the climate change impacts they face. Additionally, micro-regional challenges such as urban heat islands, water scarcity, food insecurity, air pollution, and mental health strain from vector-borne diseases burden city dwellers worldwide.

In India, the increasing pace of urbanization and associated challenges are aggravating the chronic stresses of cities making them vulnerable to acute shocks. Cities, being the economic drivers, have the opportunity to provide residents with an improved quality of life with access to better basic service provisions and infrastructure. However, cities are currently underprepared and are struggling to manage shocks like urban floods. Climate change is increasing the probability, frequency and intensity of extreme events, as well as spurring the emergence of new hazards and vulnerabilities with differential spatial and socio-economic impacts. Such phenomena are having a devastating impact on living conditions of people, particularly in areas where the poor and vulnerable population live.

URBAN SANITATION IN A CHANGING CLIMATE

The impacts of climate change are felt through the impacts on the water cycle. This in turn, leads to major secondary impacts for the sanitation chain, especially in the case of sewers which rely heavily on water for transport, treatment, and disposal. Drought, flooding, and other extreme weather events can all undermine the provision of basic sanitation services, with disastrous health impacts for urban populations. During extreme climate-related events, non-resilient urban sanitation systems often lose their ability to deliver essential services due to direct infrastructure damage (from floods, cyclones, and tide surges) or lack of water (e.g., during drought). The sanitation systems become a significant source of chemical and biological contamination of ecosystems, water bodies and soil because of their discharges and pollution overload in the case of flooding and overflows, leading to major public health impacts and increased water scarcity. This contamination may sometimes be irreversible and may also affect areas beyond borders. More gradual climatic changes such as rising sea levels also have an impact on urban sanitation systems. Some coastal communities experience gradual flooding, making their area uninhabitable, damaging infrastructure, and reducing access to sanitation.

In many Indian cities, the urban sanitation systems are not adequately equipped to cope with the effects of current climate variability and are thus vulnerable to direct shocks and stresses caused or exacerbated by climate change, for instance, extreme heat, water scarcity and droughts, increased precipitation, flooding, and extreme weather and rising sea levels. The impacts are considerable on infrastructure, service provision, finance, water cycle, environment, and public health.

Drought and Water Scarcity:

Anthropogenic activities have significantly increased the number of drought years, a trend which is expected to continue due to climate change. Irregularities in dry weather due to extreme drought can cause a severe imbalance in water cycles, resulting in low surface water volumes and groundwater recharge, thus affecting the hydrological systems on which some sanitation systems rely on. At the user-interface level, in conditions of drought and reduced water availability, securing sufficient volumes of water for the normal operation of flush toilets may be challenging. Water scarcity can impact the frequency of flushing, the functionality of the handwashing stations, and the overall cleanliness of the toilet, potentially reducing the level of hygiene by exposing users to faeces, odours, and vectors. Lack of cleanliness of toilets discourages their consistent use; users often prefer investing considerable time and energy in avoiding a toilet rather than suffering the indignity of using a dirty one. Water scarcity and drought have direct and indirect impacts on treatment infrastructure as well.

Erratic rainfall and Flooding:

There is substantial evidence that continued anthropogenic warming has led to an increase in the occurrence, magnitude, and volume of heavy precipitation events. Changes in precipitation alter surface water flows, groundwater levels, and storm events leading to floods, which are among the most damaging and costly natural disasters. Onsite sanitation facilities are vulnerable to flooding and consequently increase the risk to public health and the environment. The typically limited oversight on the design, construction and emptying of decentralised onsite sanitation facilities allows for several points of failure in flood-prone areas. When flooded, the contents of containment systems (e.g., pit latrines, septic tanks) enter the environment, polluting flood waters, groundwater and surface water with contaminants and pathogens, leading to infectious waterborne diseases such as cholera, typhoid fever, and Hepatitis A. This in turn increases morbidity and mortality rates of populations within these flood prone areas. Flooding of onsite sanitation facilities limits households' ability to access a safe toilet, increases its emptying frequency, and leads to its destruction. The drainage systems – often linked to road networks are unable to cope with increased intensity of rainfall, leading to negative impacts on the environment and public health. These often fail during extreme weather events.

Rising sea levels:

Sea levels are expected to rise worldwide as a result of climate change, especially in tropical and subtropical regions. Coastal zones are at a high level of risk, expected to experience inundation, flooding, and erosion. Coastal areas experiencing sea-level rise may become uninhabitable and face water scarcity due to saline intrusion. As sea levels rise, coastal communities experience flooding. Sanitation infrastructure in these areas is at risk of damage and inundation, potentially reducing access to sanitation and increasing exposure to public health hazards.

In the light of the above, integrating climate resilience and sanitation into new and existing sanitation strategies, targets and plans is a much-needed starting point for governments, financing institutions and sanitation authorities to move towards the creation of a climate resilient WASH.

POLICY LANDSCAPE ON CLIMATE RESILIENT WASH IN INDIA

In the context of WASH, the policy framework needed to integrate climate-resilience in WASH infrastructure and services is reflected in the three national WASH related policies-Swachh Bharat Mission-SBM 2.0 or Clean India Mission 2.0, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0, Jal Jeevan or Water for Life Mission with budget outlays of 463 million AUD, 466 million AUD and 1851 AUD respectively, to strengthen scientific method of waste management and improved grey and black water management, ensure 100% water supply coverage of 4,700 cities and provide 100% sewerage-septage management to 500 cities.

While AMRUT 2.0 enables us to negotiate improved water and sanitation infrastructure for the informal settlements, SBM 2.0 enables us to prioritize the needs of women, transgender, sanitary workers, persons with disabilities and tribal populations. In fact, AMRUT 2.0 aims to fund, close to 500 cities under the scheme, with an investment of ₹50,000 crore, over a period of five years. Some of the key thrust areas under AMRUT that every city included in the programme has to engage with include the development of an integrated master plan, development of public transportation infrastructure with a focus on non-motorised forms of mobility, sustainable water management and increasing green spaces within the city.

There are also funds allocated for capacity building of officials of Municipal Corporations. This creates the scope for synergies between the two goals, as well as the integration of planning and reform efforts. It also offers the opportunity to generate awareness about a co-benefits approach to climate action and WASH at the urban level, as well as building capacity of municipal officials to effectively deal with climate change challenges.

The Government of India and the state governments are committed to the implementation of the Sustainable Development Goals (SDGs), including SDG 6 on Water and Sanitation. The idea is to 'leave no one behind' while ensuring equitable access to water and sanitation services which can make a significant difference to the lives of all with the potential to transform the lives of marginalised groups.

THE STUDY

The study aims to assess risks and vulnerabilities faced by marginalised communities in WASH services during extreme climate events, prioritise interventions, and disseminate findings to foster collaboration and develop climate and disaster preparedness strategies for WASH, with a focus on resilience, inclusivity, and sustainability for the most vulnerable populations. The key objectives of the study are:

a. To assess risks from extreme climate events like cyclones, floods, droughts, and heat waves and identify groups most affected by the risks experienced by individuals and as a community in various locations The study aims to analyses the specific vulnerabilities faced by marginalised communities in relation to WASH services in the context of climate change and hazards. By understanding these risks and vulnerabilities, the study aims to prioritise interventions and strategies that address the

b. needs of the most affected groups. B. Disseminating the study's findings to government bodies, experts, civil society organisations (CSOs), and the community through a multi-stakeholder consultation. The study intends to engage relevant stakeholders in a consultative process to address climate-related interventions. The goal is to foster collaboration between the government and the community, leading to the development of climate and disaster preparedness strategies for WASH.

Special attention will be given to marginalised communities as the focal point of the study. By achieving these objectives, the study aims to enhance understanding of the risks marginalised communities face concerning WASH services in the context of climate change and disasters, especially during cyclones, floods, droughts, and heat waves. The findings will inform individual slum/settlement-wise evidence-based policies, programs, and strategies that promote resilience, inclusivity, and sustainability in WASH practices, ultimately benefiting the most vulnerable populations.

RATIONALE

India has made significant progress in improving WASH infrastructure and services, yet struggles with challenges hindering the complete development of climate-resilient WASH infrastructure and services, in particular for informal and so-called unauthorized slum settlements. The project in Bhubaneswar and Jaipur aims to engage with the impact that climate change is having on WASH services in the slums of these two cities. Addressing the climate-related complexities is essential to ensure equitable access to these services amid climate disruptions. Recognising the link between WASH services in informal settlements, climate change, and related hazards is the key. This helps to reduce risks for vulnerable groups like women, girls, elderly, and persons from diverse gender and other marginalised communities including SCs and STs.

In the first phase (2018-2022) of the project, the objective was to establish universal access to WASH services in the slums of Bhubaneswar and Jaipur, with a distinct emphasis on inclusivity and catering to all marginalised groups. This effort particularly concentrated on meeting the unmet needs of vulnerable populations, including persons with disabilities, single women, the elderly, socio- economically disadvantaged communities, as also sexual and gender minorities.

The second phase (2023-2024) focuses on advancing safe and sustainable WASH practices in slums while proactively addressing climate impacts. Notwithstanding progress in establishing basic and safe WASH services, the initiative recognises the need for a comprehensive strategy to enhance resilience in the face of climate change. A pivotal aspect of this phase is the study on Climate Risk Assessment, which identifies vulnerable slum areas and assesses potential climate impacts. Informed by these findings, interventions are prioritised, and adaptive measures will be implemented. Beyond infrastructure, the approach emphasises climate resilience, contamination prevention, and system reliability, particularly during extreme climatic conditions. The initiative seeks a more people-centric and inclusive strategy that navigates the complexities of climate change while addressing community vulnerabilities.

In the light of the above, this study is being conducted in marginalised slum areas of Jaipur and Bhubaneswar cities to identify the potential climatic risks and its impact on WASH services and

infrastructure, to design appropriate local actions for enhancing resilience of the marginalised groups. The study lays special emphasis on understanding the key vulnerabilities of women, children, specially-abled, and so on from the gender and social inclusion lens.

STUDY METHODOLOGY

The methodological framework for this study followed a mixed method approach including secondary literature review on the intricacies of WASH and climate change followed by field level assessments in the slum areas of Jaipur and Bhubaneswar through qualitative and quantitative surveys.

Desk review of secondary data and literature:

In order to get a brief overview of the climate change impacts in the cities of Jaipur and Bhubaneswar, relevant studies and secondary research was reviewed to understand climate change trends in both the cities. Further, relevant research papers and reports were also studied on impacts of climate change on WASH, loss and damages caused by disasters and its relevance to WASH sector, previously conducted Vulnerability Assessment, City Resilience Strategies, Hazard Risk and Vulnerability Analysis (HRVA) of Bhubaneswar (undertaken by Bhubaneswar Municipal Corporation), Climate documentation from the Meteorological Centre, Jaipur, and the Indian Meteorological Department, Government of India. Guidance Notes from Global Water Partnership (GWP), UNICEF, and other bodies on climate change was also referred to during the desk review.

Policy documents such as State Action Plans on Climate Change for the states of Rajasthan and Odisha were reviewed along with related State Disaster Management Plans of both the states which provided relevant insights into the areas of intervention and sectoral planning as envisaged by the state governments.

Data Sources:

Data for this study was drawn from both secondary and primary sources.

Secondary sources included:

1. Census of India, 2011 – Primary Census Abstract and Households by Amenities and Assets table.
2. India Meteorological Department (IMD) – Climate variables and Hazards in Jaipur.
3. Bhubaneswar Municipal Corporation (BMC) – City profiling and data on Water, Toilet seats, collection of wastes, and Desludging services.
4. Jaipur Municipal Corporation (JMC) – Data on Water supply, Toilet seats, collection of wastes, and Desludging services.
5. Climate Resilience Strategy of Bhubaneswar, developed by ICLEI-South Asia
6. Climate data of Jaipur

Primary sources included:

1. Yearly and half-yearly water testing reports.
2. Field-collected primary data, using semi-structured questionnaire and Focus Group Discussions (FGDs).
3. Key Interviews with stakeholders engaged in WASH services.

This comprehensive desk-based review provided insights into climate change and disaster management perspectives at various levels – global, national, state, district, and city. This foundational understanding informs decision-making and the formulation of effective strategies to tackle climate risks and enhance resilience in the study areas of Bhubaneswar and Jaipur.

Analytical Hierarchy Process Methodology:

The Analytical Hierarchy Process (AHP) methodology employed in this study aimed to systematically assess and prioritize key indicators related to Socio-economic Vulnerability (SeVI) and WASH services. This method facilitated the identification of influential factors and its relative importance, contributing to a comprehensive understanding of community resilience and vulnerabilities especially during extreme climate events. The AHP process consisted of the following steps:

- ***Variable Selection and Redundancy Removal:*** Initially, a set of variables was considered for the assessment, encompassing both socio-economic indicators and WASH-related indicators from Census of India, 2011. Redundant variables were identified and removed from the analysis to ensure focus on the most relevant indicators.
- ***Indicator Ranking:*** The remaining indicators were then subjected to a comparison process according to pairs. Each indicator was compared to every other indicator to determine its relative importance in influencing vulnerability.
- ***Calculation of Weights:*** The comparisons generated a matrix of comparison values according to pairs. These values were synthesized to derive the relative weight of each indicators.
- ***Priority Calculation:*** The priority percentage of each indicators was computed based on the derived weights. Higher priority percentages indicated greater vulnerability or importance of the indicator in influencing the phenomenon being studied.
- ***Application to SeVI and WASH-SeVI:*** The priority percentage of indicators obtained through the AHP process was applied to calculate both the socio-economic Vulnerability Index (SeVI) and the WASH-related SeVI. These indices integrated the 'weighted' indicators to quantify vulnerability and resilience in terms of socio-economic conditions and WASH services.

The AHP-generated priorities were used to interpret and understand the implications of each indicator on vulnerability. This informed decision-makers about the relative significance of each factor and guided the identification of targeted interventions. The use of AHP in both SeVI and WASH-SeVI calculations helped tailor interventions to address specific challenges in the context of climate change and other stressors on the existing WASH services in the selected slums.

Risk Scoring Method for Hazard, Vulnerability and Exposure:

The methodology employed to derive the hazard, vulnerability, and exposure indices involved a systematic process of selecting and analysing key indicators that contribute to the hazard, vulnerability, and exposure of communities in the context of climate-related risks. Indicators for these were carefully chosen based on guidance provided by the Joint Report of the Global Water Partnership and the United Nations Children's Fund (GWP and UNICEF, 2017).

The methodology for deriving the 'Risk Scoring' followed a structured process involving hazard classification based on frequency and intensity, data collection for various exposure types, and assigning confidence scores to vulnerability components and assessment factors. This approach ensures a comprehensive understanding of vulnerabilities within the framework of climate-related risks and hazards.

Initially, hazards were classified based on their occurrence frequency and intensity. Data was then organized by exposure type, and separate records maintained for hazards with multiple exposures. Additionally, the hazards sharing the same exposure were treated individually, and confidence scores allocated to vulnerability components in the high-level assessment and assessment factors in the detailed climate assessment. These confidence scores signify the level of risk associated with specific components or factors.

The hazard scoring considered aspects such as current and projected occurrence frequency, changes in frequency, and relevance to specific hazards. Exposure scoring involved criteria like critical infrastructure importance, population density, water source availability, and relevance to particular hazards. Vulnerability scoring encompasses factors like social network strength, risk awareness, adaptive capacity, and alignment with specific hazards. The criteria was further adapted to suit the context and needs of the assessment, thereby facilitating informed decision-making and targeted interventions to enhance resilience and disaster preparedness within socio-economic and WASH-related vulnerabilities.

Qualitative and Quantitative Field Assessments:

After the secondary data and information analysis, the study undertook qualitative and quantitative assessments in the selected slums of Jaipur and Bhubaneswar cities to understand people's perceptions (vulnerable groups) and experiences in the climatic variations in the last couple of decades and its impacts on WASH systems in their communities. Special emphasis was laid on understanding Climate Change-induced WASH vulnerabilities in women, children, especially- abled groups, and so on. Gender and social inclusion lens was also used to draw inferences during the qualitative study.

This was followed by a questionnaire-based spot survey conducted in the same locations. Based on the findings of climate data analysis and qualitative study information, a structured questionnaire was designed. The enumerators in the field were trained in data collection and compilation.

Sampling Methodology for Field Assessments

The qualitative and quantitative survey employed a combination of systematic and purposive sampling techniques to ensure a comprehensive representation of the target populations in both Bhubaneswar and Jaipur.

To select households within each ward and slum settlement, a systematic sampling approach was used. The list of households in each ward and slum was obtained, and a sampling was determined based on the total number of households and the desired sample size. To take at least450 households for each of the cities, 6% of the total slum households in each of the 19 Wards and 24 Wards in Bhubaneswar and Jaipur respectively were selected.

Wards were systematically selected based on the vulnerability and alignment with the research objectives. In order to give immediate attention to areas of higher vulnerability and prioritize interventions, specific priority wards were identified. Purposive sampling was employed to select households within these priority wards, ensuring a focused approach to address pressing issues. Within these selected wards, vulnerable groups such as the Elderly, Persons with Disabilities (PwDs), Sexual and Gender Minorities, Single Women / Widows, Sanitary Workers, along with the General Population were identified to participate in the FGDs.

The combination of systematic and purposive sampling techniques allowed for both a structured representation of households (6%) across wards and slum settlements, as well as a targeted engagement with specific vulnerable groups through the FGDs. This approach ensured that the survey captured a wide range of perspectives and insights related to water, sanitation, livelihood challenges, and WASH-related issues, leading to a more comprehensive understanding of the communities' needs and vulnerabilities related to climate change.

In Bhubaneswar, the survey extended to 455 households across 19 wards (out of 67) and encompassed 49 settlements, including seven priority wards selected for immediate interventions. Additionally, 14 FGDs were conducted to ensure coverage of the population not included in the household survey. Similarly, in Jaipur, the survey included 461 households across 24 wards (out of 150) and covered 49 settlements, involving eight priority wards earmarked for immediate interventions.

Moreover, 13 FGDs were conducted within these wards to capture the population not accounted for in the household survey. These discussions included participation from six different vulnerable groups Elderly, Persons with Disabilities (PwDs), Sexual and Gender Minorities, Single Women / Widows, Sanitary Workers, and the General Population.

Data Analysis and Report Compilation

After the qualitative and quantitative surveys, the data and information gathered was analysed and synthesized to compile the report.

CITY CLIMATE PROFILE: BHUBANESWAR, ODISHA

Bhubaneswar, the capital of Odisha, also known as "City of Temples", is one of fastest growing cities located in eastern part of India. Bhubaneswar is located along the Chennai-Kolkata Highway (NH 5) around 40 km west of North Bay of Bengal in the eastern coastal plains of Odisha on the Mahanadi Delta. It is located on 85° 44' E to 85° 55' E longitude and 20° 12' N to 20° 25' N latitude in Khordha district of Odisha. It lies on western bank of river Kuakhai, which is a tributary of Mahanadi River, 30 km southeast of Cuttack. The city is bound by the river Daya along the eastern part. Enormous hillocks and forest are spread across the northern western and southern parts. Growth is most evident in the north, north-east and south-western parts of the city.

Population, growth trend and population density

The total population of the city (based on Census 2011) is 8,37,737. The percentage rate of growth during 1961-71 was 176%, which declined to 57% during 1991-2001 and subsequently to 27% in the year 2011. The population density of the city is 6,205 persons per sq. km. based on 2011 data, which has increased from 4,800 persons per sq. km. from the previous decade.

Climatic scenario

Bhubaneswar is located 45 meters above the mean sea level. It has a tropical climate, specifically a tropical savanna climate. Sudden afternoon thunderstorms are common in April and May. The average rainfall per year is 1,260 mm and average number of rainy days per year is 72. The relative humidity is 75%. The average temperature in the summer season is 32°C, monsoon season is 22°C, and winter season is 20°C.

The city is mainly impacted by three climatic hazards – increase in temperature, increase in precipitation, and increase in extreme events. These hazards impact several sectors in the city. Further, shortage of water has been identified as a key issue. Water supply is completely handled by Public Health and Engineering Organization (PHEO). 60% of the community has access to safe-drinking water. The lack of access to safe drinking water in a major part of the city and the existing shortage of water supply is resulting in key social, economic and environmental impacts being faced by the city, such as an increase in number of cases of waterborne or other diseases, loss in number of working days, decrease in productivity, depletion of groundwater table, increase in water pollution and so on (Source: City Resilience Strategy, Bhubaneswar, 2013).

Past climatic trends

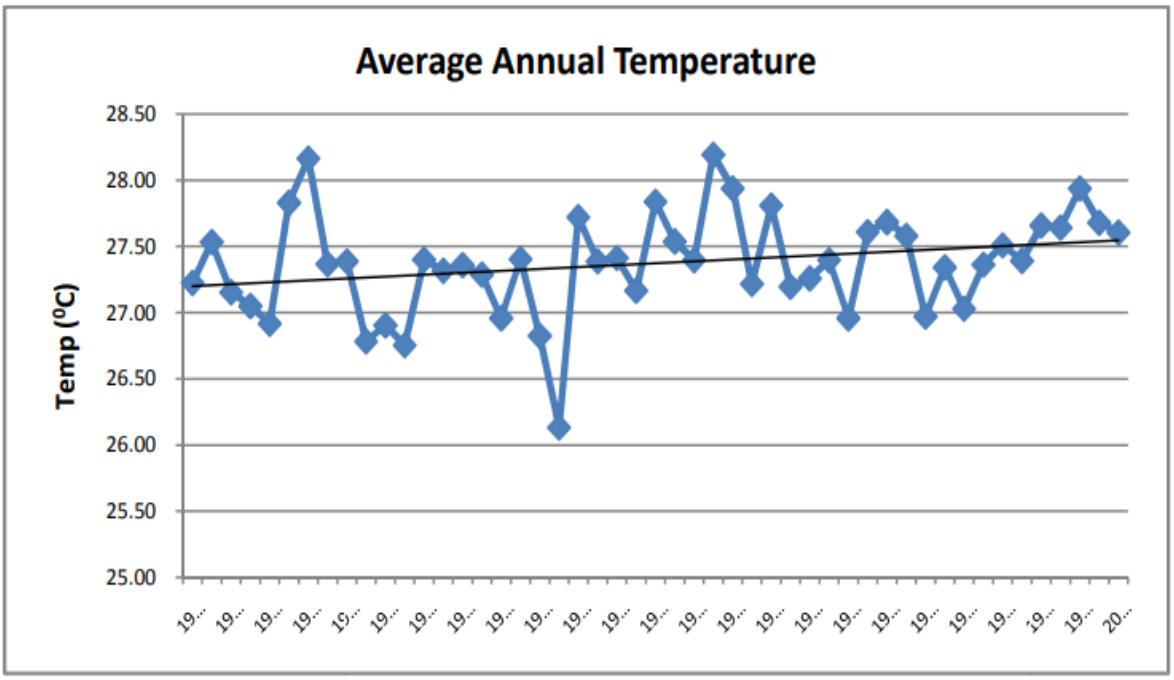
Climatic data trend analysis and projections at the city level are rarely available. Hence, in order to better understand past trends in temperature and precipitation for Bhubaneswar city, preliminary analysis of climatological parameters was undertaken based on historic data available at the India Meteorological Department. Climatological data for Bhubaneswar from the Indian Meteorological Department was used for assessment of past trends and preliminary trend assessment for future. Data from 1952 to 2000 (49 years; monthly time steps) was used for this purpose. The data was checked for missing values and since the data was complete with no missing values, no correction factors were applied to the data set. The analysis has been done for two key parameters: **Temperature and Rainfall**.

Temperature:

Data for Maximum and Minimum temperature for 49 years was analysed separately and annual averages were calculated.

Average Annual Temperature: Maximum and minimum monthly temperature values to arrive at the annual average temperature showed a clear trend of increase in temperatures over time. An average increase of nearly 1^0C in the annual average temperature was observed.

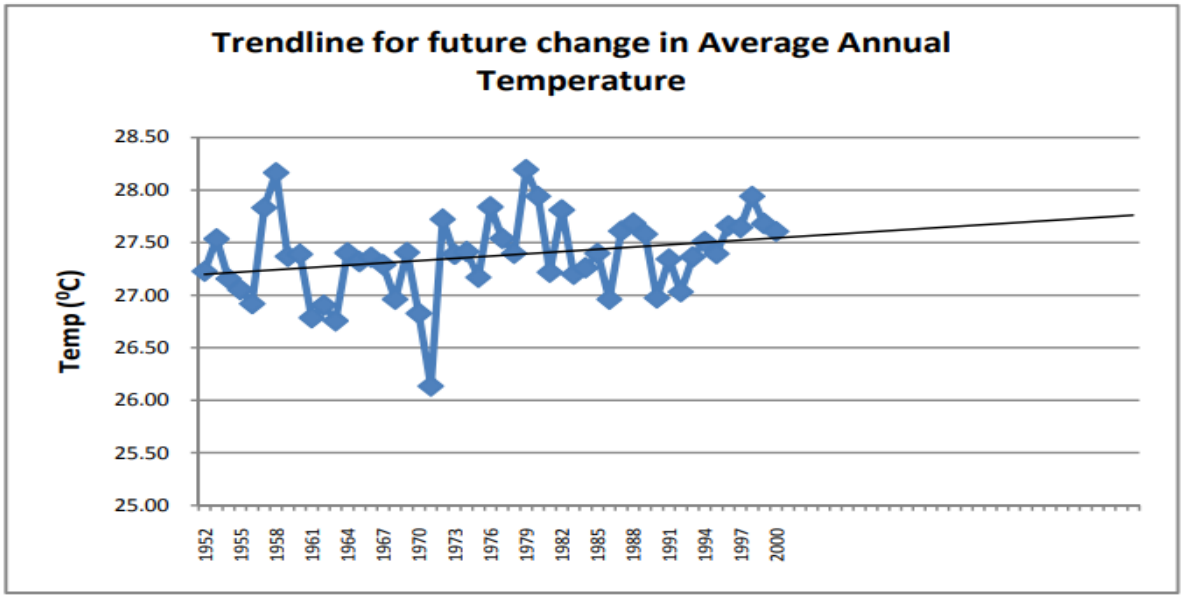
Graph 1: Average annual temperature from 1952 to 2000, Bhubaneswar



Source: Indian Meteorological Department.

b. ***Trend line for Average Annual Temperature:*** A preliminary trend analysis for the annual average temperature for Bhubaneswar showed an increasing trend. Hence, the average annual temperature for Bhubaneswar can show an increase of up to 0.5 ^{0}C over the next 20 years. This can be a crucial determinant for the City Authorities as an increase in average annual temperature can translate into more evapotranspiration losses from the already stressed water resources and increased power consumption for cooling, leading to an increase in power demand for the city in future.

Graph 2: Trendline for future change in average annual temperature, Bhubaneswar

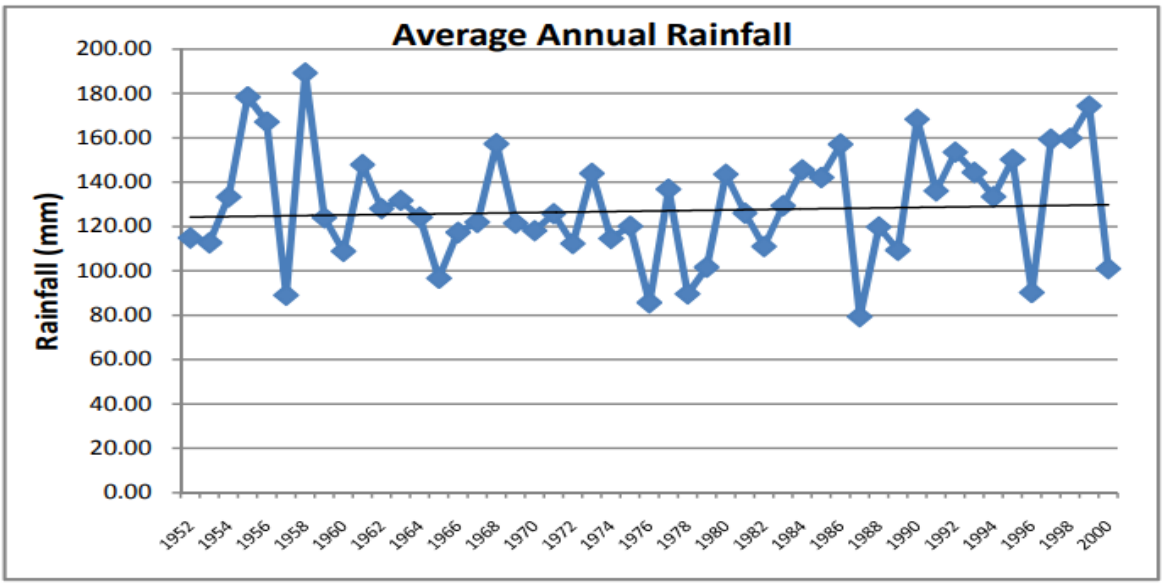


Source: Indian Meteorological Department.

Rainfall:

***Average Annual Rainfall*:** Monthly rainfall data from 1952 to 2000 (49 years) shows the trends in rainfall. The average annual rainfall showed high variability with more than 10% fluctuation in several years. The trend analysis for rainfall data showed a slight increase in average annual rainfall.

Graph 3: Average annual rainfall from 1952 to 2000, Bhubaneswar



Source: Indian Meteorological Department.

Future climatic projections:

For enhancing the climate resilience of a city, it is crucial to understand the future climate change projections for that city to be able to plan development interventions accordingly. Although climatic projections have started drawing lot of attention from the scientific community, the projections being made are mostly national or regional. We still do not have city level projections available for many cities. In the absence of such climatic projections for the city of Bhubaneswar, regional projections have been used for this assessment. In this study the Government of India report called 'Climate Change and India: A 4×4 Assessment' has been referred. Following are the projections made in this report for the Eastern Coast of India. The table below shows the quantum of expected change, the rate of change and the extent of seasonal variability for the Eastern coast of India for precipitation change, temperature change and extreme events. It is based on the A1B scenario of IPCC.

Table 1: Projected Climate Change and Variability in the Eastern Coast of India

Changing Climate Condition	Amount of Expected Change	Geographical Area	Rate of Change	Extent of Variability
Precipitation change	Increase in average annual rainfall in the range of 2 mm to 54 mm in 2030's as compared to 1970's	Eastern Coast	The trend of rainfall in 2030's is showing an increase with respect to the 1970's by 0.2% to 4.4 %	Seasonal Change in 2030 with respect to 1970: MAM – an average increase of 14 mm (maximum increase) Winter rainfall is projected to decrease by 6 mm
Temperature change	Annual average Temperatures are projected to rise in the range of 1.6 to 2.1°C in 2030 as compared to 1970	Eastern Coast	Surface annual average temperature is set to increase from 28.7°C to 29.3°C in the 2030's	The maximum increase in temperature is for MAM ranging from 1°C to 3.3 °C
Extreme events	The frequency of cyclonic disturbances is likely to decrease in 2030 as compared to 1970, however the intensity of these activities might increase	Eastern Coast		

Precipitation change: There is a high probability of an increase in Average Annual Rainfall in the range of 2 to 54 mm in the Eastern Coastal Region by the year 2030. The projected change of an increase from 0.2% to 4.4%, is expected to show an average increase of 14 mm rainfall in March, April and May; a decrease on an average by 6 mm in winter rainfall.

Temperature change: There is a high probability of a rise in Average Annual Temperatures by 1.6 to 2.1°C in the Eastern Coastal Region by the year 2030. The maximum increase in temperature is for March, April and May ranging from 1°C to 3.3 °C.

Extreme events: There is a high probability of decrease in the frequency of cyclonic disturbances in 2030 ranging between 102-134 as compared to 95-144 in June, July, August and September in 1970. However, the intensity of these activities could increase in 2030 between 32.8-34.6 m/s as compared to 31.4-32.4 m/s in 1970 (JJAS).

CITY CLIMATE PROFILE: JAIPUR, RAJASTHAN

Jaipur is located on 26° 55' north latitude and 75° 49' east longitude. Its municipal boundary extends from 26 degrees 46 minutes' north latitude to 27 degrees 01 minutes' north latitude and 75 degrees 37 minutes' east longitude to 76 degrees 57 minutes' east longitude. The city is surrounded by the Nahargarh hills in the north and Jhalana in the east, which is a part of Aravalli hill ranges. To the south and the west of the city are hillocks that are isolated and discontinuous in formation.

The southern end of the city is open to plains and stretches far and wide towards Sanganer and beyond. The walled city was originally located on the rocky stretch to provide an easy drainage system on either side of the city but the future expansion of the city took place to the south and west on the alluvial plains formed in the confluence zone of the Amani Shah nala in the west and Jawahar Nagar nala in the east and beyond.

Climate

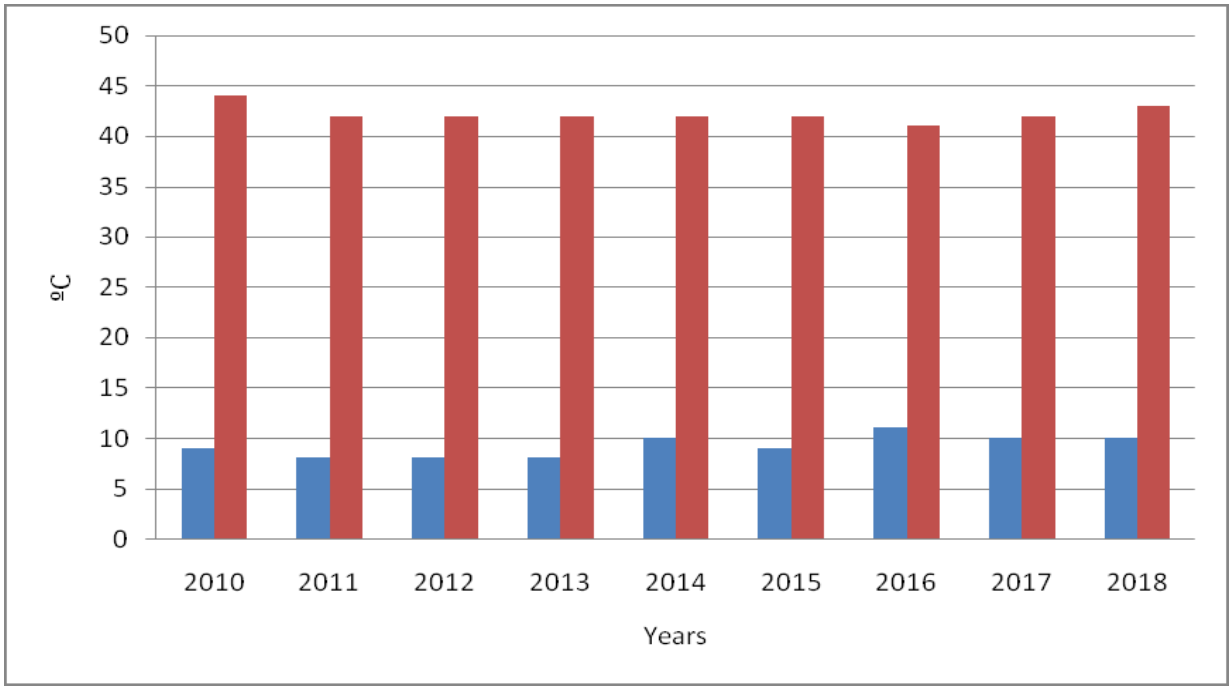
Jaipur is located in the semi-arid zone. It is characterized by high temperature, low rainfall and mild winters. The mean temperature of Jaipur is 36°C varying from 18°C in winter (January) to 40°C in summer (June). Thus, January and June are the coldest and hottest months respectively. The normal rainfall in Jaipur is 600 mm; nearly 90 percent of which takes place in the summer monsoon period i.e. from June to September, the rest comes from the winter cyclones.

Temperature:

The ambient temperatures are at their lowest in January and highest in the month of May. Winters in Jaipur are frigid and stretch from mid-December to mid-February with temperatures hovering between 4-9°C sometimes plummeting to sub-zero under the influence of the northerly winds flowing from the Himalayan region in the north. Prevalence of mist and fog at dawn is a common scenario after the westerlies. The minimum temperatures in the area was 2.2 °C recorded on two instances first on 31 January and next on 1 February in 1905.The maximum temperature recorded in the area was 47.7°C (May 25, 1932). The onset of the summer season is from late March and begins to taper off by the end of June. The summer season starts intensifying in April and peaks in mid- May with maximum temperatures

ranging from 40 to 47 °C. Heat wave influences and increases the average temperature to 4-6 °C. Maximum and minimum temperatures for the last 10 years (from July 2009 to March 2019) years was recorded for the month of May and January respectively (Table 1.2 & Fig. 1.2). The maximum temperature recorded in the last year (2018-2019) was 43°C in the month of May in 2018 and the minimum was 11°C recorded in the month of January, 2019.

Graph 4: Year-wise maximum and minimum temperature from 2010 to 2018, Jaipur.

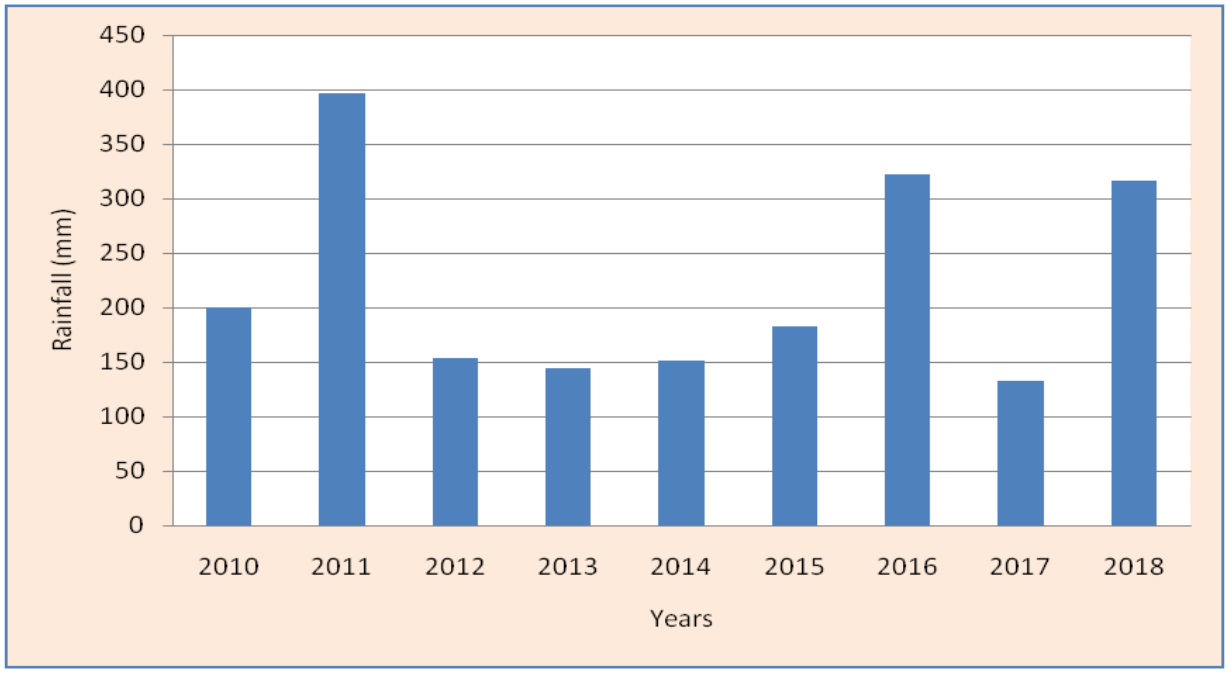


Source: Indian Meteorological Department.

Rainfall:

- The onset of the Monsoon begins from the end of June and declines by mid-September. July and August register heavy rainfall which decreases in October and November.
- These months of decreasing rainfall are termed the transit period. From May onwards rainfall picks up slightly and reaches its peak in the month of August.
- Total annual rainfall variation during the period 2010-2018 ranged between 132.11 mm in 2017 to 396.93 mm in 2011
- During 2010-2018, monthly highest rainfall 170.52 mm was recorded in the month of August, 2011.

Graph 5: Average annual rainfall from 2010 to 2018, Jaipur



Source: Indian Meteorological Department.

SOCIO-ECONOMIC VULNERABILITY INDEX (SEVI) AND WASH-SEVI

The Socio-economic Vulnerability Index (SEVI) is a comprehensive composite indicator that evaluates the vulnerability of populations or regions by considering economic, social, demographic, environmental, infrastructure, and governance factors. By amalgamating various indicators such as poverty rates or socio-economic status, education levels, access to basic services, exposure to natural disasters, and institutional effectiveness, SeVI provides valuable insights into the relative vulnerability of different communities. This analysis helps in getting deeper insights into specific community groups that are most vulnerable and prone to higher degree of vulnerability with the added climate change impacts on them. These communities lack the required resources and resilience capacities to overcome climate shocks and stresses. Therefore, this information aids policymakers in identifying areas and groups that require targeted support and interventions to enhance resilience, promote sustainable development, and foster a more equitable and disaster-resilient future. The comprehensive assessment equips decision-makers with the essential knowledge to prioritise interventions and design targeted policies, reducing the impacts of adverse events and working towards a more robust society.

The socio-economic and WASH vulnerability assessment has considered various indicators at the ward level from Census 2011 to identify vulnerable populations and areas prone to hazard risks primarily due to extreme climate events. These key indicators, encompassing factors such as age, marginalised communities, education, housing conditions, access to basic amenities, and communication facilities, were selected based on their potential impact on communities' vulnerability to cope with climate-related

risks and hazards. By analysing these indicators, the assessment aims to facilitate targeted assistance and support during and after disasters, enabling a more effective disaster response and recovery planning and promoting inclusive and resilient disaster management strategies at the ward level.

Each indicator reflects different dimensions of vulnerability, and taken together, this provides a comprehensive understanding of the socio-economic conditions that influence a community's resilience.

Age is a significant factor in vulnerability assessment as certain age groups, such as the elderly and young children, are often more susceptible to differentiated impacts of climate-induced disasters. Elderly individuals may have limited mobility and health issues, making them less capable of responding to emergencies. In the case of children being still at their development phase are physiologically and metabolically less able than adults to cope with high exposure to climatic hazards. Such exposure also threatens all other aspects of their well-being including psychological health, education, safety and protection, and recreation. Living in cities can present further hazards for those children living in urban poverty, in precarious situations (like slums) with respect to housing, land, basic water and waste management systems, healthcare and emergency services, which can result in increased risks that undermine children's development.

Marginalised Communities including vulnerable populations, such as Scheduled Castes (SC), Scheduled Tribes (ST), and Other Backward Classes (OBC), often face socio-economic disparities and lack access to resources and opportunities. Their marginalization can amplify their vulnerability during disasters due to limited access to information, resources, and services in addition to the existing unequal access to resources due to socio-cultural restrictions on these marginalised groups. Also, such communities are spatially vulnerable too, as they reside in the low lying areas, near railway lines and so on which further exacerbates their vulnerability.

Education level is a determinant both of a community's awareness and preparedness for disaster risks and their ability to understand and follow climate-related disaster response protocols. Communities with higher levels of education may be more informed about climate-related disaster preparedness and better equipped to make informed decisions during emergencies.

The **quality of housing** significantly affects the community's resilience against climate-related challenges. Substandard housing, especially in flood-prone or disaster-prone areas, can increase vulnerability, leading to greater damage and difficulty in recovery after a disaster.

Access to basic amenities such as clean water, sanitation facilities, electricity, and healthcare services plays a critical role in climate-related disaster preparedness and response. Communities lacking these amenities are more vulnerable to health risks and disruptions during disasters.

Effective communication is essential for disseminating early warnings, sharing information, and coordinating disaster response efforts. Communities with limited access to communication facilities like radio, may face challenges in receiving timely alerts and information during disasters.

By analysing these indicators at the ward level, the SeVI and the WASH-SeVI assessment seeks to identify vulnerable populations and areas that are prone to hazard risks. The indicators collectively provide insights into the social, economic, and demographic factors that contribute to vulnerability. This

knowledge enables the authorities and stakeholders to design and implement targeted interventions that address specific vulnerabilities within communities.

The table below provides a detailed list of the key indicators employed in the study:

Table 2: List of Selected Indicators for SeVI and WASH-SeVI assessment

Sl. No.	Indicators	Rationale for Inclusion
1	Age	Number of people falling below 6 years of age are considered as minors and require assistance as they are not self-sufficient. Therefore, they require centralised assistance and support.
2	Marginalised (SCs and STs)	Objective of considering centralised groups are cultural barriers that eventually reduce the social security net, thus increasing the impact of disasters.
4	Lack of Education	Education is the most important indicator for assessment as lack of education is a major gap in development. This increases the impact of disaster.
5	Marginal Workers	Marginal workers have no security of income, savings, and employment benefits, especially in the case of occupational health and safety issues. Therefore, it increases the dependency on others for their livelihood which eventually increases the vulnerability of the marginal workers.
6	Condition of Houses used as Residence	Construction quality of the house is directly linked to risk and capacity. A dilapidated structure indicates a lack of ability to prioritise safety due to various economic and other factors.
7	Source of Drinking Water	The source and quality of drinking water suggest access to basic amenities for survival and health.
8	Electricity Connection	The absence of electricity indicates a lack of capacity, as electricity is necessary for other basic amenities.
9	Availability of latrine	Toilets are an essential requirement for good health and hygiene. Lack of toilets means a higher risk of disease and, as a result, a lower capacity.
10	Availability of drainage	The drainage system is a basic health and hygiene amenity. Lack of Access to drainage outlets, indicates a reduction in capacity.
11	Type of Fuel used for Cooking	The lack of access to basic utilities is reflected in the utilisation of natural sources for cooking. This indicates a greater reliance on aid during and after a disaster.
12	Availing of Banking Services	Lack of access to banking services indicates greater reliance on cash transactions.

13	Availability of Radio	Communication facilities like radio etc. are important for early warning about the situation. Lack of access to information and communication channels reduces response capacities.
14	Availability of Mobile	Mobile is very important for alerting and spreading awareness among people. Lack of access to information reduces the capacity to respond.
15	Ownership of the House	People living in rented properties indicate less access to the benefits of the schemes. Consequently, there is reduced access to assistance post-disasters for recovery.

Source: *Primary Census Abstract and Households by Amenities and Assets table from Census of India, 2011.*

After selecting the indicators, data was gathered from the primary census abstract and household amenities and assets table of the Census of India 2011. The data for the city at the ward level was compiled and normalised to represent percentages of households. A factor analysis was conducted to identify correlations between the variables and eliminate indicators with high correlations to others. After removing redundant variables, the remaining ones were subjected to an analytical hierarchy process (AHP) to determine their weights for socio-economic vulnerability. In the case of Bhubaneswar city, the redundant variables were availing of banking services and type of fuel used for cooking, leaving 13 indicators for the AHP consideration. Similarly, in Jaipur city's case, radio availability was the redundant variable, and the AHP considered the remaining 13 indicators.

The AHP method was utilised to identify indicators with a significant influence on WASH services and to assign weights to these indicators. AHP ranked each indicator compared to others, and priority percentages were calculated accordingly. These priority percentages were then used as weights for the SeVI calculation. Here, the **higher priority percentage shows greater vulnerability**.

In the context of the AHP, priority percentages serve the purpose of establishing the relative significance or weight of individual indicators in relation to one another. AHP functions as a structured decision-making framework that facilitates the systematic evaluation and comparison of multiple criteria or factors, essential for intricate assessments like the Socio-economic Vulnerability Index (SeVI) analysis presented later in this study.

The fundamental objective behind computing priority percentages within AHP was to allocate appropriate weights to each indicator based on its comparative importance in shaping the overall vulnerability assessment. Priority percentages, essentially, offer a quantified representation of the contribution that each indicator makes to the comprehensive vulnerability evaluation. In practical terms, indicators holding higher priority percentages exert greater influence on the final assessment outcome.

Through the calculation of priority percentages, the AHP method ensures that the end evaluation accurately captures the varying degrees of significance among the indicators. This process adds a layer of objectivity and rigour to decision-making, as it translates subjective judgments from comparisons

according to pairs into a quantifiable framework that accurately represents the hierarchy of importance among indicators.

The results of the AHP process for both Bhubaneswar and Jaipur cities are presented in the table below.

Table 3: SeVI indicators with priority percentage and rank

Sl.No.	SeVI Indicator	Bhubaneswar		Jaipur	
		Priority (%)	Rank	Priority (%)	Rank
1	Percentage of illiterate population	12.2	1	17.9	1
2	Percentage of households without access to radio	11.8	2	*	*
3	Percentage of ST population	10.3	3	13.5	2
4	Percentage of households without Mobile	9.7	4	9.1	4
5	Percentage of SC Population	8.8	5	13.1	3
6	Percentage of households without latrine facility	7.9	6	7.3	6
7	Percentage of households without drainage	7.6	7	6.8	7
8	Marginal workers as a percentage of population	7.5	8	8.8	5
9	Percentage population under age of 6 years	7.0	9	4.4	9
10	Percentage of households without ownership of the House (rental)	6.8	10	2.8	13
11	Percentage of households without electricity connection	4.0	11	5.3	8
12	Percentage of households with dilapidated condition of houses used as Residence	3.6	12	3.3	11
13	Percentage of households without treated source of drinking water	2.8	13	3.5	10
14	No access to LPG/ PNG	*	*	2.7	12
15	Total number of households not availing of banking services	*	*	1.5	14

Source: *Primary Census Abstract and Households by Amenities and Assets table, Census of India 2011.* ***Note:*** *Some indicators marked with an asterisk (*) in the table are considered redundant variables and insignificant in this case.*

The table compares SeVI indicators for Bhubaneswar and Jaipur, with priorities and ranks assigned that are based on the percentage of each indicator. In both cities, indicators such as the percentage of illiterate population, lack of access to radio, and the presence of marginalised communities (ST and SC populations)

are identified as significant vulnerability factors and ranked higher in priority. Additionally, indicators related to inadequate infrastructure and essential services, such as access to mobile phones, latrine facilities, electricity, and treated drinking water, also contribute to vulnerability. Addressing these key areas of vulnerability is crucial for enhancing resilience and reducing the impact of extreme climate events and disasters affecting the most vulnerable populations in both cities.

Further, the table also compares WASH SeVI indicators for Bhubaneswar and Jaipur, with priorities and ranks assigned based on the percentage of households affected by specific WASH vulnerabilities. In both cities, the indicators with the highest priorities and ranks are households without latrine facilities and households without drainage. These indicators reflect significant vulnerability in WASH services, more so in the event of climate change impacts and induced disasters. Lack of proper sanitation facilities, including latrines, can lead to increased health risks. As climate change brings about more intense and unpredictable weather events, such as heavy rainfall and flooding, slums with inadequate drainage systems can experience sewage overflow, leading to contamination of water sources and the spread of waterborne diseases like cholera, diarrhea, and typhoid. Women and girls often bear the brunt of inadequate sanitation facilities and the increased burden of care during and after climate-related disasters. They face greater challenges in maintaining personal hygiene and privacy, and their safety is compromised when accessing sanitation facilities located far from their homes. These inferences emphasize the urgent need for targeted interventions in the informal settlements of both Bhubaneswar and Jaipur.

Table 4: WASH-SeVI indicators with priority percentage and rank

Sl. No.	WASH SeVI Indicator	Bhubaneswar		Jaipur	
		Priority (%)	Rank	Priority (%)	Rank
1	Percentage of households without latrine facility	45	1	41.5	1
2	Percentage of households without drainage	43.2	2	38.6	2
3	Percentage of households without treated source of drinking water	11.8	3	19.9	3

Source: *Households by amenities and assets, Census of India 2011.*

Using the AHP weights for each indicator, the SeVI and the WASH SeVI scores are calculated for each ward of Bhubaneswar and Jaipur. Only the intervention wards are mentioned here for reference. The intervention wards for Bhubaneswar and Jaipur are listed in the table with priority wards marked in **bold green**.

Table 5: Ranking, SeVI Score, and WASH-SeVI Score across Selected Wards

SeVI Score and WASH SeVI Score in Selected Wards								
Bhubaneswar				**Jaipur**				
Ward	**SeVI Score**	**WASH SeVI**	**WASH SeVI Rank**	**Ward**	**SeVI Score**	**WASH SeVI**	**WASH SeVI Rank**	**New Wards**
49	0.209	0.057	1	63	0.150	0.006	1	93
23	0.213	0.071	2	60	0.119	0.007	2	139
19	0.195	0.079	3	9	0.106	0.007	3	24
26	0.209	0.106	4	**62**	0.150	0.008	4	**99**
11	0.210	0.115	5	45	0.159	0.011	5	108
42	0.208	0.122	6	**6**	0.118	0.011	6	**18**
22	0.207	0.137	7	26	0.120	0.013	7	41
18	0.214	0.149	8	**51**	0.164	0.016	8	**110, 113**
20	0.232	0.168	9	50	0.141	0.017	9	123
21	0.235	0.190	10	**3**	0.132	0.019	10	**6**
24	0.250	0.197	11	68	0.163	0.026	11	76
38	0.253	0.224	12	30	0.148	0.032	12	54
46	0.270	0.231	13	10	0.118	0.033	13	27
9	0.244	0.251	14	58	0.126	0.040	14	79
5	0.247	0.264	15	**67**	0.174	0.045	15	78, **84**
37	0.263	0.282	16	25	0.156	0.046	16	37
30	0.266	0.289	17	43	0.142	0.047	17	80
43	0.269	0.302	18	42	0.168	0.055	18	147
27	0.269	0.306	19	24	0.155	0.066	19	35
57	0.271	0.430	20	23	0.159	0.070	20	32
66	0.257	0.457	21	54	0.197	0.081	21	132
63	0.286	0.501	22	55	0.191	0.091	22	77
16	0.367	0.573	23	**4**	0.165	0.100	23	**7**
				11	0.157	0.242	24	35
				49	0.226	0.281	25	114
				31	0.256	0.402	26	53

Source: *Primary Census Abstract and Households by Amenities and Assets table, Census of India 2011.*
Note: *Ward numbers in bold **Green** and filled in grey are chosen as Model Wards through FGDs and Surveys.*

The table presents data on SeVI and WASH SeVI scores that focus on the vulnerability related to water, sanitation, and hygiene services. The scores range from 0 to 1, with higher values indicating higher vulnerability and greater challenges faced by the communities in these wards. These scores are essential

for identifying areas that require targeted interventions and resources to enhance the resilience of vulnerable populations.

For selected wards of Bhubaneswar, the SeVI Scores range from 0.195 to 0.367, and the WASH SeVI Scores range from 0.057 to 0.573. For Jaipur, the SeVI Scores range from 0.106 to 0.256, and the WASH SeVI Scores range from 0.006 to 0.402.

The higher SeVI scores and WASH SeVI scores in these particular wards can be explained by their geographical characteristics, including the low-lying location, hilly areas with high down slopes, and having a river or forest in their area. The wards experience a higher level of vulnerability, specifically on issues of water, sanitation, and hygiene factors, compared to the broader socio-economic context. The variation in the score ranges and the higher vulnerability in the WASH indicators table emphasise the need for targeted interventions and resources to address these specific challenges and ensure improved access to adequate WASH services in these wards.

While examining WASH indicators, it was found that 53% of households in Bhubaneswar (Census of India, 2011) relied on untreated water sources, and 25% lacked access to latrine facilities. While for Jaipur, it is 16% and 5% respectively. These statistics highlight the pressing need for interventions to address these issues and improve the living conditions of the urban poor. The analysis revealed that the wards with high SeVI scores were not only highly vulnerable but also exhibit greater vulnerability, particularly concerning WASH indicators. These results highlight the pressing necessity to address WASH-related vulnerabilities in these wards and enhance the overall living conditions of the residents. Immediate attention and targeted interventions are essential to mitigate the risks and improve the resilience of these communities to cope with potential disasters and climate-related challenges.

The AHP was utilised to establish the relative importance or weight of various indicators within the SeVI) and the WASH-related SeVI assessments. These indicators were chosen based on their potential influence on community vulnerability to cope with climate-related risks and hazards. By integrating AHP with SeVI and WASH SeVI, the analysis provided a comprehensive understanding of the vulnerability of communities to various risks, hazards and climate-related stressors, enabling informed decision-making and targeted interventions to enhance resilience and disaster preparedness.

Risk represents the potential for outcomes or consequences when something valuable is at stake, and the outcome is uncertain, considering the diversity of values involved. It is commonly depicted as the combination of the probability of hazardous events or trends occurring multiplied by the magnitude of their impacts. In assessing risk, consideration is given to the likelihood of events and their potential consequences, acknowledging the varying perspectives and importance placed on different values.

The Risk Index combines hazards, vulnerability, and exposure assessments to measure potential risk comprehensively. It considers the probability and magnitude of hazards, vulnerability factors, and the presence of assets and populations in vulnerable areas. The index helps prioritise resources, develop mitigation strategies, and implement targeted interventions to reduce risk and enhance resilience.

Hazards:

In this report, the term "hazard" refers to the possible manifestation of a natural or human-induced physical event, trend, or its resulting impact that has the potential to cause loss of life, injury, health impacts, damage, and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. Specifically, when discussing hazards, the focus is primarily on climate-related physical events, trends, or their associated physical impacts.

Table 6: Hazards Index for Bhubaneswar and Jaipur

Hazards	Bhubaneswar	Jaipur
Flooding	2	2
Water Scarcity	1	2
Heat wave	2	3
Groundwater depletion/ contamination	3	2
Disease outbreak	2	2
Tropical Cyclone	2	NA

Note: The risk index values represent the level of risk associated with each hazard, with higher values indicating higher risk. For Tropical Cyclone in Jaipur, the risk index value is not applicable.

The table presents the Hazards Risk Index for Bhubaneswar and Jaipur, indicating the relative level of risk associated with different hazards in each city. Bhubaneswar and Jaipur both have a Risk Index of 2 for Flooding and Disease outbreaks, signifying a moderate level of risk. Water Scarcity and Groundwater depletion/contamination have a Risk Index of 1 and 3 in Bhubaneswar and 2 and 2 in Jaipur, respectively. Heat wave has a Risk Index of 2 in Bhubaneswar and 3 in Jaipur, suggesting a higher risk. Notably, the Risk Index for Tropical Cyclone in Bhubaneswar is 2 and is not applicable to Jaipur.

To summarise, groundwater depletion/contamination turned out to be the major hazard in Bhubaneswar while in Jaipur, heat wave impacts were seen to be greater risk.

Climate change impacts in Odisha have been manifesting in the form of water scarcity, drought, floods, groundwater depletion, etc. In 4 years, between 2013 and 2017, the groundwater extraction has increased from 30 to 42 per cent, There has been a massive increase in annual groundwater extraction. On the other hand, there has been a reduction in annual groundwater recharge and a considerable depletion in the annual extractable groundwater resources. According to the Central Ground Water Board (CGWB), Odisha's groundwater volume was assessed at 16.69 cubic metres in 2009. This has dropped to 15.57 cubic metres in 2017, leading to a loss of 1.12 billion cubic metres (6.71 per cent) of groundwater.

While unmindful use of water for domestic and commercial purposes is the reason behind exhaustion of groundwater, it is further catalysed by prolonged dry spells, extreme precipitation events resulting in run-off, massive deforestation and concretisation. Water scarcity is a significant contributor to WASH vulnerabilities, especially of marginalised community groups residing in informal settlements and slum colonies.

In Jaipur, higher temperatures and more intense heat waves are becoming increasingly frequent due to climate change resulting in urban heat islands in many pockets of the cities. With a constant decline in green cover and degenerated waterbodies, the city is exposed to extreme heat conditions. The slum communities have greater exposure to extreme heat, and residents are more susceptible to its negative health effects, having fewer options available to adapt to rising temperatures. All of these factors increase vulnerability to heat and result in greater impacts on these communities. Identifying the specific factors that increase exposure and vulnerability to extreme heat is necessary to craft targeted recommendations for building resilience to future heat events.

Exposure:

Exposure refers to the presence of individuals, livelihoods, species, ecosystems, environmental functions, services, resources, infrastructure, or economic, social, and cultural assets in locations and settings that have the potential to be negatively impacted. It entails being situated in areas that are susceptible to adverse effects from various hazards or risks.

Table 7: Exposure Index for Bhubaneswar and Jaipur

Component	Possible indicators of exposure	Bhubaneswar	Jaipur
Physical Infrastructure	Critical Infrastructure	2	2
Environmental	Location of settlements	3	2
	Ground Water contamination	2	2
	Prevalence of extreme weather events	2	2
Human	People affected	1	2
	Quality of water	2	2
	Open drainage	3	2
	Open Defecation	1	2
	Maintenance of the system	1	2
	Disease outbreak	3	3
Financial/ Economic	Effect on livelihood: Source of income disruption	2	2

Note: *The risk index values represent the level of risk associated with each exposure, with higher values indicating higher risk.*

The table compares the Exposure Risk Index, evaluating potential exposure to various hazards based on different components. In Bhubaneswar, moderate exposure was observed for critical infrastructure and settlement locations, while higher exposure was seen for groundwater contamination, open drainage, and disease outbreaks, which correlated with the above findings on hazard risks in these cities. Jaipur also exhibited moderate exposure to critical infrastructure and settlement locations, with higher exposure to people affected, water quality risks, open drainage, and disease outbreaks. Understanding these exposure levels helps in devising targeted strategies to mitigate hazards and enhance resilience in both cities.

Vulnerability:

Social scientists and climate scientists often attribute different meanings to the term "vulnerability." For social scientists, vulnerability signifies the combination of socio-economic factors that influence individuals' capacity to withstand stress or adapt to change. On the other hand, climate scientists perceive vulnerability as the probability of weather and climate-related events occurring and their potential impacts. These divergent perspectives on vulnerability reflect the multidimensional nature of the concept and highlight the importance of interdisciplinary collaboration to address vulnerabilities in the context of climate change comprehensively (Brooks, 2003).

In the context of climate change and WASH services, the differing perceptions of vulnerability between scientists are crucial. Social scientists focus on socio-economic factors that can help identify vulnerable populations in terms of their ability to cope with climate-related stressors, such as extreme weather events affecting WASH services. On the other hand, climate scientists emphasise the likelihood and impacts of such events, providing insights into the potential risks to WASH infrastructure. By combining both perspectives, policymakers and practitioners can develop comprehensive strategies to enhance the resilience and adaptability of WASH services, considering the socio-economic vulnerabilities of communities and the climate-related risks they may face.

Table 8: Vulnerability Index for Bhubaneswar and Jaipur

Component	**Possible indicators of Vulnerability**	**Bhubaneswar**	**Jaipur**
Environmental	Water quality	2	2
	Protected water sources	2	2
	Alternative sources of water	1	2
	Alternative source of sanitation	2	3
Social	Access to social safety nets	2	2
	Community-based risk assessments	3	3
	Community engagement in early warning systems	2	2
Physical	Technology for WASH infrastructure	3	3
	Construction standard of WASH infrastructure	2	2
	Design standard for water supply	2	2
	Water storage infrastructure	3	2
Human	Percentage (%) of young people	1	1
	Understanding of local hazards	2	2
	Understanding of WASH benefits	3	2
Financial/ Economic	WASH sector investment	3	3
	Livelihoods	2	2

Note: *The risk index values represent the level of risk associated with each vulnerability, with higher values indicating higher risk.*

The table presents the Vulnerability Risk Index, evaluating the level of vulnerability to various factors affecting WASH services. In both cities, the Environmental component had a Risk Index of 2, indicating a moderate level of vulnerability concerning water quality and protected water sources. In Bhubaneswar, the Human component had a Risk Index of 1, suggesting lower vulnerability in terms of the percentage of young people. The Social component in both cities had a Risk Index of 2, reflecting moderate vulnerability in terms of access to social safety nets and community-based risk assessments.

The Physical component had a Risk Index of 3 in both cities, indicating higher vulnerability concerning technology and construction standards of WASH infrastructure. The Financial/Economic component had a Risk Index of 3 in both cities, suggesting higher vulnerability in terms of WASH sector investment. Understanding these vulnerability levels can aid in developing targeted strategies to enhance resilience and minimise the potential impacts on WASH services in both Bhubaneswar and Jaipur.

The following tables provide a comprehensive assessment of various hazards in Bhubaneswar and Jaipur, respectively, along with their corresponding risk scores and ranks. The risk scores are determined by evaluating each hazard's exposure, vulnerability, and overall impact.

The hazards are categorised into different dimensions, such as Physical, Environmental, Human, and Financial/Economic. These tables provide valuable insights into the relative risks posed by different hazards in Bhubaneswar and Jaipur, aiding in prioritising interventions and planning strategies to enhance resilience and mitigate the adverse effects of these hazards on the city.

An example can be observed as follows: the resulting risk score of 18 in the initial column is calculated by multiplying the Hazard score (Tropical Cyclone "2") with the Exposure score (Physical "3"), and the Vulnerability score (Physical "3"). In other words, 2 multiplied by 3, and then multiplied by 3, equals 18.

Table 9: Risk Assessment for Bhubaneswar: Hazard, Exposure, Vulnerability, and Risk Scores

Bhubaneswar				
Description			**Risk score**	**Rank**
Hazard	**Exposure**	**Vulnerability**	**Hazard x Exposure x Vulnerability**	**Calculated from Risk score**
Tropical Cyclone	Physical	Physical	18	**1**
Tropical Cyclone	Financial/ Economic	Financial/ Economic	18	**1**
Groundwater	Physical	Physical	18	**1**
Groundwater	Environmental	Environmental	18	**1**
Flooding	Physical	Physical	12	**2**
Flooding	Environmental	Environmental	12	**2**
Tropical Cyclone	Environmental	Environmental	12	**2**
Heat wave	Physical	Physical	12	**2**
Heat wave	Financial/ Economic	Financial/ Economic	12	**2**
Groundwater	Human	Human	12	**2**

Disease outbreak	Environmental	Environmental	12	**2**
Disease outbreak	Financial/ Economic	Financial/ Economic	12	**2**
Groundwater	Financial/ Economic	Financial/ Economic	9	**3**
Flooding	Human	Human	8	**4**
Flooding	Financial/ Economic	Financial/ Economic	8	**4**
Tropical Cyclone	Human	Human	8	**4**
Heat wave	Environmental	Environmental	8	**4**
Disease outbreak	Human	Human	8	**4**
Water scarcity	Physical	Physical	6	**5**
Disease outbreak	Physical	Physical	6	**5**
Water scarcity	Environmental	Environmental	4	**6**
Water scarcity	Human	Human	4	**6**
Heat wave	Human	Human	4	**6**
Water scarcity	Financial/ Economic	Financial/ Economic	3	**7**

In Bhubaneswar, topping the list are hazards such as **tropical cyclones, groundwater, and flooding**, all with a risk score of 18, placing them at rank 1. These hazards possess high physical and financial/economic exposure and vulnerability. Following closely behind are flooding, tropical cyclones, heat waves, and disease outbreaks, with risk scores of 12, putting them at rank 2 due to their significant impact on both physical and environmental aspects. Hazards like groundwater, flooding, and tropical cyclones, with risk scores of 9, 8, and 8, respectively, occupy rank 3 and are mainly associated with human and financial/economic vulnerabilities. lastly, hazards with risk scores of 6, 4, and 3, such as water scarcity, heat wave, and water scarcity, are placed at rank 5, 6, and 7, respectively, highlighting their relatively lower overall impact.

Table 10: Risk Assessment for Jaipur: Hazard, Exposure, Vulnerability, and Risk Scores

Jaipur				
Description			**Risk score**	**Rank**
Hazard	**Exposure**	**Vulnerability**	**Hazard x Exposure x Vulnerability**	**Calculated from Risk score**
Water Scarcity	Environmental	Environmental	27	**1**
Heat wave	Physical	Physical	27	**1**
Heat wave	Environmental	Environmental	27	**1**
Heat wave	Financial/ Economic	Financial/ Economic	27	**1**
Groundwater	Physical	Physical	27	**1**
Groundwater	Environmental	Environmental	27	**1**
Disease outbreak	Environmental	Environmental	27	**1**
Disease outbreak	Financial/ Economic	Financial/ Economic	27	**1**

Flooding	Physical	Physical	18	**2**
Flooding	Environmental	Environmental	18	**2**
Flooding	Financial/ Economic	Financial/ Economic	18	**2**
Water Scarcity	Physical	Physical	18	**2**
Water Scarcity	Financial/ Economic	Financial/ Economic	18	**2**
Groundwater	Financial/ Economic	Financial/ Economic	18	**2**
Disease outbreak	Human	Human	18	**2**
Flooding	Human	Human	12	**3**
Water Scarcity	Human	Human	12	**3**
Heat wave	Human	Human	12	**3**
Groundwater	Human	Human	12	**3**
Disease outbreak	Physical	Physical	9	**4**

In Jaipur, hazards like **water scarcity, heat waves, groundwater, and disease outbreaks** all have a risk score of 27, making them the top-ranking hazards at rank 1. These hazards exhibit high exposure and vulnerability in both physical and environmental aspects. Following closely are flooding and water scarcity, each with a risk score of 18, placing them at rank 2, primarily due to their significant physical and financial/economic exposure. Groundwater, disease outbreaks, and heat waves, with a risk score of 12, occupy rank 3, mainly concerning human vulnerabilities. Disease outbreaks, with a risk score of 9, are placed at rank 4, having a relatively lower impact.

QUALITATIVE ASSESSMENT

In the slums under study of Bhubaneswar and Jaipur, the convergence of inadequate sanitation infrastructure, extreme weather events, and the impacts of climate change have given rise to a range of interconnected challenges affecting the health and well-being of communities. The lack of proper sanitation facilities and hygiene practices, further hindered by extreme weather events, have created an environment conducive to disease vectors. Stagnant water, poor sanitation, and limited access to clean water has contributed to an increased risk of waterborne diseases and other health issues.

Climate change exacerbates the spread of vector-borne diseases, such as dengue and malaria, as heightened temperatures and altered rainfall patterns lead to increased mosquito breeding in stagnant water. Disrupted water supply infrastructure and contaminated water sources during extreme weather events like heavy rainfall, flooding, and cyclones further compound the problem, leading to outbreaks of waterborne diseases. Rising temperatures and heat waves also amplify water demand, putting additional strain on already scarce water resources.

The Theme-wise key findings from the qualitative assessment are summarised as below:

Lack of access to clean drinking water

Access to clean water is limited, with households receiving water only twice a day for a short duration. Quality testing of supplied water is absent in some cases, raising concerns about health risks associated with drinking untreated water.

Lack of sanitation infrastructure

Sanitation infrastructure also faces serious challenges. Lack of individual toilet facilities and open defecation due to inadequate toilet infrastructure are common problems. Climate change worsens these issues, as increased rainfall and flooding can damage or render toilets unusable, leaving communities vulnerable to sanitation-related health risks. Moreover, waterlogging also induces mixing of faecal matter, contaminating the water sources, and resulting in spread of waterborne diseases.

Inadequate drainage system

Inadequate drainage systems are a major concern during the monsoon season, resulting in overflowing of wastewater that contaminates living spaces and affects vulnerable groups like children and the elderly. This leads to the spread of waterborne diseases, increased mosquito breeding, and health risks for vulnerable populations. Drains passing through settlements become contaminated, further deteriorating water quality and increasing disease transmission. Even where sanitation infrastructure exists, improper usage practices and inadequate disposal of waste contribute to the contamination of water sources.

Lack of sewage management systems

Largely, the colonies are not connected with the city's sewage management systems. Some households have constructed septic tanks independently to compensate for the lack of proper sewer connections. Communities have taken the initiative to manage these issues, often resorting to self-help measures due to delays in official support.

Groundwater contamination

Groundwater contamination is another significant concern. Inadequate infrastructure and poor drainage systems leads to groundwater contamination during heavy rainfall, jeopardizing the health of the population. Climate change-induced extreme weather events exacerbate these issues, as contaminated water from drains and sewers can seep into groundwater sources.

Unhygienic conditions

Lack of proper sanitation, drainage, and hygiene facilities creates unhygienic conditions, affecting the health and well-being of slum communities, particularly during disasters. Inadequate disposal of menstrual waste, lack of proper handwashing facilities, and poor hygiene practices disproportionately impact women and girls.

Reliance of other water sources

Communities are often forced to rely on alternative water sources like rivers, ponds, or private tankers, which often do not meet safety and cleanliness standards, especially during climate-related disasters. Initiatives by some communities, such as setting up community bore wells, aim to mitigate water challenges, but these efforts are often insufficient in the face of climate impacts.

In a nutshell, in both Bhubaneswar and Jaipur, several settlements grapple with inadequate access to safe drinking water and sanitation facilities, and the effects of climate change further amplify these challenges. While households in some areas have access to piped water supply from the government, the availability and quality of water is marred by issues like water scarcity, irregular supply, and contamination during extreme weather events.

Heavy rainfall and flooding can damage water supply infrastructure, leading to disruptions in the supply of clean drinking water. Contaminants from drains, waste dumping sites, and damaged pipelines can degrade water quality, posing serious health risks, particularly for vulnerable groups such as children, the elderly, pregnant women, and people with disabilities.

Inadequate government response, poor infrastructure maintenance, and lack of alternatives further magnify the impact of climate-related hazards. Addressing these interconnected issues requires comprehensive strategies that consider the intersection of climate change, urban development, and public health, ensuring the resilience and well-being of these communities in the face of an increasingly uncertain climate future.

WASH Vulnerabilities for Specific Vulnerable Groups

The settlements, located in areas susceptible to climate change impacts, demonstrate vulnerabilities in their water and sanitation services. These vulnerabilities affect specific groups within the communities:

Women and children were disproportionately affected by climate-induced challenges. The increased risk of waterborne diseases due to flooding and water contamination directly impacts their health and well-being. Flooding and waterlogging disrupt daily routines, making it harder for women to maintain hygiene practices and manage household responsibilities. Children were at a heightened risk of illnesses from inadequate sanitation and contaminated water sources.

In the face of changing weather patterns and inadequate water supply systems, women in the communities found themselves burdened with additional responsibilities. Chandrama Panda's experience in Sabar Sahi, Bhubaneswar Ward 46, highlights how women often take on the task of boiling water to ensure that their families have safe drinking water after heavy rainfall leads to muddy water in the pipeline. This extra effort ate into their time and also affected their overall well-being.

Moreover, the lack of proper sanitation facilities disproportionately affected women's privacy and dignity. Rajeswari Gouda of Jharana Sahi shared that reliance on neighbours for water storage due to work timings further highlights the challenges women face in managing their households and daily routines.

Children, being one of the most vulnerable groups, suffered from the impacts of climate change on water, sanitation, and hygiene services. Open defecation due to insufficient toilet facilities, as observed in

Kedarapalli, Bhubaneswar Ward 53, exposed them to various health risks and infections. The unclean surroundings resulting from inadequate sanitation facilities posed a threat to their overall health and development.

The elderly and people with disabilities faced increased difficulties during extreme weather events. Their limited mobility made it challenging for them to access safe water and sanitation facilities, particularly when flooding occurs. They were more susceptible to health risks associated with unsanitary conditions and contaminated water sources, exacerbating their vulnerability.

The elderly members of these communities faced unique challenges due to the interplay between climate change and water and sanitation services. Golap Sahoo's observations in Kalpana Flat Basti drew attention to the heightened concerns of the elderly about the safety of hand pump water, which can have serious health implications on them. Sahadev Reedy's reflections in Ward-26 highlight the vulnerabilities of elderly residents during climate-related disasters when water supply systems fail. These challenges impacted their mobility, health, and overall quality of life.

Climate change impacts tend to compound the challenges faced by disabled individuals when it comes to accessing water, sanitation, and hygiene services. Urmila's experience in Jaipur Ward 123 underscores the additional difficulties for people with visual disabilities in obtaining water during the rainy season, emphasizing the need for tailored and inclusive solutions. Renu's concerns about the physical toll on disabled individuals of manual cleaning of grey water pits spotlight the importance of considering their unique needs when designing sanitation systems.

Settlements situated in low-lying areas faced a higher risk of flooding and waterlogging. These challenges affected all socio-economic groups residing in these areas, regardless of their financial status. The lack of climate-resilient infrastructure and sanitation facilities disproportionately affected marginalised communities with limited resources, exacerbating existing social inequalities.

The physical location of settlements plays a significant role in shaping their vulnerability to climate change impacts. Chayya Sabar's insights from Sabar Sahi, Bhubaneswar Ward 46, emphasize how low-lying areas are particularly susceptible to waterlogging and related health risks during monsoons. In densely populated spaces, challenges are compounded as limited drainage systems struggle to cope with heavy rainfall. Similarly, Santosh's observations in Jaipur Ward 113 shed light on how varying localities experience shifts in climate patterns differently, affecting residents' daily lives and livelihoods based on their geographical context.

Socio-economic disparities magnify the effects of climate change on marginalised communities. The struggles of construction workers and labourers, highlighted by Kusa Bhoi in Laxmisagar Tala Sahi of Jaipur Ward 31, highlight how those reliant on daily wages face significant income losses due to weather disruptions, particularly during heavy rainfall and heat waves. Additionally, low-income families were caught in a cycle of heightened medical expenses due to climate-related health issues, leaving them economically vulnerable and struggling to meet basic needs. The unequal distribution of resources compounds the challenges faced by these groups in adapting to the additional burdens posed by climate change impacts on water, sanitation, and hygiene services.

Vulnerable individuals, such as PwDs, elderly residents, pregnant women, and children, experienced difficulties in accessing water sources and maintaining proper hygiene practices. The timing of the water supply has become an inconvenience, especially for those with limited mobility or special needs, hindering their ability to access water during specific hours. In Bhubaneswar's Ward 5, communities residing near the Kuakhai River were particularly vulnerable to the impacts of climate change on Water, Sanitation, and Hygiene (WASH) services. This vulnerable group includes elderly individuals, pregnant women, persons with disabilities (PwDs), and children. These residents are situated in low-lying areas, which renders them susceptible to flooding, waterlogging, and health risks. Due to their socio-economic disadvantages, these communities were disproportionately affected by the changing climate.

The impact of seasonal change is evident through their exposure to frequent flooding during the monsoon season. Erratic and intense rainfall patterns, attributed to climate change, lead to river overflow and subsequent flooding in the area. This has put their WASH infrastructure at risk, causing damage to toilets, water supply systems, and sewage facilities. The semi-pucca and kutcha housing structures in this region are especially prone to damage during floods, further deteriorating the access to proper sanitation and clean water.

In Bhubaneswar's Ward 23, residents of Khandagiri Bari were also severely affected. Particularly, marginalised communities, such as Scheduled Castes, remain at heightened risk due to their spatially vulnerable location and socio-economic disadvantages. Their limited resources and social vulnerabilities have made them more susceptible to the adverse impacts of climate change on WASH services.

These communities often live in flood-prone areas and experience greater exposure to climate hazards such as increased flooding and extreme weather events. Discriminatory practices, including water access prioritization based on caste, further exacerbate their challenges. Clean water availability has become even more scarce during climate events like droughts or prolonged dry spells. Additionally, inadequate sanitation amenities and open defecation practices expose them to health hazards.

The intersection of climate change impacts and caste discrimination has intensified health risks among these marginalised groups. They face a higher vulnerability to waterborne diseases and infections, particularly during and after climate-related disasters when proper hygiene practices are crucial. Due to their being excluded from essential resources and services, including disaster relief and evacuation plans, these marginalised communities have limited capacity to cope with and recover from climate-related challenges. Discrimination has directly violated their fundamental human rights to equality, dignity, and access to basic services like clean water, sanitation, and healthcare.

Climate-related disasters, such as floods, can lead to temporary or even permanent displacement of communities. This situation has disrupted access to WASH services and facilities. Displaced residents often face inadequate sanitation and hygiene conditions in temporary shelters, further compromising their well-being and health.

The vulnerability of these specific groups is intertwined with the overall challenges faced by the settlements. Climate change impacts, such as flooding and water contamination, intensified the risks they already faced due to inadequate infrastructure and resources. The situation emphasized the urgent need

for targeted interventions that prioritize the needs of these vulnerable groups to ensure equitable access to clean water, sanitation facilities, and hygiene services.

In summary, vulnerable groups within these communities experienced multifaceted challenges stemming from climate change impacts on water, sanitation, and hygiene services. These challenges extend beyond physical discomfort to encompass health risks, economic burdens, and disruptions to daily routines. Addressing these issues requires tailored solutions that consider the diverse needs and vulnerabilities of these groups, emphasizing the importance of holistic and equitable strategies for building resilience in the face of changing climatic conditions.

QUANTITATIVE ASSESSMENT

The total number of observations, as households in the quantitative survey sample, was 455 for Bhubaneswar and 461 for Jaipur. A questionnaire- based quantitative assessment was held to understand the WASH related vulnerabilities in slum communities in the light of climate change impacts and induced disasters.

The key findings from the quantitative assessment are as below:

Spatial location of slums:

The distribution of households across slum settlements in Bhubaneswar and Jaipur was categorised on the basis of different geographical features. This data offers insights into urban dynamics and potential challenges faced by marginalised communities in these cities' based on their spatial location. The geographical locations of slum settlements play a significant role in shaping the challenges related to climate-related WASH services.

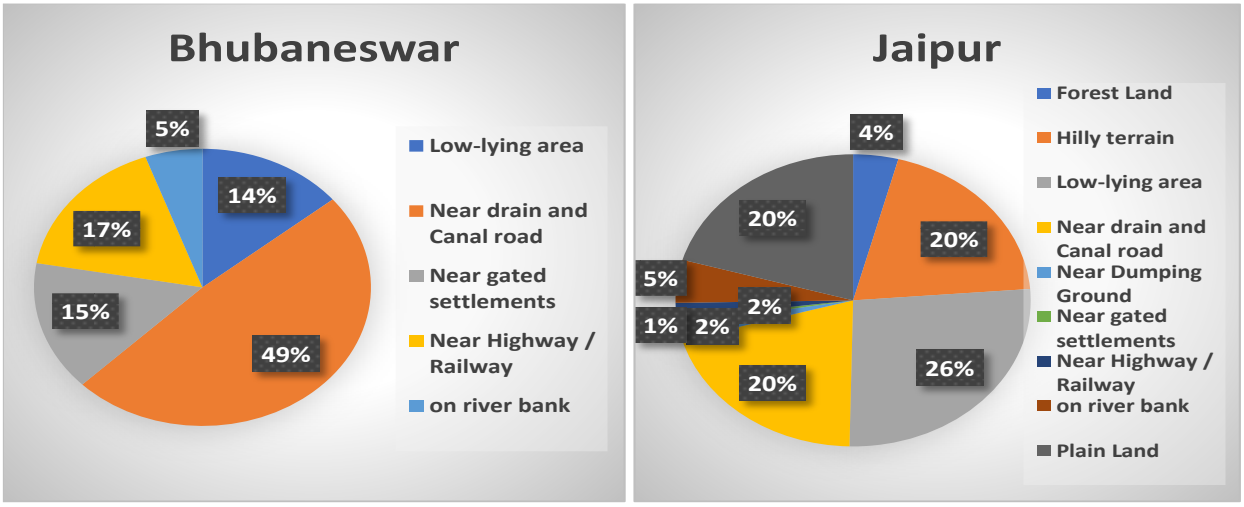
In Bhubaneswar, a considerable 48.6% of these settlements were situated near drain and canal roads, exposing them to potential flooding during heavy rains. Moreover, 16.7% of the slums were located close to highways and railways, which further exacerbates their vulnerability to waterlogging and fear of eviction, especially amongst children.

Similarly, in Jaipur, slum areas were affected by distinct geographical challenges. Around 26.6% of the settlements were spread across low-lying regions, making them prone to waterlogging and increased risk of waterborne diseases. The presence of slums near drain and canal roads (20.3%) raised concerns about pollution and inadequate drainage during monsoons. Furthermore, 19.7% of the slums were situated in hilly terrains, making access to reliable WASH services a challenge for these communities especially at the time of climate-related hazards.

Riverbanks also posed a shared challenge in both cities, with 5.5% of Bhubaneswar's slums and 4.8% of Jaipur's slums located in these areas. Flooding and contamination of water sources during floods can seriously compromise WASH services for these populations.

Settlements near gated communities often suffer from waste dumping and unhygienic conditions.

Graph 6: Location of Surveyed Slum Settlements



Source: Primary survey, 2023.

Sources of drinking water:

The pie-charts (Graph 7) show sources of drinking water in Bhubaneswar during normal circumstances and the alternative sources utilised during and after climate-related hazards.

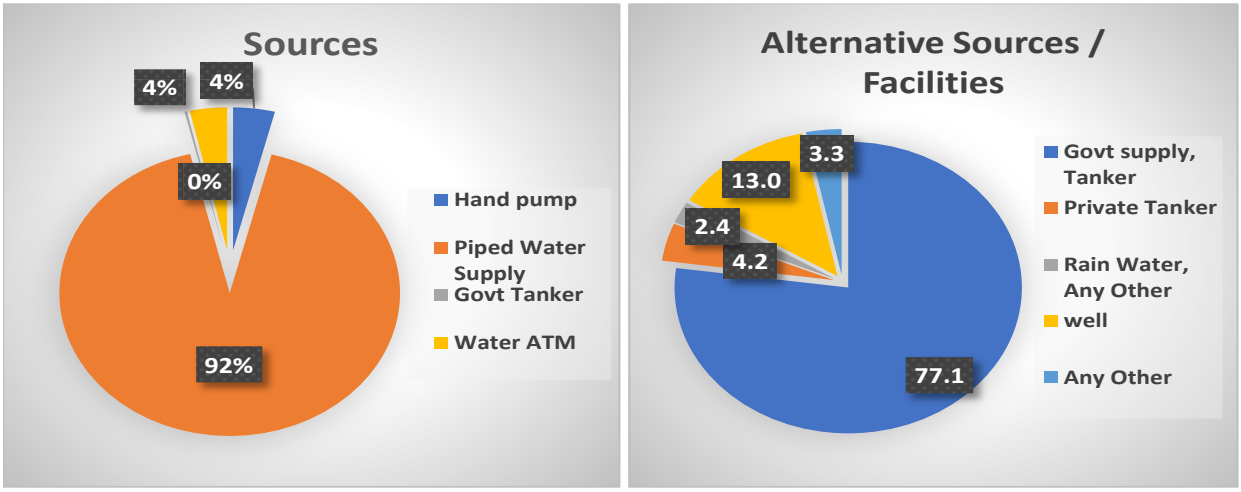
In regular circumstances, piped water supply serves as the main source (majority) for 92.3% of the population, showcasing established urban infrastructure. A smaller fraction relied on hand pumps (4.0%) and water ATMs (3.5%), indicating a relatively diversified supply.

However, when climate-related hazards arise, the city's water-sourcing dynamics undergo significant transformations. Government supply and tankers emerge as the predominant source, meeting the needs of 77.1% of residents. This underscores the pivotal role of governmental intervention in securing water access during crises. Private tankers (4.2%), wells (13.0%), and other sources and facilities (2.4%) collectively contribute significantly, highlighting the necessity for adaptable water access options in emergency situations.

The geographical locations of these water sources also play a crucial role. As climate-related challenges impact specific areas disproportionately, the shift towards tankers and wells illustrates the role of local conditions in determining the resilience of water supply systems. This adaptability is vital for ensuring consistent access to safe drinking water, especially during times of heightened vulnerability.

Faced with shifting weather patterns and insufficient water supply systems, women within these communities shoulder extra responsibilities. Chandrama Panda's account in Sabar Sahi, Ward 46 of Bhubaneswar, highlighted how women are often compelled to boil water to ensure their families have clean drinking water –after heavy rains muddy the pipeline supply, This added effort not only would eat into their time but also took a toll on their overall well-being. Rajeswari Gouda from Jharana Sahi further underscored the challenges women encounter in managing households and daily routines, as they rely on neighbours for storing water due to work timings and fixed water supply timing.

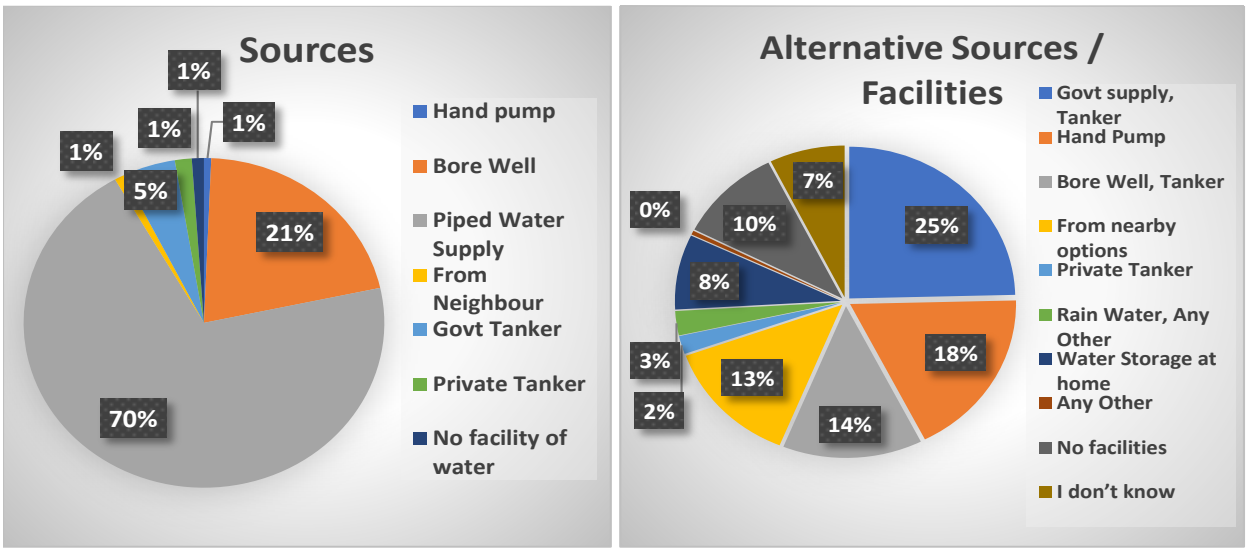
Graph 7: Sources of Drinking Water during Ordinary Time and Alternative Sources / Facilities during and After climate hazards in Bhubaneswar.



Source: Primary survey, 2023.

The following pie-charts (Graph-8) provide comprehensive insights into the sources of drinking water for residents of Jaipur during ordinary times and the alternative sources or facilities they relied on during and after climate-related hazards. During regular circumstances, the majority of residents (70.2%) accessed their drinking water through the piped water supply, reflecting a substantial level of urban infrastructure development. Borewells also contributed significantly, serving 21% of the population. A smaller percentage obtained water from neighbours (0.9%), government tankers (4.8%), and private tankers (1.5%), while 1.1% faced a lack of water facilities.

Graph 8: Sources of Drinking Water during Ordinary Time and Alternative Sources / Facilities during and After climate hazards in Jaipur.



Source: Primary survey, 2023.

In the context of climate-related hazards, the data shows that 24.6% of residents primarily rely on government supply and tankers to meet their drinking water needs, indicating a coordinated effort to ensure access during challenging times. Hand pumps remain a vital source for 17.9% of the population, while 13.6% used borewells and tankers. Residents also turned to nearby options (13.4%) and private tankers (1.9%). A smaller portion utilised rainwater and other methods (2.6%) and stores water at home (8.0%). Here, storage at home includes water collected from the municipal piped connection days earlier and water collected from private tankers and stored at home.

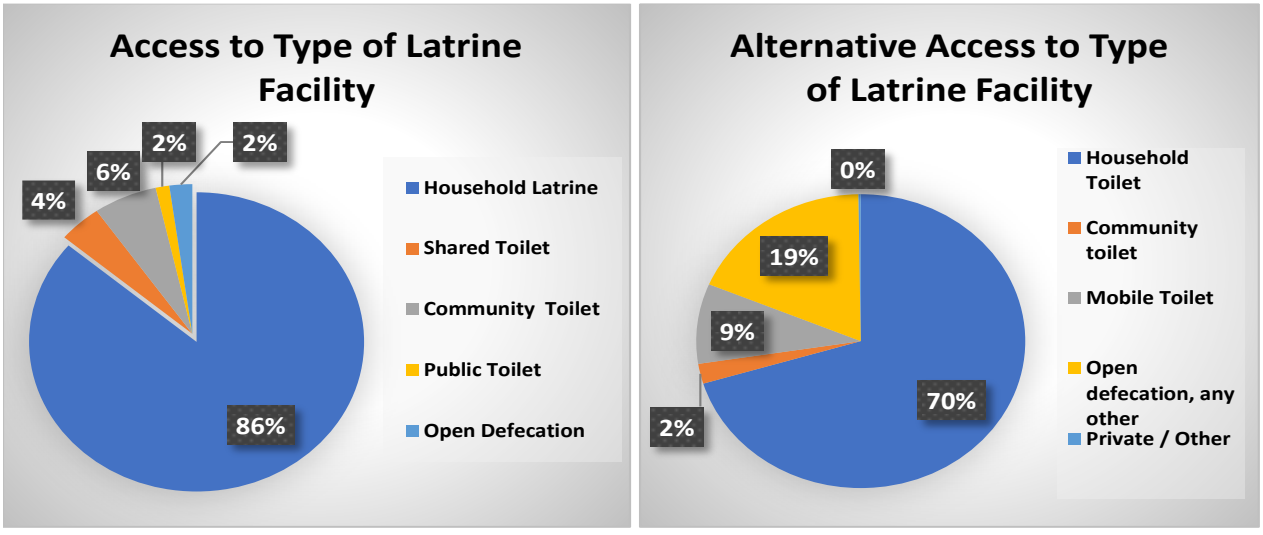
These were stored in a 500-1,000 litre black tank placed in front of the houses. Importantly, 10.2% indicated having no access to alternative facilities, underscoring potential vulnerabilities. The 7.3% response of "I don't know" suggested a lack of awareness about available options. Overall, the table underscores the dynamic nature of water access in Jaipur, influenced by both regular urban services and the challenges posed by climate-related hazards.

Urmila's concerns in Jaipur Ward 123 echoed the challenges that children encounter while fetching water from distant sources during the rainy season, raising the question of their safety and well-being amidst changing weather patterns.

Access to latrine facilities:

The following pie-charts (Graph 9) provides a comprehensive overview of access to latrine facilities in Bhubaneswar, both in ordinary times and periods following climate-related hazards. During ordinary times, the city exhibited a relatively high level of latrine coverage, with 86.2% of households having access to household latrines, indicating an established infrastructure for sanitation. Shared toilets accounted for 4.2% of facilities, while community toilets served 6.2% of the population, and public toilets were available to 1.3%. A minor percentage, 2.2%, still practiced open defecation.

Graph 9: Access to Latrine Facility During Ordinary Time and During & After Climate-related Hazards in Bhubaneswar.



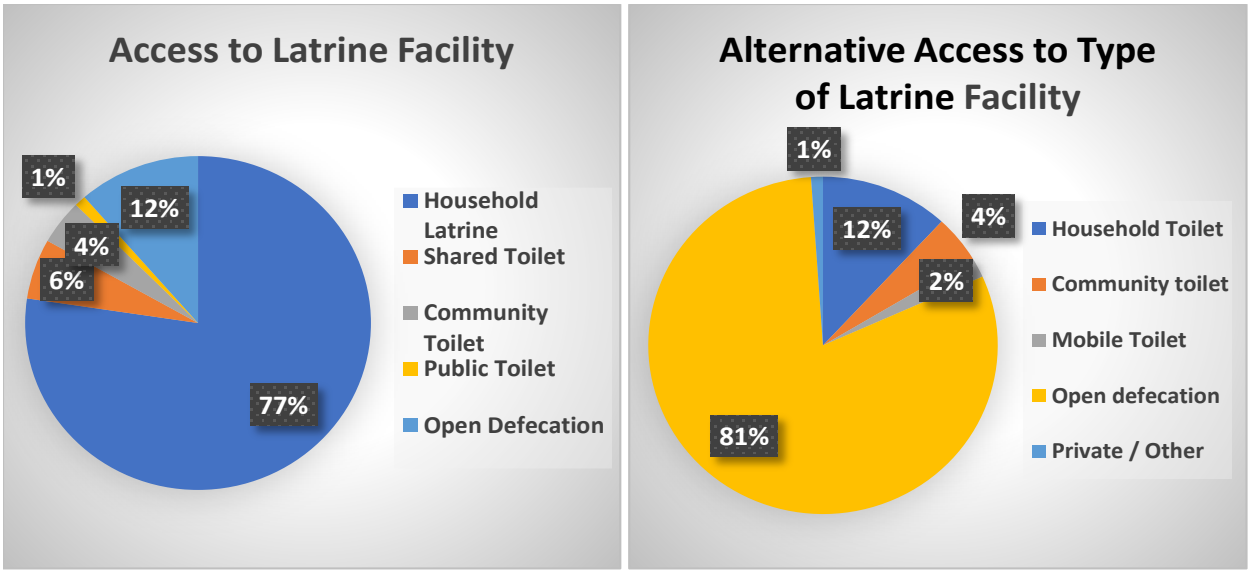
Source: Primary survey, 2023.

However, when faced with climate-related hazards, the access dynamics shifted. The percentage of households with functional household toilets decreased to 70.3%, possibly due to damage or disruption caused by hazards. The reliance on community toilets remains relatively stable at 2.2%, while mobile toilets became crucial, representing 8.8% of access during these challenging periods. Notably, a significant proportion, 18.5%, resorts to open defecation, emphasizing the vulnerability of sanitation infrastructure to climate-related impacts. A fraction of 0.2% turned to private or other facilities.

In Bhubaneswar Ward 5, the prevalence of open defecation and improper waste disposal stemmed from inadequate facilities. The situation is exacerbated by recurrent flooding due to the community's proximity to riverbanks. This vulnerability to floods, intensified by climate variability, has disrupted lives, amplified health risks, and accentuated the existing challenges faced by the tribal communities living near the river bank in the low-lying areas.

In the case of Jaipur, the following pie-charts (Graph 10) show the access to latrine facilities under both ordinary conditions and during and after climate-related hazards. During ordinary times, 77.3% of households had access to a household latrine, while 5.8% relied on shared toilets, 4.3% used community toilets, and 1.1% ha access to public toilets, with 11.4% resorting to open defecation.

Graph 10: Access to Latrine Facility During Ordinary Time and During & After Climate-related Hazards in Jaipur.



Source: Primary survey, 2023.

However, when faced with climate-related hazards, the scenario changed significantly. Only 11.9% of households could access household toilets, while 4.5% used community toilets and 1.9% used mobile toilets. A striking 80.6% of the population resorted to open defecation, indicating a substantial drop in proper sanitation facilities during such hazards. Additionally, 1.1% used private or other sanitation options.

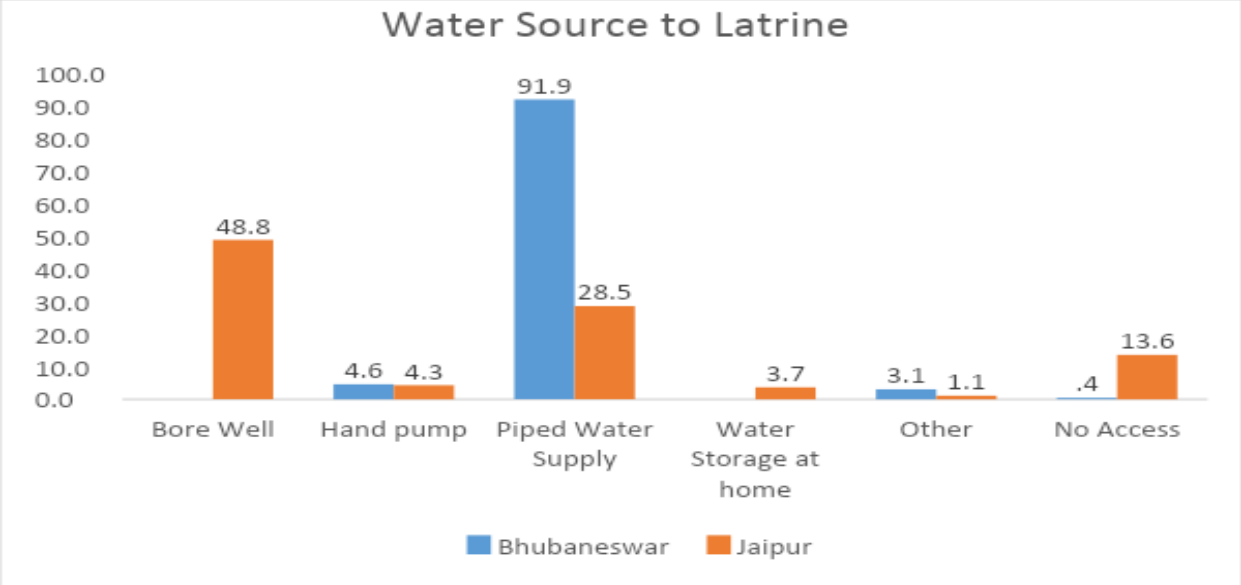
In Jaipur's Ward 93 and 123, vulnerable ST communities faced water scarcity and sanitation issues, relying on makeshift toilets and open defecation. Extreme summer conditions and low-lying settlements rendered them particularly susceptible to flash floods, further magnifying their vulnerability and forcing them to resort to practice open defecation.

Kushal Chand's perspective on greywater management highlighted the challenge of water resource sharing within the community, intensifying household water scarcity. The pressing need for access to the Bisalpur connection and water line underscored the importance of equitable distribution'. The lack of toilet doors and reliance on a distant temple for toilet water underscored the necessity for improved sanitation facilities.

Water source access to latrines:

The clustered bar graph (Graph 11) presents information about the accessibility of water sources to latrines during ordinary times in the cities of Bhubaneswar and Jaipur. In Bhubaneswar, a significant majority of households with latrines had access to water through piped water supply (91.9%), making it the predominant source. A smaller percentage of households had access to water from a hand pump (4.6%), while a minority received water through other sources (3.1%), including water collected from nearby sources and households that had no water access to a toilet facility was very low (.4%). Notably, there was a complete absence of water access for latrines.

Graph 11: Water Source Access to Latrine During Ordinary Time in Bhubaneswar and Jaipur.



Source: Primary survey, 2023

On the other hand, in Jaipur, the water source dynamics are different. The largest portion of households with latrines accessed water from borewells (48.8%), which is notably higher than in Bhubaneswar. Additionally, a substantial proportion received water through piped water supply (28.5%), followed by water storage at home (3.7%) and hand pumps (4.3%). There is a smaller utilization of 'other' sources (1.1%). Conversely, a significant 13.6% of households with latrines in Jaipur lacked access to water

altogether. Th data highlights the varying water source scenarios in these cities, signifying the potential challenges and disparities in water availability and infrastructure for sanitation facilities among the slum communities.

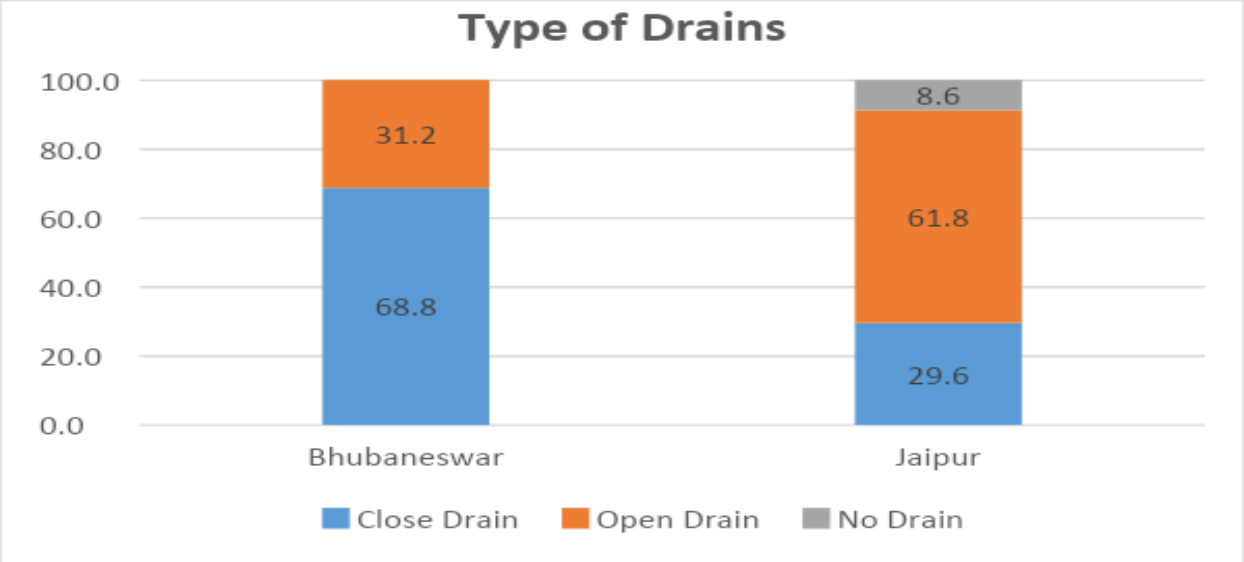
In Bhubaneswar Ward 42, the convergence of poor housing conditions and confined spaces intersects with daily labour occupations, intensifying the challenge of accessing safe water. These households relied on community-operated borewells, grappling with both water scarcity and quality concerns. The disparity in sanitation was evident through limited access to community toilets, amplifying hygiene and health risks. During heavy rainfall, recurring waterlogging issues accentuated the intersection of climate change with insufficient infrastructure and greater difficulties in collecting water from community point.

Chandrama Panda's account in Sabar Sahi, Bhubaneswar Ward 46, also highlighted how poor availability of water for household use disproportionately impacts women's privacy and dignity in the phase of inadequate sanitation facilities.

Types of drains:

The stacked bar graph provides a breakdown of the types of drains present in the slum settlements of Bhubaneswar and Jaipur, the diverse sanitation and infrastructure conditions in these two cities' slum areas, which are crucial factors influencing the living conditions and quality of life for their residents highlighting the distribution between "Close Drain," "Open Drain," and "No Drain" categories.

Graph 12: Type of Drains in Bhubaneswar and Jaipur.



Source: Primary survey, 2023

In Bhubaneswar, the majority of slum settlements are being serviced by "Close Drain" systems (68.8%), indicating that a significant portion of these settlements had access to enclosed or covered drainage infrastructure. Conversely, in Jaipur, the distribution is notably different, with a higher reliance on "Open Drain" systems (61.8%), suggesting that a substantial portion of the slum settlements there had drainage

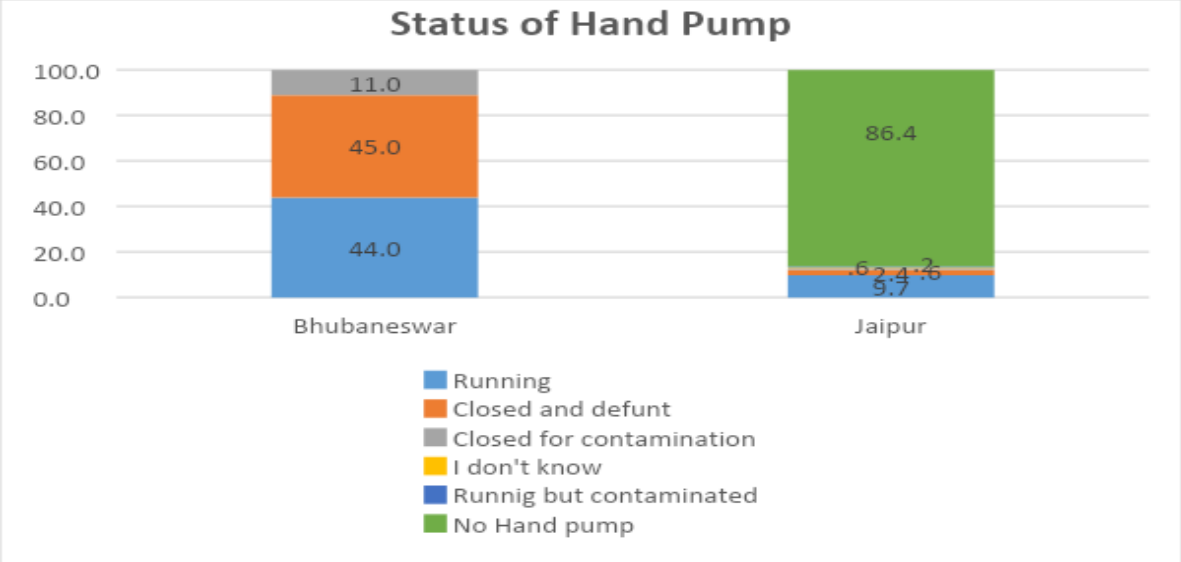
systems that are open and exposed. Additionally, in Jaipur, a smaller percentage of slum settlements lacked drainage altogether ("No Drain" at 8.6%).

In Bhubaneswar's Kalpana Flat Basti (Ward 51) and Kedarapalli (Ward 53), the absence of individual toilets has led to hygiene concerns, particularly for women uncomfortable with open defecation. Poorly constructed septic tanks risk groundwater contamination. Overcrowded community toilets in certain areas remained unused due to early departures of daily wage laborers. Settlements near drains suffered contamination and disease risks. In Sabar Sahi, insufficient toilets forced residents to use open drains for open defecation during disasters, risking accidents.

Status of handpumps:

The stacked bar graph (Graph 13) provides an overview of the status of hand pumps in Bhubaneswar and Jaipur, detailing their functionality and conditions. This data highlighted the disparity in access to functional and safe water sources between the two cities, underscoring the potential challenges related to water quality and availability for the populations residing there.

Graph 13: Status of Hand Pumps in Bhubaneswar and Jaipur.



Source: Primary survey, 2023

In Bhubaneswar, 44% of hand pumps were reported to be in working condition, offering access to clean water and groundwater. Another 45% were closed and defunct, mainly due to disrepair or malfunction. The remaining 11% were closed due to contamination concerns, suggesting that the water from these sources may be unsafe for consumption. In Jaipur, the scenario was different, with only 9.7% of hand pumps reported as operational, implying limited access to clean water and groundwater. In contrast, a significant 86.4% of hand pumps were indicated as non-functional, signifying a lack of access. Additionally, a small percentage of hand pumps were either closed due to contamination (0.6%), running but contaminated (0.6%), or their status was unknown (0.2%). Contaminated floodwater mixed with drinking water sources, has increased the risk of waterborne diseases. Inadequate drainage systems have resulted

in stagnant water, creating breeding grounds for disease vectors like mosquitoes. Lack of proper sanitation facilities and open defecation during these conditions have contributed to the spread of diseases such as diarrhoea, dengue, malaria, and skin infections.

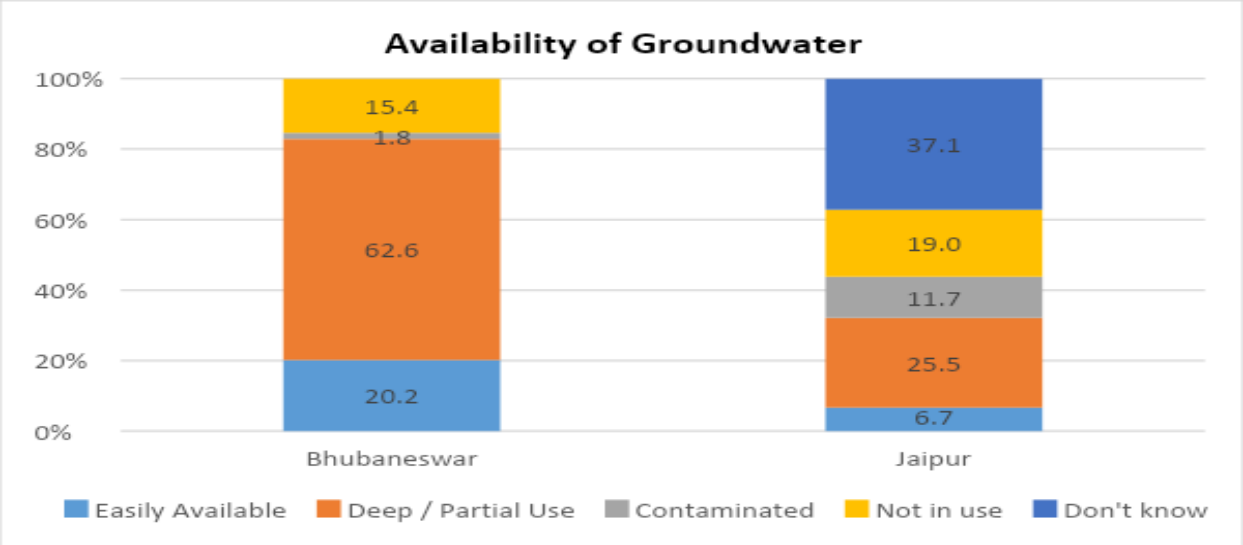
Weather pattern changes, like hotter days, heatwaves, and heavy rain, have made locals link these shifts to climate change. Heavy rainfall affected water pipelines, making the water muddy and unsuitable for drinking, pushing residents to rely on hand pumps. However, the metallic taste in hand pump water raised safety concerns. Water scarcity worsened existing challenges. Some use hand pump water that may not meet safety standards. Extreme weather events like floods and droughts disrupted clean water availability. Changing weather patterns directly impacted wells and hand pumps, worsening scarcity during dry spells.

Chandrama Panda, a Sabar Sahi SHG member in Bhubaneswar's Ward 46, highlighted reliance on hand pumps. Rain transforms pipeline water to muddy water, making hand pumps essential. Even in her 50s, Chandrama persisted despite joint pains, boiling alternative water sources.

Availability of groundwater

The stacked bar graph (Graph 14) presents data on the availability and quality of groundwater sources drawn from multiple sources, including wells, hand pumps, borewells, and other modes, in the cities of Bhubaneswar and Jaipur. The data suggests that while a significant portion of Bhubaneswar's population relied on groundwater, as emerged in WASH SeVI as well, Jaipur faced challenges with a larger share perceiving both limited availability and contamination issues.

Graph 14: Availability of Groundwater in Bhubaneswar and Jaipur.



Source: Primary survey, 2023

In Bhubaneswar, 20.2% of respondents found groundwater easily available, while a majority of 62.6% reported deep or partial use of groundwater sources. A small percentage of 1.8% indicated that the groundwater is contaminated, and 15.4% were not dependent on the groundwater. In contrast, in Jaipur,

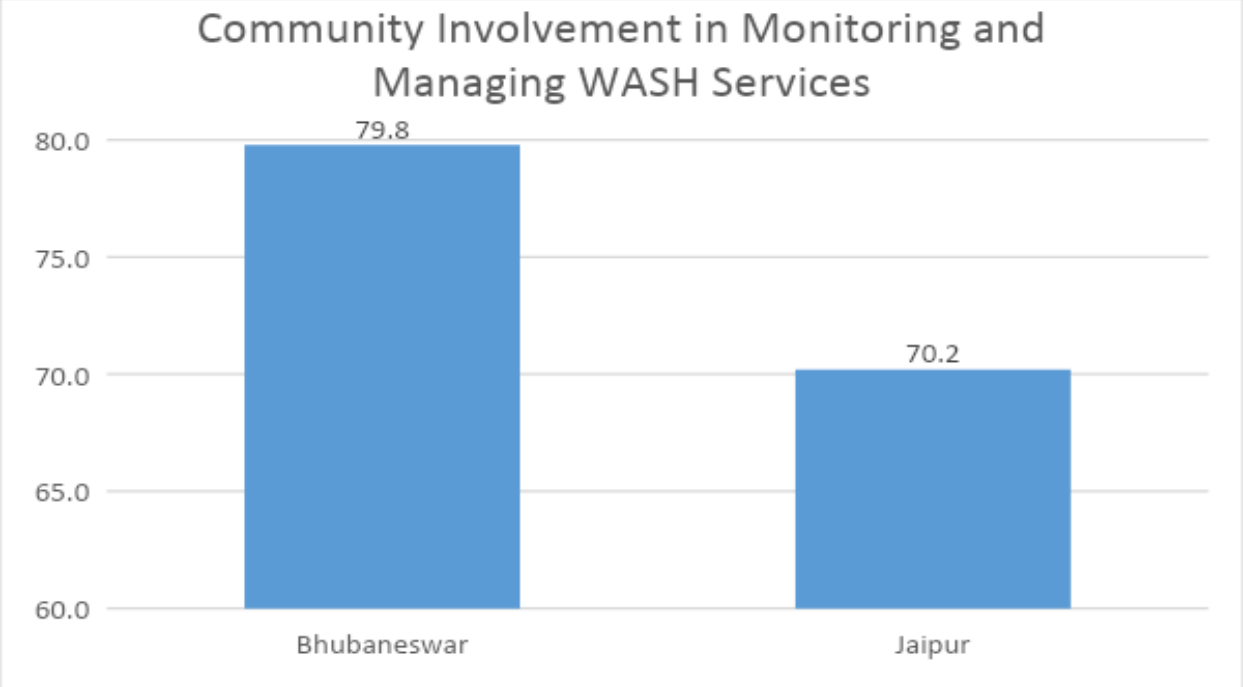
only 6.7% of respondents stated that groundwater was easily available, and 25.5% mentioned deep or partial use mainly due to the fluctuation of the water table, especially during the summer season. A substantial 11.7% of respondents perceived the groundwater as contaminated, and 19.0% claimed that it was not used. The highest proportion, 37.1%, expressed uncertainty about the availability of groundwater.

In Jaipur, Ward 23 has to contend with groundwater depletion and contamination, while Ward 93 needs to deal with water scarcity and open defecation, aggravated by the hilly terrain that is prone to landslides. Meanwhile, Wards 114, 123, and 147 grapple with a mix of water scarcity, groundwater depletion, contamination, and poor sanitation facilities, amplifying their climate vulnerabilities.

Involvement of communities in managing WASH services:

The bar graph (Graph 15) presents the extent of community involvement in monitoring and managing WASH services in the cities of Bhubaneswar and Jaipur. This data underscores the crucial role of community engagement in ensuring effective and sustainable WASH services, highlighting Bhubaneswar's relatively higher community-driven approach in this regard compared to Jaipur.

Graph 15: Involvement of Community in Monitoring and Managing WASH Services in Bhubaneswar and Jaipur.



Source: Primary survey, 2023

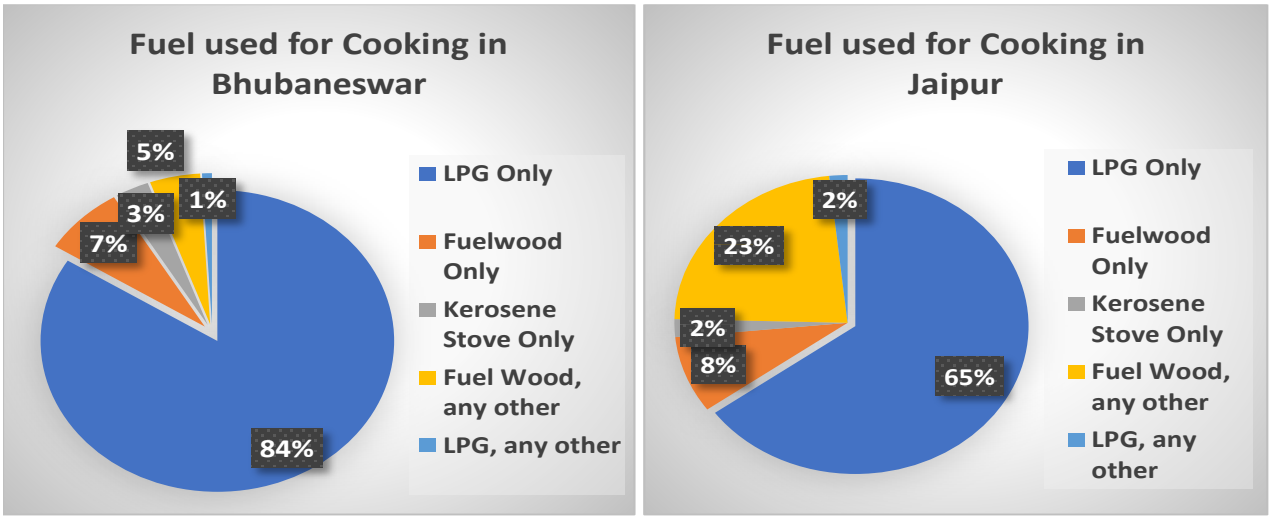
The percentages, 79.8% for Bhubaneswar and 70.2% for Jaipur represent the level of engagement by local communities in overseeing and administering WASH-related services. A higher percentage in Bhubaneswar indicated a greater degree of community participation in activities such as water supply and sanitation, including managing the cleanliness of drains and hygiene initiatives. In Jaipur, while still significant, community involvement was comparatively slightly lower.

Type of cooking fuel:

The pie-charts (Graph 16) provide an overview of the types of fuels used for cooking in the cities of Bhubaneswar and Jaipur, indicating the percentage distribution of households using different fuel sources. In Bhubaneswar, the majority of households (84.0%) relied on LPG (liquefied petroleum gas) as their primary cooking fuel, which is a cleaner and more efficient option compared to traditional fuels. A smaller percentage of households used fuel wood exclusively (7.5%), followed by kerosene stoves (3.1%). Additionally, 4.6% of households in Bhubaneswar used a combination of fuel wood and another fuel source, and 0.9% used a combination of LPG and another fuel.

In Jaipur also, LPG was the dominant cooking fuel, used by 65.0% of households, albeit to a lesser extent than in Bhubaneswar. Fuel wood was used exclusively by 8.4% of households, while 1.9% relied on kerosene stoves. A significant proportion of households (22.9%) in Jaipur used a combination of fuel wood and another fuel, reflecting a reliance on both traditional and modern cooking methods. Additionally, 1.7% of households used a combination of LPG and other fuels. The pie-charts underscore the varying fuel usage patterns between the two cities, highlighting the predominance of LPG usage in both, along with the persistence of traditional fuels, particularly in Jaipur, which could have implications for air quality, health, and environmental sustainability.

Graph 16: Type of Fuel used for Cooking in Bhubaneswar and Jaipur.



Source: Primary survey, 2023

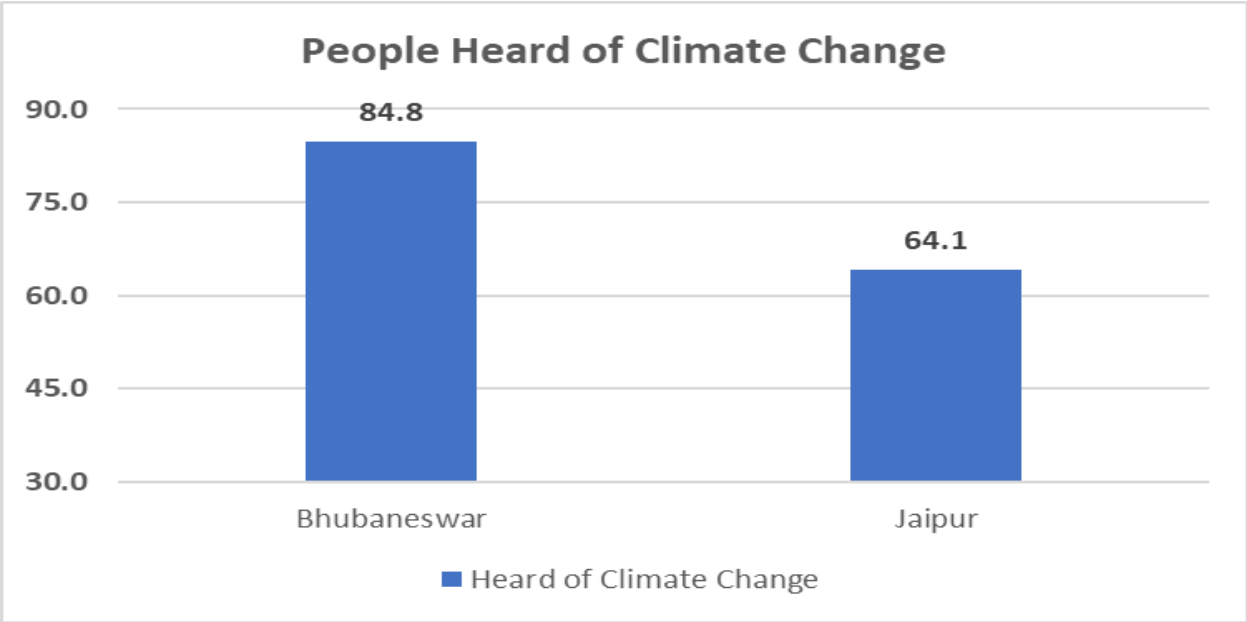
This data is particularly relevant in terms of its impact on climate and disaster-related challenges. The high reliance on traditional biomass fuels like fuelwood and kerosene stoves in both cities can have severe environmental consequences. Burning these fuels releases substantial amounts of greenhouse gases and particulate matter into the atmosphere, contributing to air pollution, deforestation, and climate change. Additionally, the use of these fuels is often associated with indoor air pollution, which can lead to adverse health effects for residents, especially women and children, who are frequently exposed to the smoke.

In the context of disasters, such as natural calamities or emergencies that disrupt fuel supply chains, the dependence on specific fuel sources can exacerbate vulnerabilities. For instance, during disasters like cyclones, or floods, access to fuelwood might be limited due to climate disruptions and supply shortages. This could force households to rely solely on alternative and potentially more polluting fuels, intensifying environmental and health risks.

Awareness on climate change:

The bar graph (Graph 17) presents the percentage of awareness levels regarding climate change in the cities of Bhubaneswar and Jaipur. In Bhubaneswar, a significant 84.8% of the population had heard of climate change, while in Jaipur, 64.1% of the population was aware of it.

Graph 17: People Heard of Climate Change in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

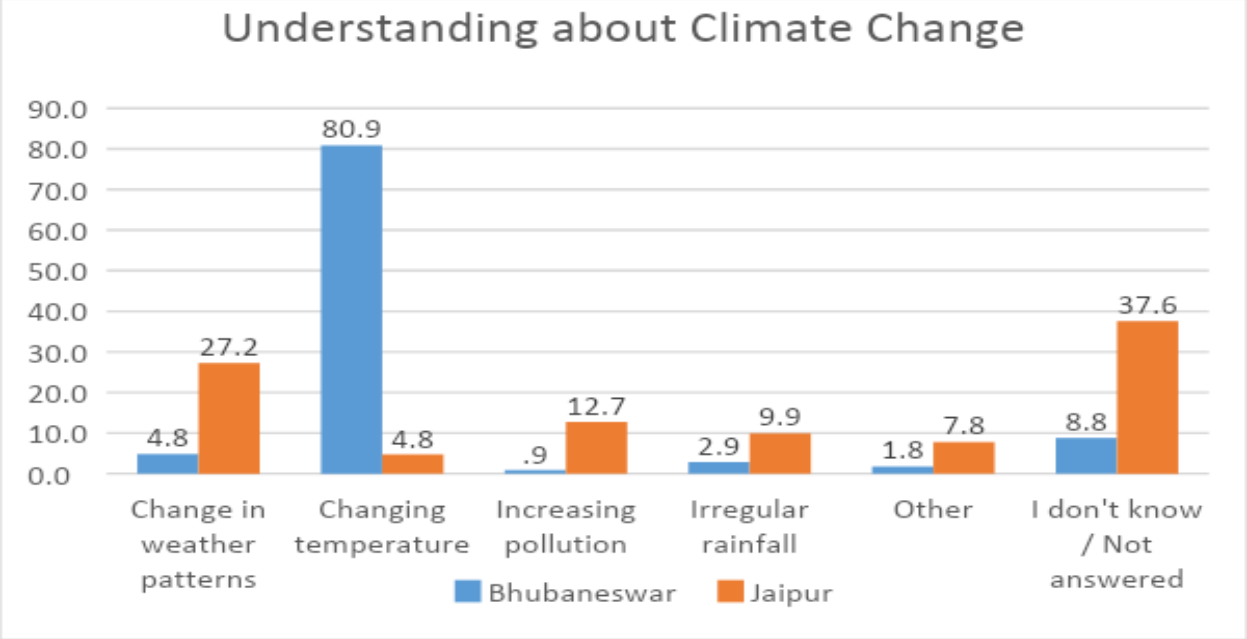
This discrepancy in awareness could have profound implications for both cities, especially considering the increasing impact of climate change on the environment and the vulnerabilities it exposes during disasters. Heightened awareness is crucial because climate change contributes to rising sea levels, extreme weather events, and unpredictable shifts in temperature and precipitation patterns. In regions like Bhubaneswar and Jaipur, where low-lying areas and riverbanks host slum settlements, increased awareness is essential as these areas are more susceptible to flooding, landslides, and other climate-related disasters.

Perceived understanding of climate change:

The following clustered bar graph (Graph 18) presents the perceived understanding of climate change among the residents of Bhubaneswar and Jaipur, focusing on factors such as changing weather patterns, increasing temperatures, rising pollution levels, irregular rainfall, and other contributing elements. In

Bhubaneswar, a substantial proportion of people recognized changing temperatures (80.9%) as a significant indicator of climate change, with a notable recognition of irregular rainfall (2.9%) and other factors (1.8%) as well, while fewer respondents associated climate change with altering weather patterns (4.8%) and increasing pollution (0.9%).

Graph 18: Peoples' Understanding of Climate Change in Bhubaneswar and Jaipur.



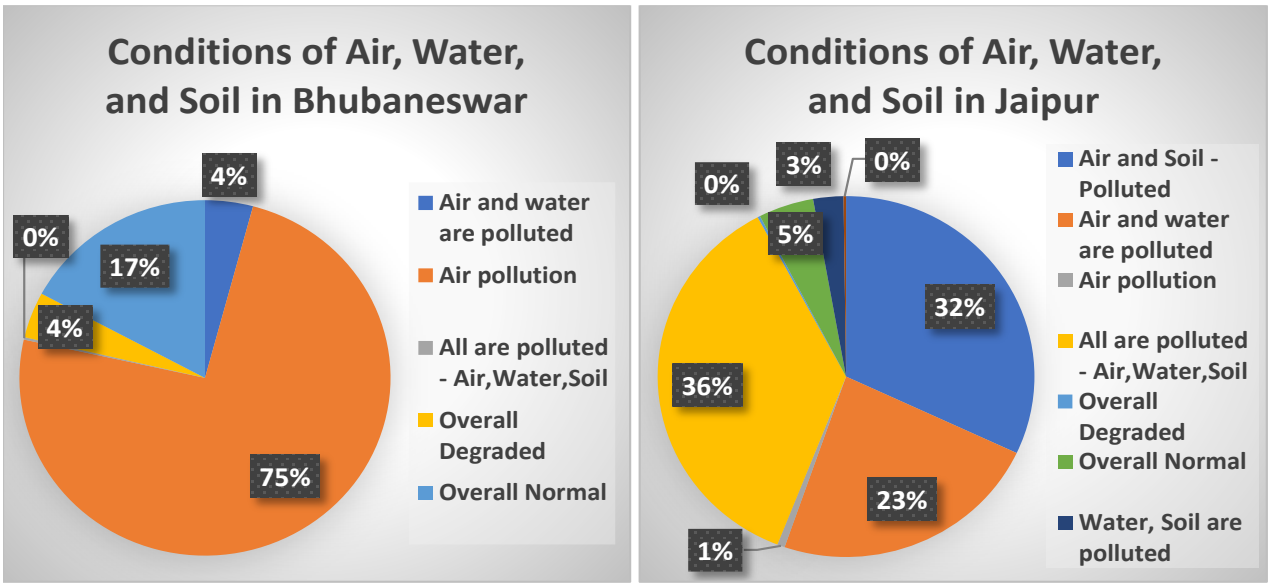
Source: Primary survey, 2023.

On the other hand, in Jaipur, respondents largely identified changing weather patterns (27.2%) and increasing pollution (12.7%) as indicators of climate change, followed by irregular rainfall (9.9%) and other factors (7.8%). Surprisingly, a substantial number of individuals in Jaipur were unsure or did not answer (37.6%) a question related to their understanding of climate change. The implications of these perceptions is significant, as climate change can exacerbate the frequency and intensity of extreme weather events, leading to disasters such as floods, heat waves, and storms. A lack of accurate understanding of these changes could hinder preparedness and response efforts, potentially increasing vulnerabilities during disasters and impeding the adoption of necessary mitigation strategies and policies.

People's perception on local environment:

The pie-charts (Graph 19) provide insights into how people perceive the conditions of air, water, and soil at both the neighbourhood and city levels in Bhubaneswar and Jaipur. The numbers in the pie-charts represent the percentage of respondents expressing these perceptions. In Bhubaneswar, 4.2% of people believed that air and water are polluted, while a significantly higher percentage of 74.3% perceived air pollution as a problem. Additionally, 0.2% of respondents believed that all three – air, water, and soil are polluted, contributing to an overall perception of 4.2% regarding the degraded state, and 17.1% perceived the overall environmental conditions as normal or not changed.

Graph 19: Conditions of Air, Water, and Soil in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

In Jaipur, a larger portion of respondents, 32%, viewed both air and soil as polluted, while 23.3% perceived air and water as polluted. Similarly, 0.6% perceived air pollution as standalone. Likewise, 36.3% perceived all three environmental aspects – air, water, and soil as polluted, resulting in an overall sense of degradation of 0.2%. In contrast, 4.8% of respondents considered the overall conditions as normal, and 2.6% perceived water and soil as polluted, with a minor percentage expressing uncertainty at 0.2%.

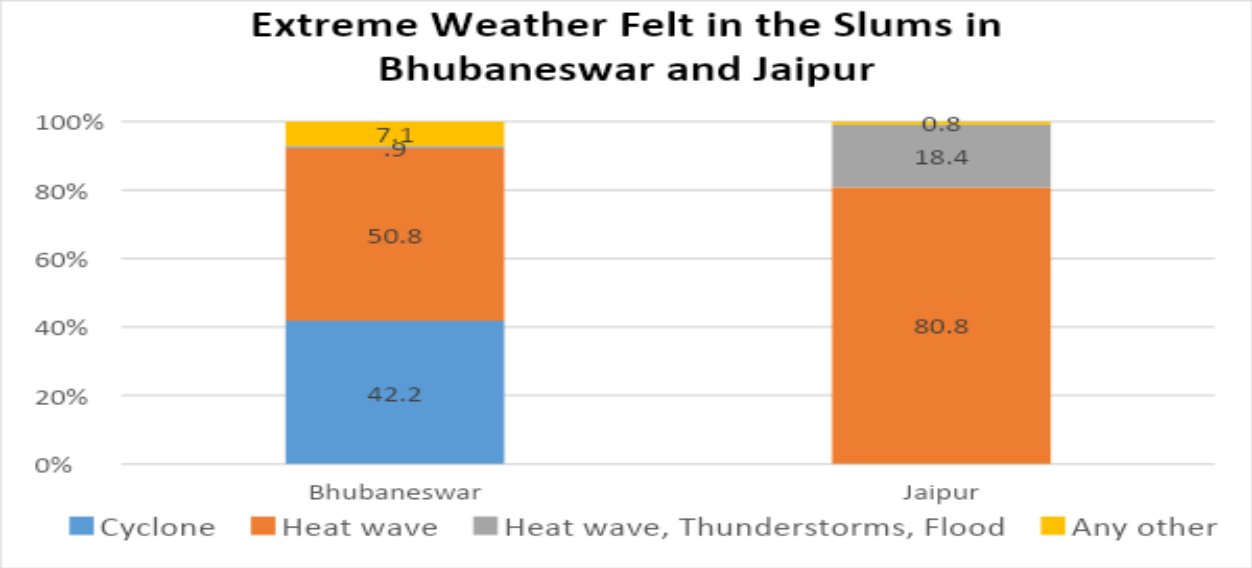
In the context of disasters, these environmental conditions can amplify vulnerabilities of these cities. Poor air quality can exacerbate health issues during disasters like heat waves. Polluted water sources can be further compromised during floods, leaving residents without access to safe drinking water and increasing the risk of waterborne diseases. Degraded soil quality could impact the resilience of urban infrastructure during events like heavy rainfall.

In Bhubaneswar's Kalpana Flat Basti (Ward 51) and Kedarapalli (Ward 53), design issues with septic tanks have led to non-sanitary conditions during monsoons. Open drains have polluted soil and groundwater. Settlements near drains and canals have suffered severe pollution due to sewage disposal.

Information on extreme weather:

The stacked bar graph (Graph 20) presents the impact of various extreme weather events on slum settlements in Bhubaneswar and Jaipur. The prevalence of extreme weather events intensifies the challenges faced by slum communities, exacerbating issues like inadequate infrastructure, limited access to resources, and poor living conditions. Cyclones can lead to property damage and displacement, while heat waves pose health risks due to inadequate shelter and limited access to cooling facilities. The combination of heat waves, thunderstorms, and floods has amplified the complexity of disaster responses.

Graph 20: Extreme Weather Felt in the Slums in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

In Bhubaneswar, cyclones have been felt by 42.2% of slum dwellers, heat waves have affected 50.8%, a small fraction of 0.9% have experienced a combination of heat waves, thunderstorms, and floods, while 7.1% have encountered other forms of extreme weather like floods and thunderstorms. On the other hand, in Jaipur, a significantly higher percentage of slum residents, 80.8%, have felt the impact of heat waves, followed by 18.4% affected by the combination of heat waves, thunderstorms, and floods, and 0.8% have been exposed to other forms of extreme weather causing vulnerability of slum populations to adverse climate conditions.

In Bhubaneswar Ward 23, communities residing in flood-prone areas were particularly exposed to climate hazards such as increased flooding and extreme weather events. Discriminatory water access practices, influenced by caste, further compounded their difficulties. Clean water availability has become more scarce during climate events like droughts or extended dry periods. Moreover, inadequate sanitation facilities and open defecation practices expose them to heightened health risks.

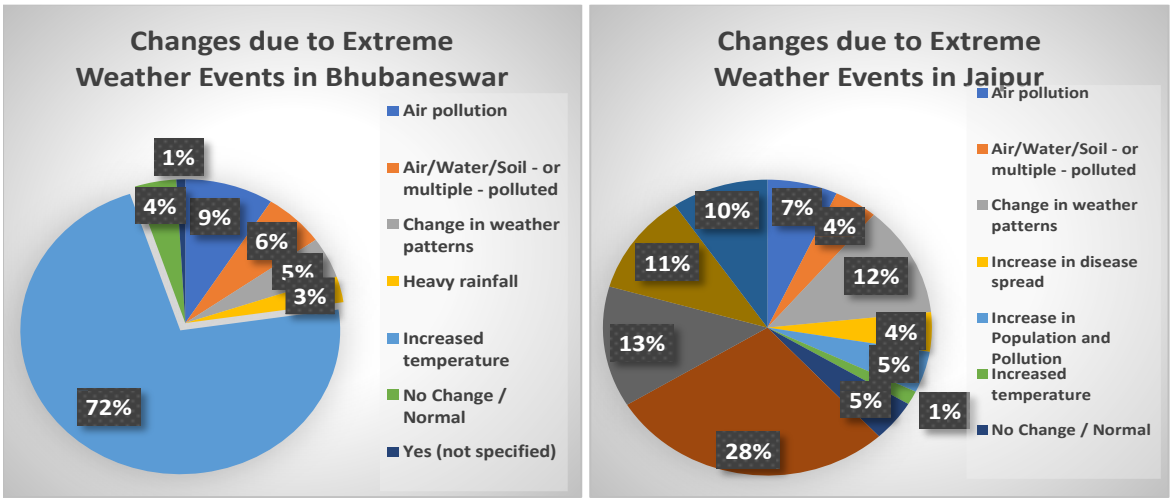
Changes occurred due to extreme weather events:

The pie-charts (Graph 21) present the impacts of extreme weather events on slum settlements in the cities of Bhubaneswar and Jaipur, particularly focusing on changes in environmental factors, weather patterns, and associated challenges. The changes in weather patterns and their resulting implications, such as increased disease spread and compromised WASH services, indicates the vulnerability of these communities during disasters.

In Bhubaneswar, extreme weather occurrences including air pollution (9%) and increased temperatures (72.3%) figured amongst the most prevalent changes felt. The impact of these events has resulted in an increase in air pollution (9%), multiple forms of pollution (6.2%), and altered weather patterns (4.6%).

Amongst the respondents, 4.2% said that no significant changes occurred and the weather had been normal like in previous years.

Graph 21: Changes Occurred Due to Extreme Weather Felt in the Slums in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

Similarly, in Jaipur, the effects of extreme weather events have been evident. These include changes in weather patterns (12.1%) as the most prominent, followed by worsened WASH services (13.2%), and resources being over-polluted (28.1%). Notably, 11% said 'Yes' but did not mention anything particular about the changes, and 9.5% responded with 'Don't know'. While air pollution (6.9%), multiple pollution types (4.3%), and increased temperatures (1.5%) were mentioned the most striking observation was a substantial proportion (4.5%) of residents who reported no change, which could either signify resilience or an unawareness of the impacts.

Based on the observations on changing climate, elderly residents Santosh and Geeta observe shifting climate patterns in Jaipur's Ward 113. Extended summers and altered winters disrupt norms, affecting health and daily routines. Their insights offer a comprehensive view on the gradual yet transformative impact of climate change. Santosh, an elderly resident, shared observations about the changing climate. He noted a shift in weather patterns, with a prolonged summer stretching till Diwali, followed by a sudden onset of winter that lingered until March. This alteration in both summer and winter temperatures has become more pronounced, transforming the familiar climate patterns of their area.

In Bhubaneswar, septic tank design issues worsen during monsoons, leading to unsanitary conditions and faecal sludge flow reversal. Open drains contaminate soil and groundwater, raising health concerns. Kedarapalli (Ward 53) has faced overflowing drains, and Sabar Sahi's narrow drains risk flooding. A lack of maintenance has worsened the situation. Settlements near drains have suffered severe pollution from sewage, exacerbating contamination via natural drainage channels. Ward 31 has covered drains, while Ward 57 lacks drainage, risking water stagnation and contamination in monsoons.

In Ward 42 of Bhubaneswar, cramped living and daily labour have hindered safe water access. Reliant on community borewells, these households have battled scarcity and quality problems. Limited community

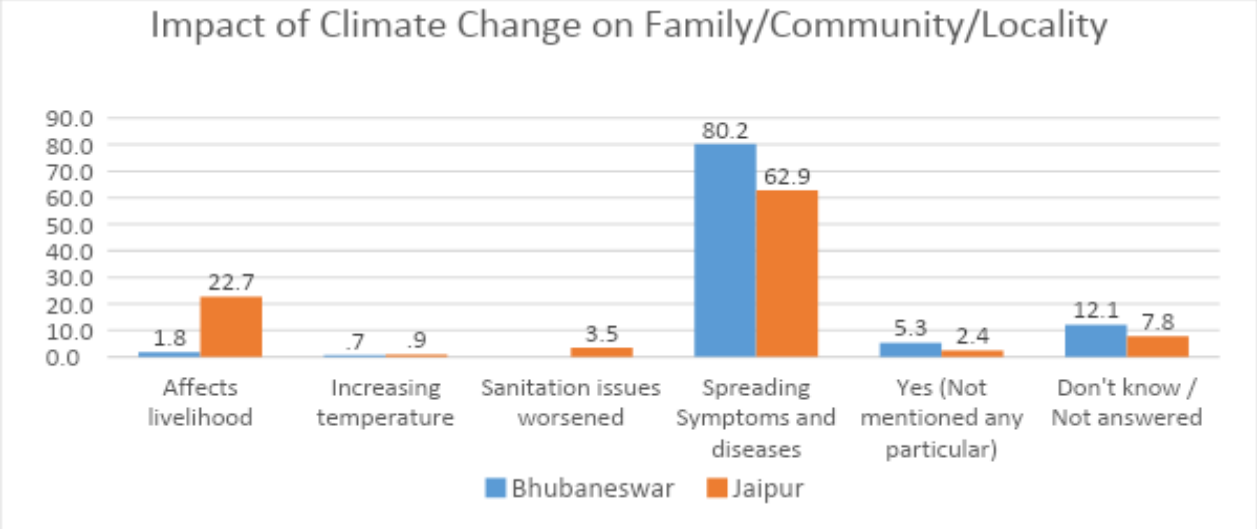
toilets have worsened sanitation disparities, raising hygiene risks. Heavy rains cause waterlogging, showing the impact of climate change on infrastructure.

In Ward 147 of Jaipur, poverty and inadequate housing have made it hard to afford daily water collection, causing scarcity, contamination, and sanitation issues. Open defecation and waste mismanagement have worsened health risks, amplified by climate change in this vulnerable setting.

Impact of climate change on communities:

The clustered bar graph (Graph 22) highlights the impact of climate change on families, communities, and localities in the cities of Bhubaneswar and Jaipur, with a particular focus on the challenges arising during disasters. These results show the substantial influence of climate change on vulnerable communities during disasters, particularly in Jaipur, where higher proportions reported various challenges.

Graph 22: Impact of Climate Change on Family/Community/Locality in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

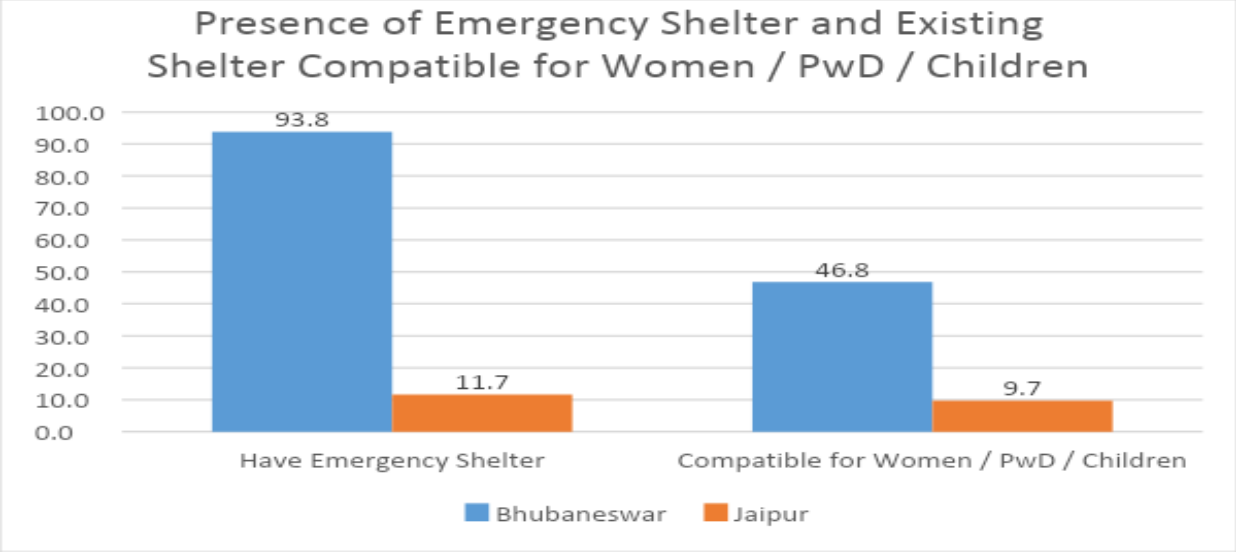
In Bhubaneswar, climate change has led to varying degrees of adverse effects: 1.8% of respondents cited impacts on livelihoods, 0.7% on increasing temperatures, 3.5% on exacerbated sanitation issues, 80.2% on the spreading of symptoms and diseases (fever, cold, dengue, skin infection, other), and 5.3% responded affirmatively to the general impact without specifying details. Conversely, in Jaipur, the impact has been more pronounced: 22.7% reported impacts on livelihoods, 0.9% on rising temperatures, 3.5% on worsened sanitation, 62.9% on the increase in symptoms and diseases, and 2.4% on a non-specified effect. Notably, a considerable percentage of respondents in both cities expressed uncertainty or did not respond to the question. Moving to Bhubaneswar's Ward 16, poor housing conditions and marginalised backgrounds have created challenges. Irregular water supply and surface water pollution have been prominent. Sanitation issues have persisted due to open drain toilets, raising health risks and vulnerability to diseases due to stagnant water. In Ward 66 of Bhubaneswar, in Sukavihar, Aralu Reedy's words have struck a chord. Neglected open drains have turned into homes for diseases and worries. These overlooked

places have become breeding spots for mosquitoes, showing the harsh truth of unclean conditions, and have made children susceptible to vector borne diseases.

Emergency shelters:

The clustered bar graph (Graph 23) provides information about the presence of emergency shelters and existing shelters compatible with the needs of women, persons with disabilities (PwD), and children in the cities of Bhubaneswar and Jaipur. In Bhubaneswar, a significant proportion of emergency shelters (93.8%) and out of these existing shelters, 46.8%, have been designed to be compatible with the specific requirements of women, persons with disabilities, and children during times of disaster or emergencies. However, in Jaipur, the numbers have been notably lower, with only 11.7% of emergency shelters out of which only 9.7% of existing shelters could offer such compatibility.

Graph 23: Presence of Emergency Shelter and Existing Shelter Compatible for Women / PwD / Children in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

This disparity in shelter compatibility had critical implications, particularly in the context of climate-related disasters. During natural disasters such as cyclones, floods, or extreme weather events, vulnerable groups like women, children, and persons with disabilities were at heightened risk due to their unique needs and susceptibilities. Shelters tailored to their requirements have played a pivotal role in ensuring their safety and well-being during emergencies. In Bhubaneswar, the higher percentage of compatible shelters has indicated a more inclusive approach to disaster preparedness, reducing the vulnerabilities of these groups and minimizing post-disaster complications. In contrast, Jaipur's lower percentages underscored potential challenges. Without shelters suitable for women, PwD, and children, there was an increased risk of their exposure to harsh conditions, health hazards, and potential separation from families during emergencies.

Vulnerable individuals, including those with disabilities (PwDs), often face considerable challenges in accessing WASH services during climate-related hazards. In areas like Ward 5 of Bhubaneswar, where communities reside near the Kuakhai River, the impact of climate change on WASH services was

particularly pronounced. This group, comprising elderly residents, pregnant women, children, and PwDs, has found itself in a precarious situation due to their proximity to the river and its susceptibility to flooding and waterlogging.

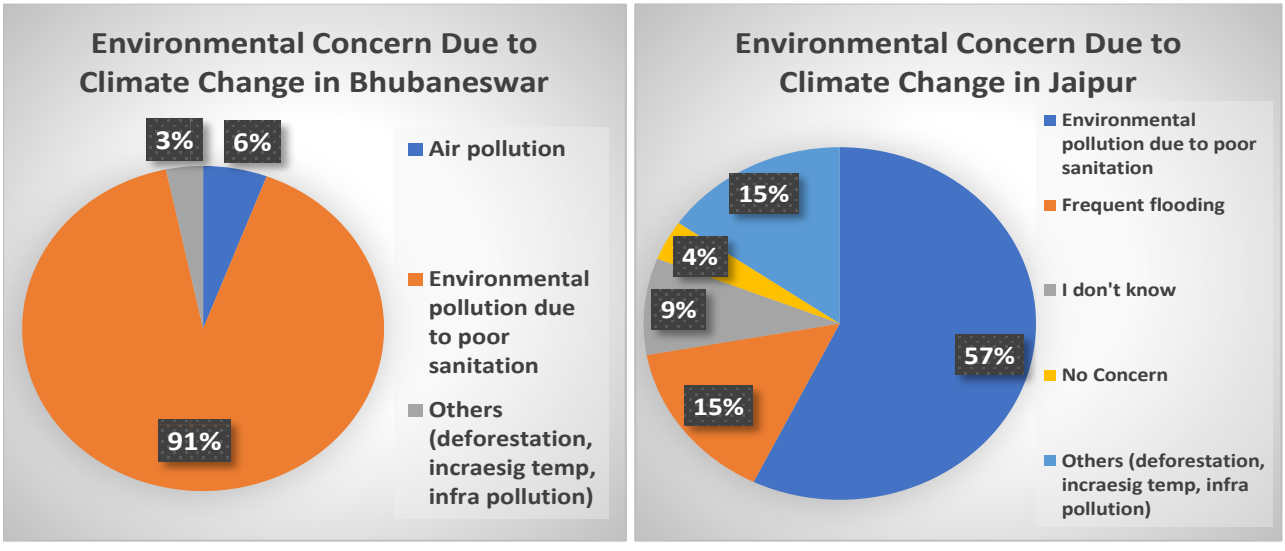
Among these challenges, people with disabilities, like Urmila from Jaipur's Ward 123, have experienced heightened difficulties when water became scarce. Urmila, who is visually impaired, explained how the situation worsens during the rainy season, making the task of fetching water even more perilous. She urgently called for inclusive solutions that can ensure safe and convenient water access for everyone, regardless of their abilities. Urmila's plea has underscored the pressing issue of water scarcity, especially for individuals with disabilities. During climate hazards like heavy rains, the predicament faced by PwDs became more complex, since navigating to distant water sources became risky and uncomfortable. As Urmila, a person with visual disabilities, sought guidance on how to overcome these challenges, it becomes evident that addressing these concerns is vital for creating a more equitable and resilient WASH infrastructure.

Environmental concerns due to climate change:

The pie-charts (Graph 24) provide insights into the level of environmental concern among slum dwellers in Bhubaneswar and Jaipur due to climate change, focusing on air pollution, environmental pollution due to poor sanitation, and other related issues.

In Bhubaneswar, 91% of slum dwellers expressed significant concern about environmental pollution caused by inadequate sanitation facilities, which aligns with the high incidence of such settlements located near drainage systems and canal roads. This concern was further compounded by the city's vulnerability to frequent flooding. Moreover, 6% of Bhubaneswar's slum residents were worried about air pollution, which could be exacerbated by climatic factors.

Graph 24: Environmental Concern among slum dwellers Due to Climate Change in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

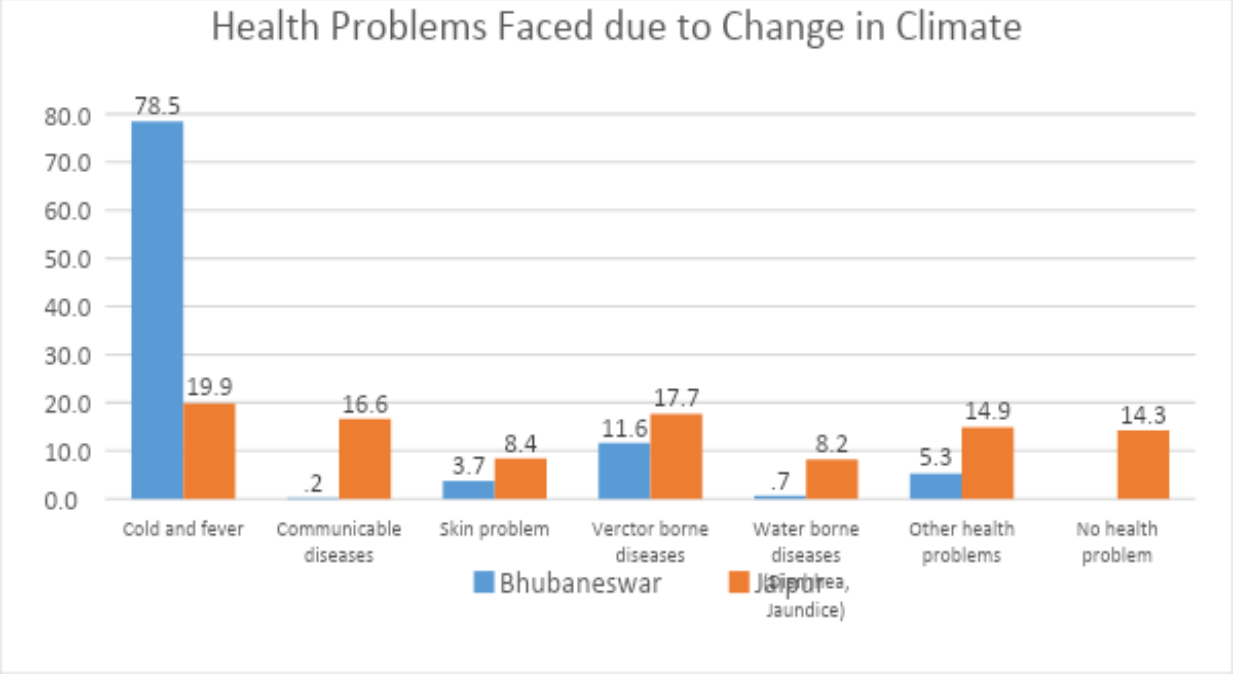
Conversely, in Jaipur, a substantial 57.2% of slum residents were deeply concerned about air pollution, possibly linked to the city's various location types like settlements near railway/roadways land and dumping grounds. This concern aligns with the region's rising temperatures, which can intensify air quality issues. Notably, 14.9% of Jaipur's slum dwellers expressed concern about frequent flooding, particularly in the city's low-lying areas. In times of disasters like flooding or extreme weather events, these issues can escalate, exposing vulnerable populations to heightened risks. Interestingly, 8.9% were unaware of any type of concern, and 3.7% of slum dwellers perceived no environmental concern at all about climate change.

Ms. Snehalata Pradhan, from Bhubaneswar's Bhagabati Basti in Ward 50, shared how overflowing drains contaminate surface water, soil, and eventually the surroundings, linking water to health. Facing challenges, Sarajini Routh from Bastibikash, Ward 26, explained how people adapt to using borewells and tubes for survival. But when disasters strike, they are forced to find water in unconventional ways as the flooded water contaminates the available water sources.

Health vulnerabilities:

The clustered bar graph (Graph 25) presents a comparison of health problems faced due to changes in climate in the cities of Bhubaneswar and Jaipur. It outlines the percentages of various health issues prevalent as a result of climate change, underscoring its impact during disasters or altered climatic conditions. These findings have illuminated the intricate relationship between climate change and health, particularly during disasters, as the altered climatic conditions can exacerbate the spread of diseases, strain healthcare resources, and increase vulnerabilities.

Graph 25: Health Problems Faced due to Change in Climate in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

In Bhubaneswar, the primary health problem observed was cold and fever, affecting a significant 78.5% of the population, followed by skin problems (3.7%) and vector-borne diseases (11.6%), such as those transmitted by mosquitoes. Waterborne diseases like diarrhoea and jaundice contribute to 0.7% of health issues. Other health problems, including diabetes, cancer, seasonal illness, and asthma, were reported by 5.3% of the population, while only a minor portion (0.2%) faced communicable diseases.

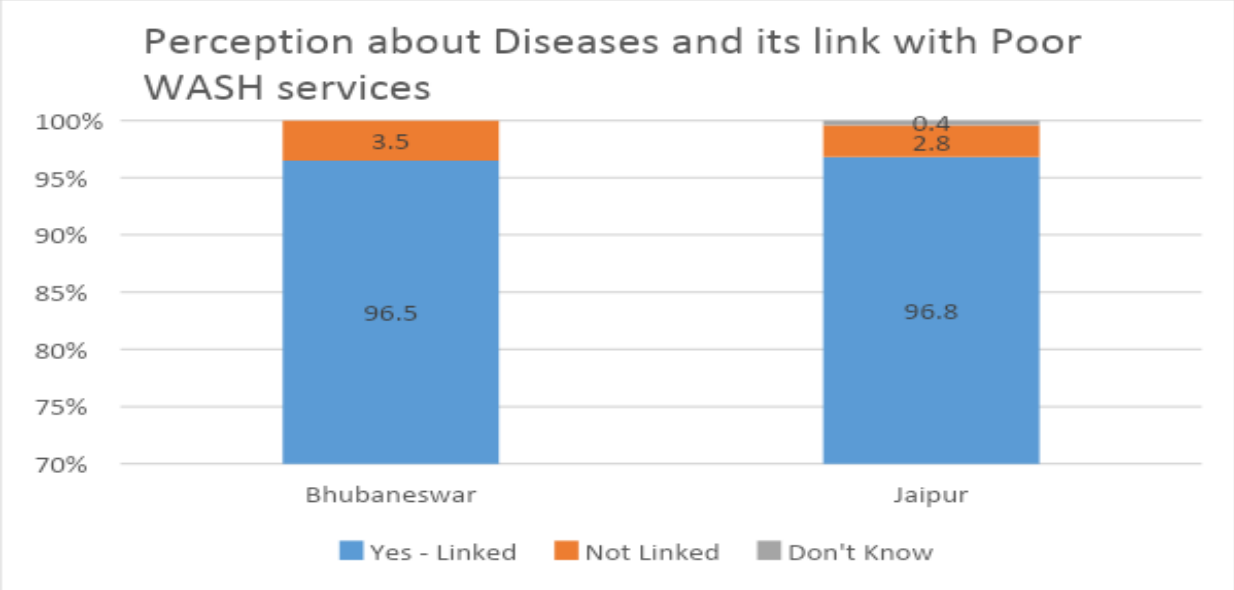
In contrast, Jaipur experienced a distinct pattern with a broader spectrum of health concerns due to climate shifts. Communicable diseases impacted 16.6% of the population, followed by waterborne diseases (8.2%) and vector-borne diseases (17.7%). Skin problems (8.4%) were also significant, as were other health problems (14.9%). Notably, cold and fever, though comparatively lower at 19.9%, still featured prominently.

In Ward 31 of Jaipur, residents voiced concern about the direct impact of changing climate on their livelihoods. Unpredictable weather has disrupted daily wage earners' ability to travel for work, affecting their income. Escalating diseases have strained limited resources, underscoring the vulnerability of these marginalised communities. Altered seasons disrupt livelihoods and contribute to diseases like fever and typhoid.

Perceptions on linkage between WASH services and diseases:

The stacked bar graph (Graph 26) highlights the perception of residents in Bhubaneswar and Jaipur regarding the connection between diseases and inadequate WASH services. In Bhubaneswar, 96.5% of residents perceived a direct link between diseases and poor WASH services, while 3.5% did not share this view. Similarly, in Jaipur, 96.8% of residents recognized the correlation between diseases and inadequate WASH services, with 2.8% having an opposing viewpoint and 0.4% expressing uncertainty.

Graph 26: Perception of Diseases and its link with Poor WASH services in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

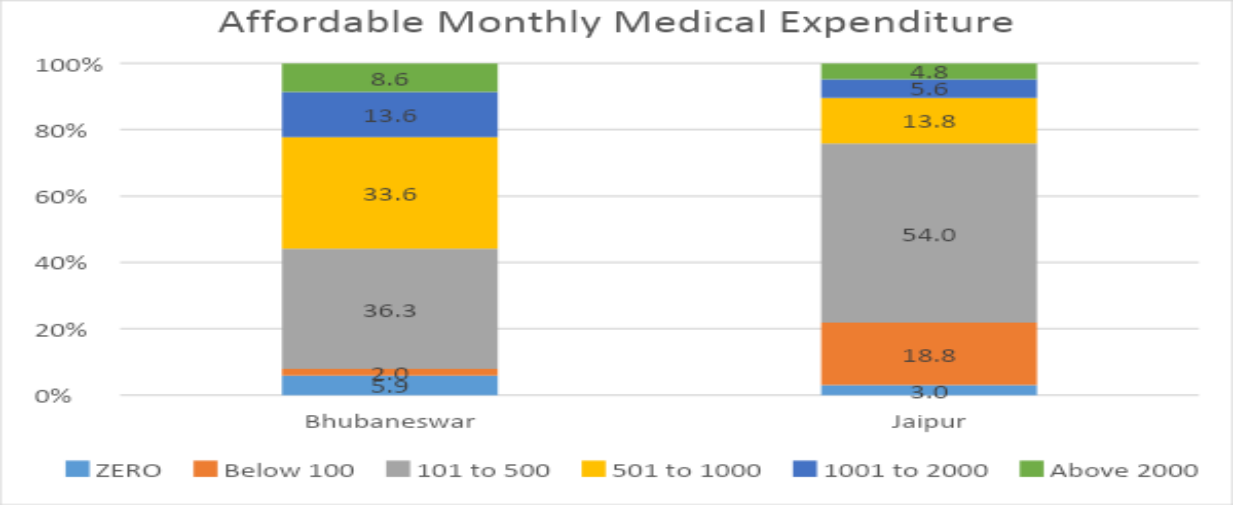
This perception is of paramount significance, particularly in the context of climate impacts and disaster situations. In regions like Bhubaneswar and Jaipur, where climatic events such as cyclones, floods, and extreme heat events can strike, the quality of WASH services becomes a pivotal factor. Inadequate WASH services during disasters can exacerbate the spread of waterborne diseases due to contaminated water sources, inadequate sanitation facilities, and poor hygiene practices. The overwhelming recognition of the connection between diseases and poor WASH services among residents reflected a heightened awareness of the vulnerabilities that arise during climate-related disasters.

For instance, in Bhubaneswar's Ward 49, several households used open drains for toilet waste due to inadequate sanitation and frequent waterlogging that can cause waterborne diseases and skin infections.

Monthly medical expenditure:

The following stacked bar graph (Graph 27) provides insights into the distribution of affordable monthly medical expenditure among slum populations in Bhubaneswar and Jaipur, categorized into different expenditure ranges, ranging from "zero" (indicating no medical expenditure) to "Above Rs. 2000." In Bhubaneswar, a significant portion of slum dwellers spent between Rs.501 to 1,000 (36.3%) and Rs.1,001 to 2,000 rupees (33.6%) on medical expenses each month. This suggests that a substantial fraction of this population allocated a considerable portion of their limited resources to healthcare. Similarly, in Jaipur, the highest expenditure range was Rs.501 to 1,000 (54.0%), followed by Rs.101 to 500 rupees (18.8%). The relatively higher medical expenditure in these cities' slums could have noteworthy implications during climate-related disasters.

Graph 27: Affordable Monthly Medical Expenditure in the slums of Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

In the context of climate and disaster impact, higher medical expenses among slum communities can exacerbate vulnerabilities during emergencies. Climate-related events such as floods, cyclones, or extreme heat can disrupt access to essential services, including healthcare facilities, in slum areas. The financial burden of medical expenses limited the residents' ability to access timely and adequate medical

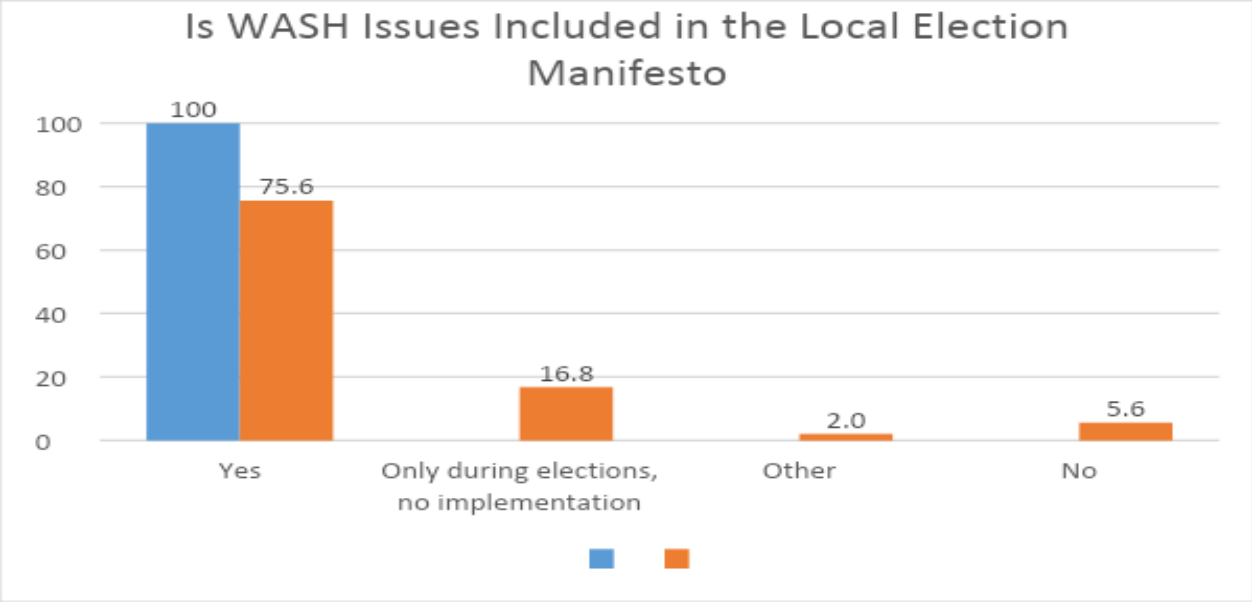
care, worsening health outcomes during and after disasters. Moreover, the unequal distribution of medical expenditures indicated disparities in the ability to cope with climate-induced health risks, that can potentially lead to increased morbidity and mortality rates.

Residents of Jaipur's Ward 113 emphasized the concerning link between insufficient waste management and disease transmission. During extreme weather, inadequate drainage and waste accumulation became breeding sites for disease-carrying insects. This highlighted the intricate relationship between climate, sanitation, and health. Frequent illnesses strained finances due to medical expenses. Poor waste management exacerbated health risks during storms, as stagnant water became a breeding ground for diseases.

Inclusion of WASH issues in local election manifestos:

The clustered bar graph (Graph 28) presents data on whether WASH issues are included in the local election manifestos of Bhubaneswar and Jaipur. In Bhubaneswar, 100% of the local election manifestos incorporated WASH issues, indicating a heightened awareness of the importance of these concerns. In Jaipur, 75.6% of the manifestos addressed WASH issues, but a notable proportion of 16.8% mentioned these issues only during elections without actual implementation. Moreover, 2% of the manifestos take an 'Other' approach, possibly referring to indirect mentions or vague commitments that included *'Not answered, 'Talked about it but not sure about the manifesto', partial mention, and 'I don't know'*, while 5.6% of the manifestos did not include WASH issues at all.

Graph 28: Is WASH Issues Included in the Local Election Manifesto of Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

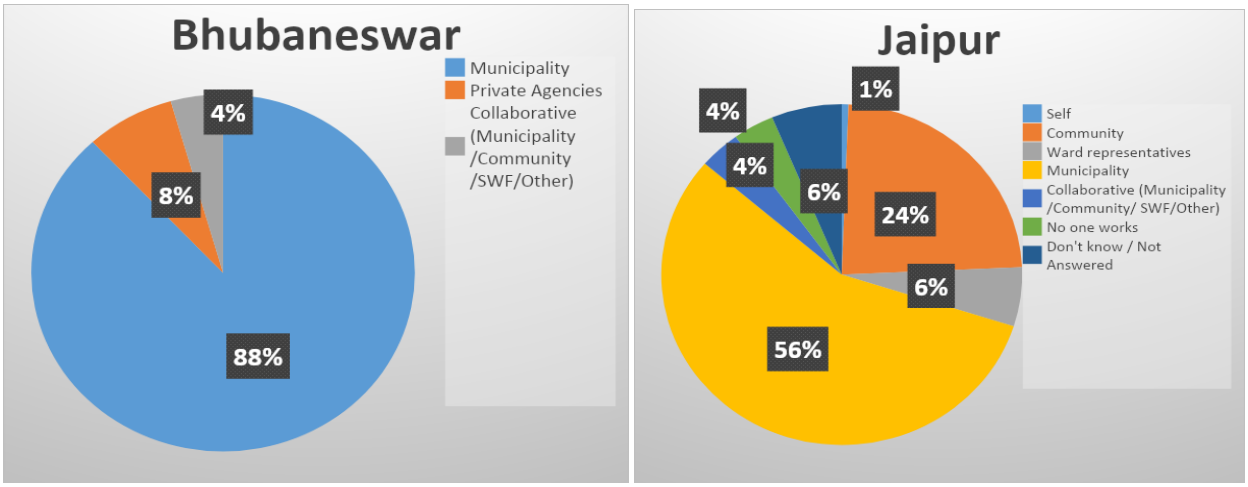
The inclusion of WASH issues in local election manifestos is pivotal, especially in the context of climate change and disaster management. Adequate sanitation facilities, clean water access, and proper hygiene practices are crucial during and after disasters to prevent the spread of diseases, ensure community

health, and maintain dignity. The absence of WASH considerations in local election manifestos, as observed in a portion of data from Jaipur, can lead to inadequate preparedness and response strategies during disasters, putting communities at greater risk.

WASH entities:

The provided pie-charts (Graph 29) outline the various entities that communities in Bhubaneswar and Jaipur approached when they came up with ideas for improved WASH services. These implications resonated particularly during climate-related disasters, underscoring the importance of effective collaboration and coordination. Effective collaboration between communities, ward representatives, municipalities, and private agencies can mitigate the impact of climate-related disasters on WASH services. Conversely, insufficient coordination or lack of awareness about suitable approaches can exacerbate problems during disasters, leaving communities more susceptible to health risks, waterborne diseases, and inadequate sanitation.

Graph 29: In case the slum community comes up with an idea for improved WASH services, whom they approach in Bhubaneswar and Jaipur.



Source: Primary survey, 2023.

In Bhubaneswar, the majority of communities (88.1%) approached the municipality, indicating a strong partnership between the community and local government in addressing WASH concerns. The collaboration between the community, municipality, ward representative and single window forum had a small share (3.7%) that optedfor collaborative efforts. Interestingly, a notable percentage (7.5%) responded that they approached private agencies to improve WASH services. In Jaipur, the picture was more diverse. A small fraction (0.6%) approached no-one and did addressed it themselves, reflecting self-initiative, while the highest proportion (56.4%) reached out to the municipality, emphasizing its critical role. Interestingly, a significant percentage (23.7%) engaged with the community, underlining the importance of collective action and community involvement. The collaboration of community, municipality, ward representatives, and private agencies (3.7%) also contributed to addressing WASH challenges. The percentages for “Don’t know/Not Answered” (6.3%) indicated a potential lack of clarity or uncertainty regarding suitable avenues for addressing WASH ideas.

CLIMATE CHANGE INDUCED WASH VULNERABILITIES IN JAIPUR AND BHUBANESWAR

Socio-economic conditions play a pivotal role in determining a community's vulnerability to climate change impacts. Lower-income groups often lack the resources to effectively adapt to extreme weather events, rendering them more susceptible to adverse consequences of floods, heat waves, and other climate-related disasters. Furthermore, the impacts of climate change on water resources leads to heightened evaporation, water scarcity, altered precipitation patterns causing droughts and heavy rainfall, and water source contamination, all of which disproportionately affect marginalised communities. Climate change also compounds existing vulnerabilities by disrupting sanitation systems, rendering them inoperative during floods, and escalating health risks, underscoring how socio-economic factors underpin and amplify the impacts of climate change on water and sanitation challenges. In both Jaipur and Bhubaneswar, the settlements are predominantly located in low-lying zones, rendering them susceptible to flooding. The presence of inadequate infrastructure has intensified the ramifications of extreme weather incidents, leading to the destruction of water supply and sanitation amenities. The information underscored the point that securing reliable water services, encompassing potable water delivery and groundwater access posed substantial difficulties for these communities. Moreover, these challenges have been further aggravated by the impacts of climate change.

The table given below provides a snapshot of the climate change variability, its manifestation and impacts on WASH services and infrastructure in the surveyed slums of Jaipur and Bhubaneswar.

Table 11: Impacts of Climate Change Variability on WASH in the Surveyed Settlements

Climate Change Variability	**Manifestation**	**Impacts on WASH**	**Example from the Surveyed Settlement**
Lesser rainfall	Lack of water availability, especially during summers	1. Limited water for toilets and bathing 2.Reduced frequency of washing/bathing 3. Contaminated drinking water 4.Increased reliance on alternative water sources	Jaipur, Ward 53
Shifting rainfall patterns	Changes in the timing and intensity of rainy seasons	1. Water scarcity during non-traditional rainy seasons 2. Challenges in water storage and management	Jaipur, Ward 31
Extreme weather events (heatwaves, heavy rainfall)	Intensified heatwaves and Flooding/Waterlogging	1. Contaminated water pipelines due to waterlogging and flooding 2. Water sources becoming turbid 3. Spread of waterborne diseases due to stagnant water 4. Overflow of drains leading to mixing of drainage and storm water, resulting in	Bhubaneswar, Ward 43

		groundwater and surface water contamination 5. Limited water availability due to extreme heat and increased evaporation	
Erratic rainfall	Waterlogging and overflowing drains	1. Contaminated water entering houses and toilets 2. Increased disease spread 3. Damage to sanitation facilities	Jaipur, Ward 113
Scanty rainfall spans	Water sources drying up during summers	1. Reduced water availability for all purposes 2. Health and hygiene challenges due to limited water	Jaipur, Ward 123
Enhanced rainfall intensity events	Open drains and open defecation	1. Compromised hygiene and sanitation 2. Increased risk of waterborne diseases 3. Impact on overall community health	Jaipur, Ward 123
Heat Wave	Rising diseases and disrupted livelihoods	1. Economic strain due to medical expenses 2. Challenges for daily wage workers during extreme weather 3. Impact on vulnerable groups like children and elderly	Jaipur, Ward 31
Extreme rainfall, strong winds	Absence of pre-announcements during disasters	1. Limited disaster preparedness and communication 2. Increased vulnerability during extreme events	Bhubaneswar, Ward 43
Erratic rainfall	Contaminated water pipelines	1. Reduced access to clean and safe water 2. Heightened health risks due to contaminated water	Bhubaneswar, Ward 50
Scanty rainfall, Lesser rains during monsoon	Inequitable sharing of water resources	1. Increased conflicts over water 2. Unequal access to water resources	Jaipur, Ward 123
Unpredictable weather	Impact on Livelihoods	1. Challenges for livelihoods and collection of water from long distances dependent on weather conditions 2. Economic instability due to incurring more money on collecting and managing water and sanitation	Bhubaneswar, Ward 43
Erratic rains	Contamination due to improper disposal of waste	1. Increased disease transmission due to poor sanitation 2. Impact on overall community health	Jaipur, Ward 113

Source: Adapted from the primary survey, 2023.

In the context of Bhubaneswar, specific challenges related to WASH within different ward numbers have been observed. The water supply timing from 6:00 – 7:00 am and 3:00 – 4:00 pm, or sometimes once a day, was insufficient for daily wage labourers who left for work early, thus being unable to fill water and store it creating water scarcity issues. During monsoons, water quality deteriorates in most cases, resulting in muddy water consumption that led to health problems like diarrhoea and abdominal cramps. Hand pump water, primarily utilised for domestic purposes, leaves soap residue after bathing due to iron content and soap incompatibility, causing dryness and itching, observed in a case in Bhubaneswar, Ward 43. Fatigue, joint pain, and suspected water quality issues suggested potential health impacts, including urinary tract infections among women. None of the water sources had been tested for quality, and hand pump water's strong metallic taste was attributed to its high iron content.

In Bhubaneswar, regarding sanitation facilities, the absence of individual toilets was prominent. Shared toilets raised hygiene concerns for women who found open defecation uncomfortable. Septic tanks were present but poorly constructed, leaking into surrounding soil and risking groundwater contamination. Overcrowded toilets in Kalpana Flat Basti (Ward 51) and Kedarapalli (Ward 53) led to non-usage due to daily wage labourers leaving for work early, increasing the risk of urinary tract infections. Settlements close to drains have connected toilets to the drainage system, resulting in foul smells, contamination, and disease vectors. Insufficient toilets in Sabar Sahi posed health risks, and some residents defecated in open drains or railway tracks during natural disasters, exposing themselves to accidents, infections, and safety risks.

In Bhubaneswar, issues with septic tank design have led to non-sanitary conditions and reverse flow of faecal sludge during monsoons. Open drains pollute soil and groundwater, leading to health concerns. In Kedarapalli, drains lack slabs and overflow during monsoons, and Sabar Sahi faces narrow internal drains that may not have the capacity to contain flood water during a disaster. Drainage facilities had not been cleaned or de-silted for years in certain areas. Settlements near drains and canals suffered from severe pollution due to sewage and waste disposal, and their connection to natural drainage channels exacerbated contamination. Ward 31 has covered drains, while Ward 57 lacks drainage, posing water stagnation and contamination risks during monsoons. These challenges highlighted the urgent need for comprehensive WASH interventions tailored to each ward's specific issues and vulnerabilities.

The following table provides a snapshot of the challenges faced by prioritised wards in Bhubaneswar and Jaipur, considering socio-economic, water, and sanitation factors and their intersection with climate change. It highlights how the vulnerability of communities to climate change is influenced by their socio-economic status and the availability of essential resources like water and proper sanitation facilities. Addressing these interconnected challenges requires a comprehensive approach that considers both the immediate needs of the communities and the long-term impacts of climate change.

Table 12: Prioritization of Wards Based on Socio-economic, Water, Sanitation, and Climate Change Impact Parameters

Ward number	Parameters for Prioritisation			
	Socio-economic	Water	Sanitation	Climate Change Impacts
	Bhubaneswar			
5	Large tribal population, socially marginalised, poor livelihoods, No electricity, Daily labourers, domestic workers, work in the brick kilns	No municipal supply, Use River water for drinking and household purposes, Absence of treatment, collect water from nearby residential colony	Open defecation, No drainage, open disposal of waste	Frequent flooding – riverbank settlements
11	Economically poor- Petty salesmen, daily workers, work as labourers in the factory	Water scarcity, water contamination from industries	Toilet connected to open combined sewer, dump waste into drains, wastewater accumulated into nearby ponds from industries, Households very closed to drain/waste dumping areas	Overflow of combined sewer during heavy rains, Heat waves, Cyclone affected area
16	Poor housing, economically very poor- domestic workers, rag pickers	Irregular water supply, Surface water pollution from industries, water contamination- households very close to drain	Open drain toilet connection	Flooding, water stagnation for longer periods, vector borne diseases
22	Poor housing, Households are rehabilitated/ shifted by the BMC, Low laying areas and prone of flooding and cyclone	Muddy water supply, takes more than 30 mins to collect water from community post-supply water pipeline passes closed to drain, waste dumping places	Neighbourhood drain not connected to city drain – causing overflows, breeding ground for mosquitoes,	Frequent flooding – high sloped-low lying area, no alternative toilets during flooding, Increased average temperature in

			irregular waste collection from Municipality	recent years, cyclone affected area
42	Poor housing-constraints of space, poor economic situation, low income as they are daily labourers, work as porters in the railway station	Not enough water, Muddy having with foul smell, Municipal water-manage community operated borewell, collect from nearby residential colony	Community toilet – difficult for PWD and elderly to access. Frequent overflow of toilets and drains. Open disposal of solid wastes.	(waste)waterlogged after heavy rain, increasing temperature – skin irritations
43	Caste discrimination in fetching water, and performing socio-cultural-religious rituals	Community taps, takes more than 30-45 mins. Pipeline passing through drains	Backflow of toilet waste, Open disposal of solid wastes	Flooding, Thunderstorm, Cyclone affected area,
49	Poor housing and economically poor-construction, domestic workers, daily labourers	Community supply takes more than 30 mins, muddy and smell of bleach. Community has borewell for drinking and cooking	No drains, Kutcha toilets, Narrow lane – problem of desludging, Improper disposal of solid waste and faecal sludge	Cyclone affected area – affects toilet building, no alternatives for WASH services during hazards
Jaipur				
23	Socio-economically backward, congested settlements, Muslim minority population and earning through making bangles	Groundwater depletion, water contamination from sewer, Water scarcity during summer	Rampant practice of open defecation (OD), no sewer – no desludging	Low lying settlements – flash floods, cause landslides, (waste)waterlogged after heavy rain, extreme winter and summer
55	Socio-economically backward, Congested settlements, Mostly engaged in begging profession	*NA (No serious water related issues observed here)*	No toilet – open defecation, Frequent sewer overflows, Lack of awareness about safe WASH practices.	High sloped – low lying settlements – flash floods,

84	Multiple case groups, economically poor – cattle rearing , daily wage laborers	No access to Municipal water connection, Water scarcity	Open defecation and water contamination, open sewer	Low lying settlements – flash floods, water contamination from sewer
93	Tribal population, no nearby health centres	Water scarcity during summer, groundwater depletion	Kutcha toilet – open defecation, No desludging	Heat waves – hilly terrain, Prone to landslides and flash flooding leading to loss of livelihoods
99	Vulnerable backward caste community – earn through cattle rearing and auto driving	Water scarcity, groundwater depletion, situated in forest land. The attacks by wild animals (leopard) have been seen.	Water depletion, contaminated water access and landslides	Heat waves – hilly terrain, Increasing temperature every year
114	Vulnerable communities from SC, economically poor – daily wage laborers, street vendors	Water scarcity during summer, groundwater depletion, water contamination	No toilet – open defecation, No access to sewer-line	Low lying settlements, near drains – flash floods, (waste)waterlogged after heavy rain
123	Vulnerable communities from SC and ST, Large number of elderly and PwDs	Water scarcity, only about 33 litres per family, water fetching time more than one hour	Kutcha toilets, No desludging services, No sewer, open defecation (OD)is common, Cases of sexual harassment during OD, open disposal of animal faeces	Extreme summer, low lying settlements – prone to flash floods, no alternative options for water
147	Socio-economically backward, poor housing	Water scarcity across year, surface water, contaminated with human and animal waste	No individual toilet, limited CTC seats – open defecation, No drains	Waterlogged for longer period, no alternative source of water during hazards,

Source: Adapted from the primary survey, 2023.

The table provided presents a comparison of different ward numbers in the cities of Bhubaneswar and Jaipur, along with specific parameters used for prioritization in terms of socio-economic factors, water availability and quality, sanitation facilities, and climate change vulnerabilities. Each ward number is accompanied by a set of conditions that outline the unique challenges faced by the respective communities residing there.

In Bhubaneswar, various wards experience distinct socio-economic challenges, inadequate water and sanitation facilities, and vulnerability to climate change. The marginalised tribal population in Ward 5 faces frequent flooding due to its proximity to the riverbank, exacerbating their already marginalised living conditions. The economically disadvantaged residents of Ward 11 contend with water scarcity and contamination from industries, coupled with heightened vulnerability to heat waves and cyclones. The relocated inhabitants of Ward 22's struggle with inadequate drainage systems, increasing their susceptibility to flooding and cyclone impacts. Additionally, Ward 16 and Ward 42 grapple with stagnant water and poor sanitation, with the former prone to flooding, while Ward 43 faces caste-related discrimination and flooding from thunderstorms and cyclones. The economically disadvantaged residents of Ward 49 face inadequate water supply, improper sanitation, and heightened vulnerability to cyclones.

Starting with Bhubaneswar, Ward 5 stood as a microcosm of socio-economic vulnerabilities. The presence of a large tribal population, coupled with social marginalization and poor livelihood opportunities, has left this community economically disenfranchised. The absence of electricity and reliance on daily labour and domestic work has further perpetuated their vulnerable status. This socio-economic backdrop is intricately linked to the water challenges they face. The use of river water for drinking and household purposes due to the lack of municipal supply and treatment infrastructure has accentuated health risks.

Similarly, in Ward 11 of Bhubaneswar, socio-economic vulnerabilities have intertwined with water and sanitation concerns. The economically poor, engaged in petty sales and daily labour, faced challenges in accessing clean and safe water due to water scarcity and contamination from industries. Sanitation issues arise from toilets connected to open combined sewers and improper waste disposal. Climate change has intensified these vulnerabilities, with heat waves and cyclones adding to the existing challenges, thereby creating a multidimensional crisis.

Transitioning to Bhubaneswar's Ward 16, poor housing conditions and economically marginalised backgrounds painted a complex picture. These households, often engaged in domestic work and rag-picking, and struggled with irregular water supply and surface water pollution, primarily stemming from industrial activities. Sanitation challenges have persisted due to open drain toilets, presenting significant health and hygiene risks. The risk of vector-borne diseases loomed large, as stagnant water in low-lying areas provided a breeding ground for disease-carrying vectors.

The landscape of Bhubaneswar's Ward 22 of poor housing was susceptible to flooding compounds exacerbating the water and sanitation challenges. Muddy water supply and irregular waste collection hindered efforts to maintain a clean environment. The vulnerability to flooding has been aggravated by climate change-induced heavier rains and increased temperatures. The overlapping nature of these challenges necessitates a comprehensive approach to building resilience.

Turning to Jaipur, several wards with socio-economic vulnerabilities have been grappling with multiple challenges exacerbated by climate change. Ward 23, densely populated and socio-economically disadvantaged, faced groundwater depletion and water contamination and was highly susceptible to floods and landslides. Similarly, the tribal population in Ward 93 has to contend with water scarcity, open defecation, and heat waves, compounded by the hilly terrain's susceptibility to landslides and flash floods.

Jaipur's Ward 23 has grappled with socio-economic vulnerabilities and water scarcity. Congested settlements and groundwater depletion underscored the fragility of water resources, especially when combined with water contamination from sewers. The absence of proper sanitation infrastructure has resulted in open defecation and sewer overflows, contributing to unhygienic conditions. The vulnerability to flash floods and landslides has become pronounced due to the ward's low-lying areas.

Jaipur's Ward 55 showcased the intricate relationship between socio-economic challenges and limited water resources. Although no serious water-related issues were observed, the socio-economic backwardness and engagement in begging professions suggested vulnerability. However, the lack of proper sanitation facilities, resulting in open defecation and sewer overflows, perpetuated health risks. Extreme weather events have magnified the consequences of inadequate living conditions.

In Ward 84 of Jaipur, economic constraints combined with cattle rearing and daily wage labour have left communities vulnerable to water scarcity and contamination. Open defecation and sewer contamination have compounded the sanitation challenges, and the risk of flash floods and water contamination has further escalated due to their low-lying settlements. The tribal population in Ward 93 has been grappling with water scarcity and groundwater depletion, presenting a unique socio-economic and environmental intersection. The absence of proper sanitation infrastructure has exacerbated their vulnerabilities, as kutcha toilets and open defecation have become the norm. The hilly terrain's susceptibility to heat waves, landslides, and flash flooding has added another layer of complexity. Ward 99's vulnerability has been shaped by water scarcity, groundwater depletion, and attacks by wild animals due to its forested location. The economic challenges faced by communities engaged in cattle rearing and auto-driving have made adaptation strategies imperative. Additionally, the ward's terrain has made it more prone to heat waves and increasing temperatures.

In Ward 114 of Jaipur, socio-economic backwardness has contributed to water scarcity and contamination, leading to open defecation and sewer-related health hazards. Their proximity to drains and low-lying areas has increased the vulnerability to flash floods and waterlogging during heavy rains. Vulnerable communities in Ward 123 are marked by water scarcity and sanitation challenges, including kutcha toilets and open defecation. Extreme summer conditions and low-lying settlements have rendered them susceptible to flash floods, further accentuating their vulnerability.

CLIMATE RESILIENT ACTIONS FOR WASH

Climate change has significantly amplified pre-existing vulnerabilities in accessing WASH services. The complexities arising from climate change and extreme weather events have impacted various dimensions within these slum areas, encompassing water management, sanitation infrastructure, public health, livelihoods, community infrastructure, and overall resilience. Shifts in climate patterns, augmented by inadequate facilities and compromised water sources, have heightened health risks and created challenges in upholding proper hygiene practices. Particularly vulnerable groups, such as Persons with Disabilities (PwDs), the elderly, and pregnant women, have borne a disproportionate burden of these impacts.

A comprehensive approach is imperative to tackle these challenges and enhance WASH resilience. This approach encompasses climate-resilient infrastructure, strengthened water management systems, upgraded sanitation facilities, and the propagation of awareness regarding climate-related risks and optimal WASH practices. Bolstering disaster readiness, improving healthcare access, and promoting sustainable behaviours further contribute to resilience-building efforts. Collaboration between the community, government agencies, and other stakeholders is essential to implement these strategies effectively, ensuring safe and sanitary living conditions for all residents, especially as climatic conditions evolve.

Creating robust WASH resilience entails the integration of multi-faceted strategies, including enhanced infrastructure, adept disaster preparation, community empowerment, and governmental support. These strategies collectively establish the foundation for bolstering the capacity to withstand climate-induced vulnerabilities. Moreover, adopting an inclusive approach that transcends caste and social status is vital to guarantee equitable access to resources and services, fostering a sense of collective responsibility towards WASH resilience. Elevating awareness about the rights of marginalised communities and educating society on the repercussions of discrimination can catalyse shifts in attitudes and behaviours, thereby contributing to building a more resilient and inclusive WASH environment.

Some of the key strategies for climate resilient WASH are summarised as below:

- **Factoring climate risk into situational analysis:** Participatory assessments of WASH infrastructure and services from a climate and gender and social inclusion lens is of utmost importance. Climate change impacts men and women differently. It impacts marginalised groups in a different way than other sections of the community. It is important to understand and mitigate these different vulnerabilities and impacts by involving these groups in the assessments and action planning.
- **Strengthening WASH systems for climate resilience:** Achievement of the SDG 6 is dependent on a strong WASH system. WASH systems, made up of actors, factors and interactions between them, ultimately need to respond to the impacts of climate change. Weaknesses or barriers will undermine a system's ability to cope with climate change. This also means that for instance, in flood-prone and water-stressed areas, various innovations have taken shape in sanitation technologies, such as 'pit latrines', 'low-flush septic systems', 'ecosan latrines' and 'high-volume septic tanks'. These have been recognised as potentially resilient to climate change. It is important to further build knowledge and research on the resilience of these technologies in specific geographies. For big WASH infrastructure—

such as underground sewerage, storm water systems, drainage and water supply pipelines—it is important to screen the infrastructure for disaster risk and climate variability, especially in areas prone to disasters. This infrastructure must be constructed with local collaboration and in a way that it provides equitable access to all.

- **Ward-level micro planning on WASH**: In the light of varying climate change impacts on WASH in different wards of the both the cities, ward-level micro planning on WASH with clear action plans will help in developing climate resilience in the wards. The 74th Constitutional Amendment which provides decentralised powers and authorities of Municipal bodies at different levels also envisages people's participation in developmental interventions and decision making.
- **Introducing the Saniclimiwall**: In the first phase (2018-2022), we developed and implemented Saniwall in both cities. In the second phase (2023-2024), it has transformed from promoting inclusive WASH to fostering climate-resilient WASH practices. Within the framework of Saniclimiwall, community monitoring has played a crucial role in tracking and overseeing climate-informed WASH services, managing disruptions, implementing adaptations, and initiating mitigation measures. This approach is aligned with the Joint Monitoring Programme (JMP) and the Rio Markers. Additionally, Saniclimiwall places a strong emphasis on exploring 'alternative sources' for water and sanitation services to enhance their resilience in the face of climate-related challenges.
- **Capacity building of the frontline stakeholders:** Enhancing community and stakeholder capacity to handle climate-related challenges in WASH services; will be developing community radio though mobile-App and partnering with the Indian Meteorological Department (IMD) and National Institute of Disaster Management (NIDM) in shaping climate change adaptation (CCA) with disaster risk reduction (DRR). Further, capacity building of city managers, Ward Corporators, people involved in sanitation supply chain and communities also needs to be done towards achieving the resilient WASH goals.
- **Integration of desludging services:** In Jaipur, there is a deliberate effort to maintain regular desludging of pits within the slum areas, primarily aimed at preventing overflow and the mixing of waste with rainwater, a common issue in these low-lying regions. In Bhubaneswar, this initiative, has been shaped by our team, is led by transgender self-help groups to manage desludging. Additionally, there is a supplementary initiative to address the desludging of liquid waste from narrow lanes, which involves the use of small vehicles provided by the Bhubaneswar Municipal Corporation.
- **Linkage with policies and programmes:** For efficient WASH services, it is important to link the vulnerable communities with WASH related programmes and schemes for them to access the required services and benefits so that no one is left behind.
- **Community level awareness:** This is also crucial, given the high percentage of illiterate communities in the slums of intervention cities. Awareness and behaviour change communication for safe sanitation is important, especially amongst women and children so that they are aware of the ill-effects of unsafe sanitation, unhygienic practices, open defecation and so on.

REFERENCES

- Brooks, N. (2003). Vulnerability, risk and adaptation: A conceptual framework. *Tyndall Centre for climate change research working paper*, *38*(38), 1-16. https://www.ipcc.ch/apps/njlite/srex/njlite_download.php?id=5463
- IPCC. (2012). *Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, USA, pp. 555-564. https://archive.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf
- Mishra, S. P., Mishra, S., & Siddique, M. (2020). The Anthropocene Dialogues on Climate Change to Human Health of Homosapiens in India. *Current Journal of Applied Science and Technology*, 13–30. https://doi.org/10.9734/cjast/2020/v39i2430869
- Climate Resilience Strategy, Bhubaneswar City, India, published by ICLEI – Local Governments for Sustainability – South Asia, New Delhi.
- http://ijrar.com/upload_issue/ijrar_issue_20544166.pdf
- UNDP. (2023). *The Climate Dictionary: Speak climate fluently.* UNDP, New York, USA.
- GWP & UNICEF. (2017). *WASH Climate Resilient Development: Guidance Note - Risk assessments for WASH*, UNICEF.

VOICES FROM THE COMMUNITY

The intricate tapestry of the impact of climate change's on water, sanitation, and hygiene (WASH) services in these identified slums and wards unveils a profound narrative of vulnerabilities and stressors etched into the daily lives of resilient communities. While comprehensive knowledge about the underpinnings of climate change eludes them, their acute observations of heightened phenomena like scorching heat waves, relentless daytime temperatures, and intensified rainfall illuminate their association of these occurrences with the potential outcomes of climate change.

Regarding climate change and adaptation strategies, the stories within these themes come together to emphasize the importance of community adaptation. As climate patterns change and impact WASH services, the experiences of residents show their resilience. From managing resources to preserving health, their stories stress the need for urgent action on climate change through adaptive strategies that empower vulnerable communities. The narratives from different slum areas offer a comprehensive understanding of how climate change worsens vulnerabilities related to WASH services. The residents' views highlight how shifting weather patterns directly affect their daily lives and reveal the difficulties they encounter in accessing clean water, proper sanitation, and maintaining hygiene. These views revolve around the following key themes:

- Community members have observed changes in weather patterns, including increased day temperatures, heat waves, and heavy rainfall. These shifts have led them to attribute these changes to climate change. Heavy rainfall, in particular, impacts water supply systems, causing pipeline water to become muddy and unsuitable for consumption. As a result, residents are forced to rely on alternative sources like hand pumps. Concerns about water safety arise due to the metallic taste and smell of hand pump water, leading to doubts about its potability.
- Inadequate drainage systems, especially during monsoons, contribute to waterlogging and overflowing drains. This results in unhygienic conditions, spread of disease, and contamination of water sources. Poor drainage systems cause drain water to enter houses and backflow into toilets, further exacerbating the risk of waterborne diseases. The lack of proper sanitation facilities, including open defecation in some instances, adds to the challenges faced by these communities.
- The direct impact of shifting weather patterns, heat waves, and increased temperatures affects people's health and livelihoods. Construction workers and labourers, who rely heavily on outdoor work, face difficulties in earning a living during extreme weather conditions. Climate-related disasters like cyclones and floods exacerbate these challenges, as lack of proper water and sanitation facilities pose severe risks to safety and well-being.
- Community members are taking initiatives to address their WASH challenges. They are engaging with local authorities and government agencies to repair water supply systems, advocate for improved sanitation facilities, and seek solutions to drainage issues. While efforts are being made, comprehensive support from local authorities and government agencies is crucial to effectively address these concerns and vulnerabilities.

- Many of the slum settlements are located in low-lying areas, making them susceptible to flooding. Poor infrastructure exacerbates the impacts of extreme weather events, causing damage to water supply and sanitation facilities. During heavy rains and floods, drainage systems often fail, resulting in contaminated water entering houses and toilets, heightening health risks.
- Extreme weather events like floods and droughts disrupt the availability of clean drinking water. While water scarcity increases during droughts, flooding often contaminates existing water sources, leaving communities without access to safe water. Changing weather patterns, such as increased temperatures and unpredictable rainfall, directly affect water sources like wells and hand pumps, worsening water scarcity during dry periods.
- Within this spectrum of awareness and adaptation, the voice of Chandrama Panda, a seasoned member of the Self-Help Group (SHG) dwelling in Sabar Sahi within Bhubaneswar's Ward 46, resonates. She draws attention to their reliance on a hand pump as a water lifeline. Yet, when torrents of rain descend, the pipeline water that once quenched their thirst transmutes into a turbid liquid akin to liquid earth. The ensuing need to resort to the hand pumps, despite disruptions, evokes an image of a resilient community that adapts, tides over and takes the initiative. In this relentless pursuit, even Chandrama, in her late 50s, navigates joint pains, redefining perseverance. The act of boiling water from alternative sources echoes their innate ability to confront challenges head-on.
- In a neighborhood called Badami in Jaipur's Ward 17, climate change badly affects WASH services. The water here, which is supposed to be clean and safe, starts off dirty and full of impurities. This is because the old, worn-out plastic pipes that carry the water contaminate it. This situation highlights the need for urgent repairs and an upgrade of the aging water infrastructure.
- In Jaipur's Ward 23, Shaheen, an Anganwadi Worker, expresses the frustration of a community's voice echoing into the void. Despite collective endeavours and dialogue with ward officials, stagnation prevails. This poignant confession resonates, emphasizing the gap between intention and implementation.
- Jali Nayak from Kedarapalli, Bhubaneswar Ward 53, articulates the dichotomy of living conditions, where neighbouring *bastis* enjoy amenities they yearn for. The quest for dignity extends to sanitation. The narrative shifts to waterlogging, drowning out hope during monsoons. Narrow drainage systems groan under the burden, while filth becomes a relentless invader. Kiran Nayak, 21, acknowledges the unspoken peril of faecal sludge. The seepage and overflow infiltrate the ground, but the damage is not limited to that. In a sense, this destroys the trust in people who aspire for clean water. Kiran's plea for community action carries echoes of hope.
- In Bhubaneswar’s Ward 26, over time, seasons change, and so does the climate. Sahadev Reedy's voice reflects the unpredictable nature of climate, mixing the expected with the unexpected. Natural disasters push people to move in search of water. Bhanumati Ghaso adds a thoughtful perspective, highlighting the gradual but significant changes in climate. These changes affect people's lives, impacting their homes and surroundings.
- As the narratives meld, the sentiment persists: water is life. The journey is shared by Radharani Mohanty, Chabita Bhoi, Jaga Bhoi, and many more from Bhubaneswar. Their observations converge

into a narrative in which the dominos of climate changetopple over livelihoods, health, and dignity. The undulating path of the impact of climate change's on WASH becomes a tapestry woven with each voice, a blend of struggle and resilience, survival and adaptation. In the throes of uncertainty, their voices stand as a testament to the need for change, empathy, and action.

- The climate change and livelihood disruption can be better understood through the voices from Jaipur's Ward 31 that echo the profound effect of climate change on livelihoods. Daily wage workers are vulnerable to unpredictable rainfall that disrupts their earning opportunities; Rising diseases strain resources, bringing into focus the vulnerability of small slum communities to direct impacts like flash floods and indirect challenges like inflation. "The effects of climate change are directly affecting livelihoods, especially those of construction workers and masons. Unpredictable weather patterns, marked by heavy rainfall and heat waves, disrupt their ability to work outdoors, impacting their daily earnings." Kusa Bhoi, from Laxmisagar Tala Sahi, emphasized this challenge.
- On the other hand, on health and sanitation challenges, residents in Jaipur's Ward 113 recount the cascading effects of climate change on health and sanitation. Common illnesses lead to economic strain due to medical expenses. Inadequate waste management exacerbates health risks during storms, with stagnant water becoming breeding grounds for disease. This dire situation demands comprehensive mitigation and adaptation measures. The residents of the slum are acutely aware of the impacts of climate change on their lives. Many have stated that their means of earning a livelihood is being disrupted due to shifting weather patterns. Unpredictable rainfall, in particular, hampers the ability of daily wage workers to commute to work. Furthermore, the changing climate has led to a rise in diseases, causing depletion of their savings due to medical expenses. The pervasive effects of climate change are profoundly affecting everyone, but the vulnerable inhabitants of these small slums are disproportionately burdened. Their struggle for basic necessities and health-related challenges are compounded by the direct impact of flash floods and the indirect influence of inflation, as the cost of essential goods rise.
- Regarding the impact on livelihoods and vulnerability, in Jaipur's Ward 31, residents echo concerns about the direct influence of a changing climate on their livelihoods. Unpredictable weather patterns disrupt the ability of daily wage workers to commute to work, affecting their income. Additionally, a rise in diseases places additional strain on already limited resources, highlighting the vulnerability of these marginalised communities.
- Regarding resilience and resource management, in these small slum settlements, the direct impacts of climate change are intertwined with broader challenges. The vulnerability of these communities becomes more evident as flash floods and inflation compound their struggles. This overarching perspective, prevalent in Jaipur's Ward 31, underscores the urgency of comprehensive interventions that address the interplay of various factors.
- Navigating water scarcity and sanitation, residents of Ward 123 in Jaipur, particularly those with disabilities like Urmila, grapple with water scarcity and sanitation challenges. The rainy season exacerbates their difficulties, demanding innovative solutions for safe water access. Meera's

experience highlights the immediate need for improved water infrastructure to alleviate long queues and ensure safety during adverse weather conditions.

- On equity in water distribution, Kushal Chand's perspective highlights inequities in water sharing within the settlement. The lack of willingness to share resources exacerbates household water scarcity. His plea for access to the Bisalpur connection underscores the importance of equitable distribution systems that prioritize the well-being of every community member.
- With regard to the impact on health and hygiene during extreme weather conditions, Renu's experience in Ward 123 exposes the challenges of maintaining hygiene in such conditions. The need for proper bathroom facilities and greywater management becomes evident, especially during the rainy season. Her account emphasizes the vital role of sanitation infrastructure in preserving community health.
- Residents in Jaipur's Ward 113 shed light on the intricacies of climate change impacts. As common illnesses escalate due to unpredictable weather changes, their economic well-being is compromised by increased medical expenses. Inadequate waste management exacerbates health risks, revealing the pressing need for comprehensive strategies to address vulnerabilities.
- Regarding education and climate challenges, in Ward 123, residents are forced to make difficult choices regarding their children's education due to the lack of schools within the slums. This disruption in education further compounds the challenges faced by the community, highlighting the complex relationship between climate change impacts and the broader social fabric.
- Related to water quality and contamination, Snehalata Pradhan's concern in Bhubaneswar Ward 50 sheds light on the issue of water quality. Contaminated water pipelines linked to drainage systems compromise the community's access to clean water, exacerbating health risks. Her perspective underscores the importance of not only water availability but also its safety.
- On infrastructure and climate resilience, the experiences of the Fire Station slum in Bhubaneswar Ward 50, as shared by Jahamgiri Maharana, highlight the connection between water availability and infrastructure resilience. The contrasting water availability between rainy and summer seasons underscores the need for robust infrastructure that can withstand climate variations.
- Regarding waste management and disease spread, residents from Ward 113 in Jaipur shed light on the impact of inadequate waste management on disease transmission. Poor drainage and waste accumulation during intense weather events creates breeding grounds for disease-carrying insects. This theme underscores the interconnectedness of climate, sanitation, and health.
- On livelihood disruptions and vulnerability, the experiences of daily wage workers and construction labourers in Bhubaneswar’s Ward 43 underscores the immediate impact of climate change on livelihoods. Unpredictable weather patterns disrupt outdoor work, highlighting the vulnerability of these occupations and their subsequent economic stability.
- Discussing early warning systems and preparedness, Gurucharan Bhoi's observation in Bhubaneswar Ward 43 highlights the importance of early warning systems during disasters. The absence of pre-

announcements through government bus services exposes a gap in disaster preparedness. This perspective emphasizes the need for improved communication strategies during extreme events.

- On the changing rainfall patterns and infrastructure, Pramila Samal's account in Bhubaneswar Ward 43 addresses the impact of changing rainfall patterns on infrastructure. The transition from traditional materials to concrete roads has led to waterlogging issues, indicating the need for climate-resilient infrastructure that takes into account evolving weather patterns.
- Across these diverse themes and narratives, a comprehensive understanding of the impacts of climate change on WASH services emerges. These residents' voices shed light on the intricate connection between climate shifts, infrastructure challenges, health risks, and vulnerability. The urgency of addressing these issues through adaptive strategies, equitable resource distribution, and community resilience becomes increasingly evident. As their stories intertwine and intersect, the call for action becomes resoundingly clear. The impact of climate change on WASH services demands immediate attention, innovative solutions, and a collective commitment to a sustainable future.

The community's collective perceptions emphasize the urgent need to address WASH vulnerabilities in the context of climate change impacts. These vulnerabilities further underscore the importance of comprehensive solutions that consider equitable access to clean water, improved sanitation facilities, and adaptive strategies to mitigate the impact of shifting weather patterns. It is evident that the voices of the residents provide valuable insights that can guide effective interventions to build climate resilience and ensure the well-being of marginalised communities.

Annexure-1

List of Members

Elected Representatives: Bhubaneswar-Minshree Khuntia, ward -5; Premananda Jena, ward-20; Pujarani Behera, ward-21; Ashish Kumar Patnaik, ward-42; Bharat Lenka, ward 43; and Sanjukata Sundaray, ward 49; Deputy Mayor: Manjulata Kahanra, ward-22

Slum Development Association: Minati Deuri, Sabar Sahi, ward-9; Rakesh Makar, Baliapata, Malati Mandala, Sumitra Tiria, Nalabandha Munda Sahi, ward-18; Chatu Das, Nirakar Mohapatra, Kimbhiria Basti, ward-19; Sanjukta Dash, Mangala Nagar, ward-20; Laxmipriya Lenka, Nirankari Nagar, ward-21; Swarnaprava Nayak, Pandakudia, ward -22; Subhadra Das, Banapgula Basti; Jhuna Pradhan, Mochi Sahi, ward-42; Bishnupriya Sahoo, Mahila Samiti Basti; Vivek Bhoi, Laxmisagar Majhi Sahi,; Subrata Behera. Laxmisagar Tala Sahi; Purbachandra Bhoi, Pramila Samal , Laxmisagar Upara Sahi, ward 43; Shyamasundar Sahoo, Tapobana School Basti, ward-49; Bhubaneswar

Sanitation Sub-Committee: Jhunubala Dash, Rangamatia Tala Sahi, ward -9; Mili Sahoo , Mayfair Nagar, ward -16; Aujadhiya Nayak , Gayatri Das, Sabitri Jena, Mangala Nagar, ward-20; Mamata Pradhan, Sampur, ward -22; Lili Samal, Puja Chatoi, Mahila Samiti Basti; Dashrathi Bhata, Laxmisagar Majhi Sahi; Namita Behera , Sulachana Behera, Laxmisagar Tala Sahi, Chabita Bhoi, Laxmisagar Upara Sahi, ward -43; and Namita Sahoo, Namita Patra, Jogendra Dakua, Tapobana School Basti, ward -49; Bhubaneswar; Farzana, Sharmila, Bandha Basti, ward- 23; Lakshmi, Swami Basti; Manju, Painter Colony,Ward 55; Ranjita, Ghat Ke Balaji; Sayar, Vishnu, Mohan Kanwar, Purana Ghat, ward-84; Vijay Lakshmi Kanwar, Sajjan Kanwar, Rekha,Meena Basti,ward- 93; Neetu, Jagga Ki Bawadi, ward 99; and Rekha Devi, Mahender,Baisi ki Dhani, ward- 123, Jaipur

Single Window Forum: Laxmi Parida, Rangamatia Tala Sahi; Gitanjali Nayak , Gadakhana Sabar Sahi , ward - 9;Mamata Nayak, Nalabandha Munda Sahi, ward -18; Pramila Chanda, Aditya Nagar, ward -20;Jyoshna Rani Sahoo, Nirankari Nagar, ward- 21; Geetanjali Bagha, Basti Bikash-2, ward -26;Jyoshna Rani Datta, Sabar Sahi, ward -46;Arati Parida, Jayanti Moharana , Bhagabati Basti; Sanatan Ojha, Rasmita Nayak, Firestation, ward -50; and Janaki Biswal, Namita Sahoo, Bishnupriya Behera, Mamata Mohanty, Sabitri Parida, Tapabana Basti, Ward 63; Bhubaneswar

Community Management Committee: Sajani Bhoi, Rashmita Sahoo, Gadakana Bhoi Sahi; Laxmirani Swain, Soudamini Nayak, Rangamatia Tala Sahi; Ahalya Chatei Arobinda Nagar;ward -9; Chandana Chaini, Kimbhiri Basti, ward -19;Bidulata Das, Shakti Vihar, ward -20;Jyoshna Rani Sahoo, Janata Nagar; Ratnakara Behera, Nirankari Nagar ward-21;Jhunulata Patra, Basti Bikash-1; Saroniji Routray, Basti Bikash-2, ward no-26;Prabhati Panda, Barabhuja Basti, ward-63;Jayanti Moharana, Suka Vihar, ward -66; Bhubaneswar

Frontline Workers: Suchitra Behera, Nilachakra Nagar, ward-16; Puswalata Patra, Sudipa Sahoo, Rasmita Behera, Nirankari Nagar, ward-21; Puswalata Sahoo, IRC village, ward- 25;Nibedita Nayak, Ganapati Nagar; Dipanjali Pani, Shantilata Sahoo, Gandhi Basti, ward 27; Kalyani Das, Gopabandhu Leprosy Colony, ward-42;Namita Bhoi, Mahila Samiti Basti, ward -43;Swapna Kumari Mohanty, Harapriya Sahoo, Puja Behera, Banojini Pradhan, Tapoban School Basti, ward-49; and Banki Rani Swain, Barabhuja Basti, ward -

63; Bhubaneswar; Daulat, Nazma, Bandha Basti, ward- 23; Pinky Gurjar, Asha Gurjar, Jagga Ki Bawadi, ward- 99; Afessen Bano, Baisi ki Dhani, ward- 123; Jaipur

Community leaders and representatives

Trans women: Sweety Fatima, Rani Kinner, Sanjana Behera, Kalinga Studio Kinner Basti, ward 23;

Sanitary worker: Sumati Behera, Purusatam Basti, ward-10, Bhubaneswar; Gopali, Banarsi, , Katputli Nagar, ward- 147, Jaipur.

Youth club members: Babuli Nayak, Rangamatia Tala Sahi; Bishnu Sahoo, Gadakana Sabar Sahi, ward -9; Bimal Bhoi, Pandra Bhoi Sahi, ward -18; Suchismita Parida, Kasturi Pradhan, Payal Nayak, Rasmi Panda, Pichupadia Basti; Suman Pradhan, Maa Mangala Basti, Ward no-46; Bhubaneswar; Kuldeep, Meena Basti, ward 93, Jaipur

Elderly forum: Nathi, Banarasi, Tata Nagar, ward- 17; Kaali Devi, Jagga Ki Bawadi, Jaipur

Persons with disabilities: Urmila, Lakshmi, Baisi ki Dhani , ward -123, Jaipur

Bhubaneswar Project Team

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