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IWMI

TRAINING MANUAL

Development of Catchment Management Plan

Title

Training Manual: Development of Catchment Management Plan

Under the Project

Integrated Rural Urban Water Management for Climate Based Adaptations in Indian Cities (IAdapt)

Supported by

International Development Research Centre (IDRC), Canada

Project Consortium

- ICLEI – Local Governments for Sustainability, South Asia
- Athena Infonomics LLC Pvt. Ltd.
- International Water Management Institute (IWMI)
- Indian Institute of Technology, Madras (IITM)

Disclaimer

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Abbreviations

CMP	-	Catchment Management Plan
GHG	-	Greenhouse Gas
GIS	-	Geographical Information Systems
GoI	-	Government of India
IAdapt	-	Integrated Rural Urban Water Management for Climate Based Adaptations in Indian Cities
IITM	-	Indian Institute of Technology, Madras
IPCC	-	Intergovernmental Panel on Climate Change
IUWM	-	Integrated Urban Water Management
IWMI	-	International Water Management Institute
IWRM	-	Integrated Water Resource Management
lpcd	-	Litres per capita per day
MLD	-	Million Litres per Day
NRW	-	Non Revenue Water
RURBAN	-	Rural Urban

1. Introduction

Conventional water management with their siloed approaches are ineffective in supporting cities to combat the impacts of climate change on their water resources. Cities are not closed systems and city-centric responses are inadequate to foster water security. A catchment level water management approach that recognises the linkages between cities, transitional zones outside the cities and surrounding rural areas can promote integrated water resource management and enhance water security in the region.

This training module has been developed to assist rural and urban local authorities, decision makers and practitioners to formulate Catchment Management Plans (CMPs) that consider the interactions and inter-linkages of water sector with other related sectors and the climate risks to them.

The process of formulating the CMP is based on the IAdapt Framework developed by ICLEI - Local Government for Sustainability, South Asia (ICLEI SA) in partnership with Athena Infonomics LLC, International Water Management Institute (IWMI) and Indian Institute of Technology, Madras (IITM) under the project - Integrated Rural Urban Water Management for Climate Based Adaptations in Indian Cities (IAdapt) funded by International Development Research Centre (IDRC), Canada. The project has been implemented in two Indian cities, Solapur in Maharashtra and Vijayawada in Andhra Pradesh.

Cities are not closed systems and city-centric responses are inadequate to foster water security.

1.1. Objective of the Training Manual

The objectives of the training manual are to:

- Improve the understanding of concepts of Integrated Urban Water Management (IUWM) and Integrated Water Resource Management (IWRM) among local authorities.
- Enable local authorities to identify relevant stakeholders for collaborative planning and decision making and formulate a RURBAN Platform.
- Conduct water resource integration assessment and climate vulnerability assessment.
- Identify and prioritize climate resilient interventions for water management at the catchment level to develop CMP.
- Assist local authorities to monitor and evaluate implementation of CMP.

2. Training Methodology

The training methodology consists of 5 training modules and follows the IAdapt Framework that is a step by step guidance for development of a climate resilient Catchment Management Plan (CMP) for water resources.

Module 1: Understanding Integrated Water Management Approaches

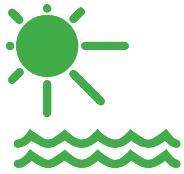
The first module provides information on Integrated Urban Water Management (IUWM) and Integrated Water Resource Management (IWRM) concepts and principles. This module will also guide local authorities to delineate catchments / micro-catchments to enable catchment level planning.

Module 2: Stakeholder Engagement and Formation of RURBAN Platform

This module discusses the formulation of a RURBAN platform and identification of stakeholders at catchment level. It explains how local governments and other stakeholders can collaborate to address the climate challenges to shared water resources.

Module 3: Water Resource Integration and Vulnerability Assessment

This module develops an understanding of local authorities regarding climate risks to their water resources, integration potential of the different water sectors and vulnerability assessment of the water sector. It will help them identify vulnerable areas and actors to be able to plan better.



Module 4: Solution Assessment and Development of CMP

The module will help local authorities identify and prioritise potential climate resilient interventions to manage existing water resources in the form of a CMP. It will enable local authorities to identify inter linkages of these resilient interventions with existing plans to make the CMP sustainable.

Module 5: Monitoring and Evaluation of CMP

The module will provide mechanisms to monitor and evaluate the CMP regularly to ensure transparency and sustainability.

3. Module 1: Understanding Integrated Water Management Approaches

General Objective

Familiarise basic concepts of hydrological cycle, Integrated Water Resource Management and Integrated Urban Water Management.

Training Contents

The Hydrological Cycle; Principles of IUWM and IWRM; Catchment Delineation Methodology.

The Hydrological Cycle

Water on the surface of earth moves in the form of a cycle from one form to another. Heat from the sun evaporates water from the oceans and other water bodies and this water is carried by winds over continents in the form of clouds. It comes down to the earth as precipitation (rainfall/ snowfall) when conditions are favourable. Precipitation is intercepted by the vegetation cover (interception) or falls directly over land. As rain/snow falls on land, a part of it flows off (run-off) and a part of it percolates into the ground to form ground water (infiltration) and some of it is retained in the soil by capillary forces. Water is temporarily stored in streams, lakes, soil and groundwater from where it is consumed by humans, plants, animals, etc.

When the soil moisture increases sufficiently, it replaces old soil water, which then either moves horizontally through the topsoil or percolates vertically into the groundwater zone. In both cases, this replaced water contributes to base flow in water bodies during summers.

Need for Catchment Management Planning

Water transcends boundaries and its management requires action at multiple scales and involves multiple stakeholders with competing needs. Conventional water management approaches tend to artificially separate water management from other allied sectors, which often results in unsustainable practices and planning in silos. Water sources for a city or a village often cater to many other settlements and to protect these shared resources, collaborative approaches must be adopted.

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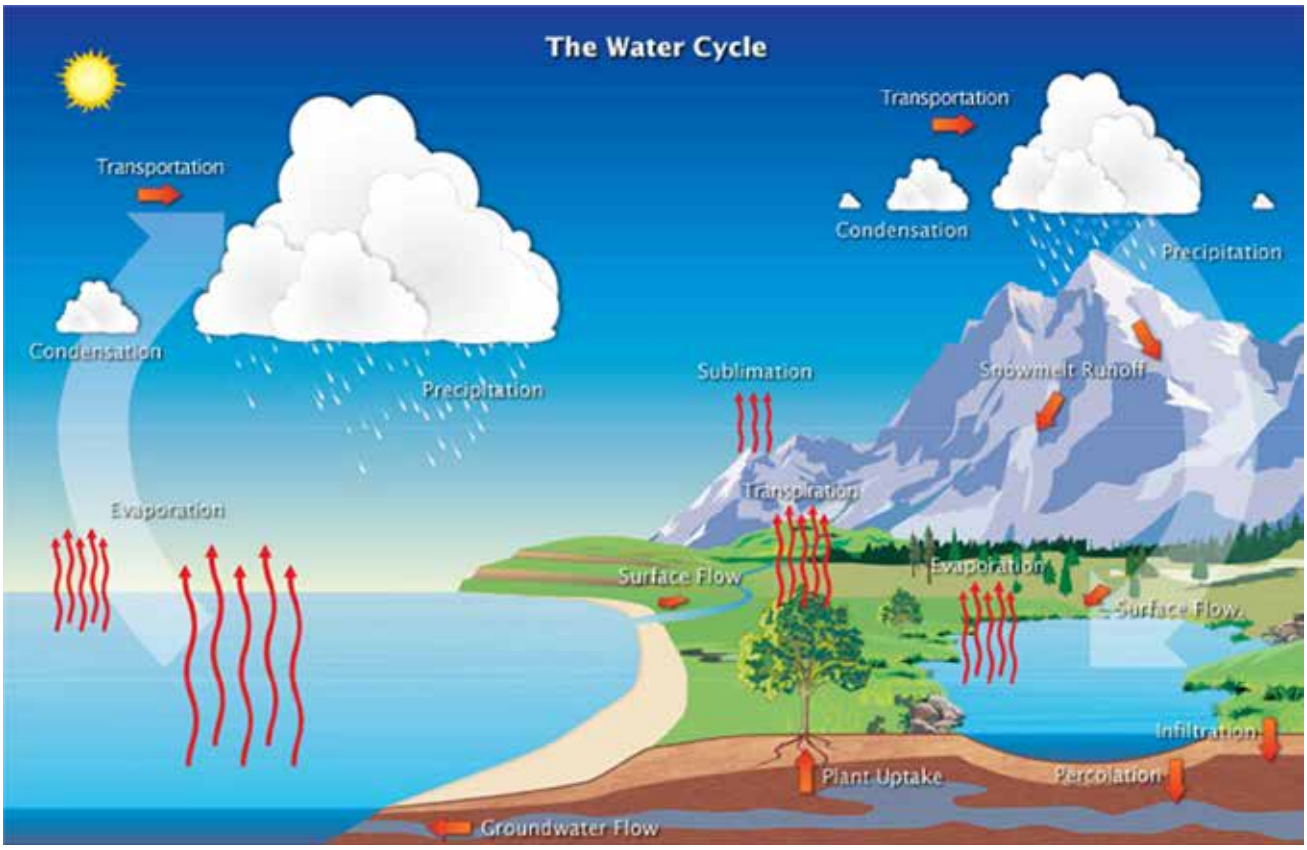

Figure 1: Hydrological processes operating in a catchment

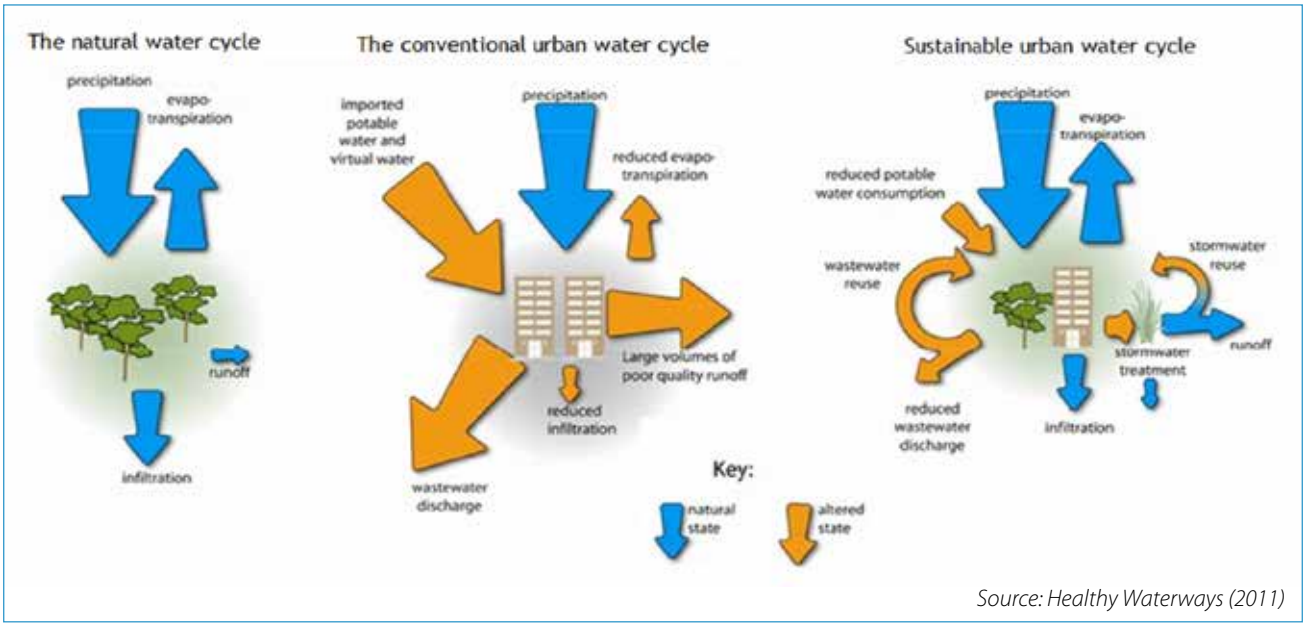

Figure 2: The natural water cycle, the conventional urban water cycle and the sustainable urban water cycle.

Integrated Urban Water Management and Integrated Water Resource Management

At present, cities are increasingly abstracting water from distant sources that lie beyond their boundaries. This is leading to increased power usage (leading to GHG emissions since most of our power is thermal power), increased transmission losses due to leakage and evaporation, as well as social disruptions due to increasing conflicts between different users of the same water source.

Escalating population growth, changing consumption patterns, deteriorating water resource, unplanned ad-hoc development, and impacts of climate change on precipitation and temperature have impacted the overall water security (both in terms of quantity and quality of water). Dependence of cities on single sources are unable to match the escalating water demands. A diverse water portfolio can be helpful to address this growing challenge. Integrated approaches are required to consider competing needs of water resources in cities and villages while designing water management projects.

The integrated approach to water management cuts across different sectors and interest groups and acts at different scales, from local to international. It involves developing favourable policy and governance mechanisms and establishing effective institutional arrangements that are supported by required infrastructural development to move towards more equitable and sustainable decisions regarding water management. As of now there are two type of approaches that are mostly adopted.

Integrated Urban Water Management (IUWM)

The Integrated Urban Water Management (IUWM) concept uses an urban ecology based approach to water management. In this approach, cities are looked at as complete ecosystems (Mouritz, 1996). Alternative management and technological solutions are considered that will help to reduce the intake of water (in the form of fresh water intake) in this ecosystem by recycling and reusing the water that flows out (e.g., storm water, waste water) of the urban ecosystem. This helps to increase the efficiency of resource use and minimise impact of polluting by – products'. The concept involves:

- Treating all aspects of urban water cycle as one system.
- Involving all relevant institutions and users.
- Using innovative and flexible technologies that promote efficient water use.
- Considering long-term sustainability.

Principles of IUWM

The following key underlying principles should be considered to achieve IUWM:

- Consider all parts of water cycle, natural and manmade, surface and subsurface, as a part of an integrated system.
- Address all water requirements: anthropogenic as well as ecological. Account for urban and non-urban users using the same water source.
- Recognize the significance of local context and address it from environmental, social, cultural and economic perspective.
- Include all stakeholders in planning and decision making process.
- Acknowledge that water can have multiple uses and different quality of water should be used for different uses.
- Recognize water storage, distribution, treatment, recycling and disposal as part of the same resource management cycle.
- Encompass alternative water sources.
- Align formal institutions (organizations, legislation, and policies) and informal practices (norms and conventions) that govern water in and for cities.

Integrated Water Resource Management (IWRM)

Integrated Water Resource Management (IWRM) provides a holistic approach to the management of water, taking into account the complex relationships between water and its users. IWRM is majorly based on the three principles that help analyse and manage water resources for a co-ordinated outcome. The three principles are:

- **Social Equity** – this means ensuring equal access for all users (particularly marginalised and poorer user groups) to an adequate quantity and quality of water necessary to sustain human wellbeing. The right of all users to the benefits gained from the use of water also needs to be considered when making water allocations. Benefits may include enjoyment of resources through recreational use or financial benefits generated from the use of water for economic purposes.

- **Economic Efficiency** – this means bringing the maximum benefit to the greatest number of users possible with the available financial and water resources. This requires that the most economically efficient option of water use and management is selected. The economic value is not only about price – it should consider current and future social and environmental costs and benefits.

- **Ecological Sustainability** – this requires that aquatic ecosystems are acknowledged as users and that adequate allocation is made to sustain their natural functioning. Achieving this criterion also requires that land use and development that negatively impact these systems, are avoided or limited.

Integrated approaches are required to consider competing needs of water resources in cities and villages while designing water management projects.

Catchment Delineation

A catchment can be defined as a contoured area with slopes and berms, naturally designed to increase runoff from rain and concentrate it in a basin, where it infiltrates and is either stored in the soil profile or gets collected in a water body such as a pond, lake, river, etc.

In order to formulate a Catchment Management Plan, it is necessary to delineate a catchment area (since catchments can be rather large areas). There are different ways of delineating a catchment area using Geographical Information Systems (GIS).

A simple way of delineating catchments would be to use the topographical maps of the region, the water resource maps of the region, the hydrological maps and digital elevation models to understand water flow. The watershed basin analysis can be carried out on GRASS GIS program. The following parameters can be considered additionally:

- The urban jurisdiction areas covered by the existing water supply system, the peri urban areas and the villages likely to be covered under future expansion of the city (urban development areas) say in the next 10-15 years.

- The additional areas from which storm water is likely to enter the city and the natural sinks which receive the storm water drainage from the city (ponds, lakes, tanks etc.).
- The peri urban and rural agricultural areas which use the wastewater from the city for irrigation, with complete mapping of the alignment of canal carrying wastewater, and area irrigated and the crops.
- The agricultural areas (villages) and peri urban areas which supply groundwater to the city during times of water stress.
- The well fields in the city jurisdiction from which groundwater is supplied to the municipal water supply system.

All this can be used to develop a catchment map with separate smaller catchments. The plan can be developed either for the catchment level or a catchment level.

Reflections

Assess the situation in your own city/village/region especially when it comes to implementation of IWRM/IUWM. Some of the questions you may want to answer are:

- What are the main sectors involved in the use of water resources in my city/village/region and what are the interactions between these sectors?
- Is there an urgency to manage water resources in an integrated manner and why?
- What will be the benefits for different sectors if integrated water use?
- Considering the government structures in your city/village/region, what institutional and legal reforms are needed to implement IWRM effectively?
- What is the general attitude towards integrated water management and what could be potential barriers to implement IWRM?

A catchment can be defined as a contoured area with slopes and berms naturally designed to increase runoff from rain and concentrate it in a planting basin where it infiltrates.

4. Module 2: Stakeholder Engagement and Formation of RURBAN Platform

General Objective

Provide tools and methodologies to identify relevant stakeholders and establish RURBAN Platform.

Training Contents

Description and use of RURBAN Platform; Identification of Stakeholders; Engagement Processes; Visioning.

This session deals with the engagement phase of the formation of CMP. Since the development of a CMP affects and involves a number of stakeholders that use and share the same resources, it is necessary to identify these stakeholders and involve them in the planning process. This session outlines the methodology to identify the stakeholders and engage with them.

Formation of Core Team

The Core Team members are responsible for driving the process. The Core Team may consist of officials at the rural and urban level who have responsibilities for, or an impact on, development planning, water use, pollution, waste, food security, water security, public health, local economic development, infrastructure, and agricultural development. A Project Nodal Officer at the rural and urban level has to be identified from this team who can be the focal point for the process. While the Core Team is responsible for participating in meetings, providing relevant sectoral information and developing the Catchment Management Plan, the Nodal Officers would support the coordination and smooth implementation of the tasks of the Core Team.

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The Core Team and Nodal Officers should be identified and approved by the municipal commissioner, panchayats and district collector.

Formation of RURBAN Platform

The Rural Urban (RURBAN) Platform is an active cross-sectoral network to facilitate inter-agency collaboration and participatory decision making on water management. It consists of decision makers and practitioners from

relevant government departments and citizens. This unique platform brings together rural and urban stakeholders to plan for integrated water management.

The Core Team will formulate a RURBAN Platform involving key individuals from the district departments, State departments, and officials from urban and rural authorities. This platform is a larger body who facilitates collaboration and participation from both rural and urban counterparts and prepares the CMP together with the Core Team and provides advisory services to the Core Team.

The RURBAN Platform members should develop a vision statement for their region stating how it would like the region to be in future regarding water resource management

Vision

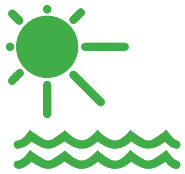
The RURBAN Platform members should develop a vision statement for their region stating how it would like the region to be in future regarding water resource management (e.g. in 5 – 10 or 20 years). This vision should consider all other vision statements of the city, district or region and should include a target year. For example: *"By 2030 ….. catchment area would have water infrastructure and systems that ensure the equitable provision of basic service to all and are climate resilient……."*

Exercise 1: Identification of the RURBAN Platform Members

1. In the table, list down the names and/or designations of all relevant stakeholders who should be involved in the development of the CMP. List the stakeholders in the different categories mentioned in the table.
2. Identify if the stakeholder has the ability to develop water strategies and actions at the community level or at the administrative (rural or urban) level.
3. Identify if the stakeholders are able to support the water management actions as per the CMP.
4. Identify the stakeholders that will be most affected by the CMP actions, since they need to be consulted to prepare an inclusive strategy.
5. List different ways of engaging with each of these stakeholders, and timing of engaging with the stakeholders.

Characteristics of RURBAN Committee	Government (local, city, block , state)	Local NGOs / CBOs	Academia	Community Representatives	Private Sectors	Any other imp stakeholder
Has the ability to develop water strategies and actions at the community level						
Has the ability to develop water strategies & actions at the administrative level						
Whose support is essential to implement actions at different levels (e.g. community, city level)						
Those most affected by water related issues						

5. Module 3: Water Resource Integration and Vulnerability Assessment



General Objective

Provide tools and methodologies to develop the water balance of the catchment area and assess its vulnerability to existing and future climate risks.

Training Contents

Water Balance; Systems Analysis; Climate Scenario Assessment; Climate Risk Assessment; Vulnerable Places and People.

Climate Scenario Assessment

This step helps to collate and analyse climate change data and generate a climate exposure scenario or projection for the catchment area. Ideally, local climate data should be used; however, if this is not available, other regional or national data can be used to understand the climate risks to the area.

This is done through an in depth secondary study to identify how the climate is already changing, as well as how it is expected to change in the future, such as average temperature, precipitation, sea level rise, and extreme events (floods, droughts, cyclones) in the area. The RURBAN team may use the services of a local university to make this assessment and identify the climate risks to the region.

Climate scenario assessment helps to collate and analyse climate change data and generate a climate exposure scenario or projection for the catchment area.

Climate Scenario Assessment

Changing Climate Condition	Assessments	Amount of Expected Change (Include baseline and planning horizon years)	Geographical area	GHG Emissions Scenario	Extent of variability	Level of confidence	Sources
Precipitation	Regional Assessments	*Example: 1268±225.2 mm to 1604±175.2 mm*	*Himalayan Region (Western Himalayas constituting of Jammu and Kashmir, Uttarakhand and Himachal Pradesh)*	*A1B scenario, IPCC*	*Overall increase in rainfall. June, July, August, September - 12mm January, February - 5mm October, November and December*	*High*	*4x4 Assessment report by GoI*
	Supplementary Local Assessments						
Temperature							
Sea Level Rise							

Climate Scenario Statements

A Scenario Statements can be framed in the following manner:

"There is a... **<insert information from 'level of confidence'>**... *degree of certainty of a...***<insert information from 'amount of expected change' i.e. the range>**... *change in the...***<insert information from 'changing climate condition'>**...*in the...***<insert information from 'geographical area'>**... *by the year...***<insert information on the planning horizon year from 'amount of expected change' column>**. *The projected change is expected to...***<insert information from 'extent of variability'>**."

Water Balancing

The water balance exercise identifies the demand-supply gap and helps to demonstrate alternative pathways to reduce this gap. This will enable the catchment to move towards a demand-supply balance based approach without any additional water abstraction by using IWRM principles. Since Indian cities face issues related to water scarcity in summer, this has been included as an additional indicator for urban water balance exercise.

Water balance exercise identifies the demand-supply gap and helps to demonstrate alternative pathways to reduce this gap.

This has 3 steps:

a. Collect data for demand and supply related to existing scenarios of water sectors. The existing demand of water can be calculated from the population and other bulk uses of water in the catchment such as agriculture, industries, etc.

   – *Water demand in urban areas: total population *135 lpcd*

   – *Water demand in rural areas: Total population *40 lpcd*

b. Calculate demand for future population scenarios based on the future population estimates (upto 2030). For sections where data is not available, realistic estimates can be used.

c. The Core Team will assess the existing and future Demand-Supply Gap.

Once the demand and supply gap is known, there is a need to look at options to reduce this gap using the principles of IWRM so as to achieve water balance in the catchment. The IWRM principles demand that the demand-supply gap be reduced using alternate approaches/options to meet the increasing water demand, without resorting to additional abstraction. Six key approaches for this integration are:

1. Wastewater reuse
2. Storm water reuse/recharge
3. NRW loss reduction
4. Per capita demand reduction
5. Revival of traditional practices (for water conservation) and local water bodies
6. Service provision, particularly to poor and marginalised

After using these key approaches for integration, the reduction in demand-supply gap will provide us the Integration Value. These values can be used to calculate the demand supply balance.

The IWRM principles demand that the demand-supply gap be reduced using alternate approaches/options to meet the increasing water demand, without resorting to additional abstraction.

Exercise 2: Water Balance

Water supply

A. Drinking: 30 MLD
B. Industries: 40 MLD
C. Green area/parks: 20 MLD

Total Water Supply, S: A+B+C = 90 MLD

Water demand

Population, P: 10000
Per capita consumption, C: 120 lpcd
Total Water Demand, D: PxC = 12000000 = 120 MLD

Water Supply Demand Gap: D-S = 30 MLD

Scenario after intervention

Integration solution of IUWM Approach: Wastewater reuse
Available water for reuse after treatment: 20 MLD
Integration Value is 20 MLD

Total water supply = water supply+ integration value: 90 + 20=110 MLD
Demand: 120 MLD
Water Supply Demand Gap: 10 MLD

Thus there is a reduction of 20 MLD in the supply demand gap.

Sectoral Analysis

For integrated water management, an analysis of water and its allied sectors is needed to understand existing situation and improvement needs. This can be done using the Integration Assessment Matrix. It is a self-assessment tool that contains questions, based on principles of IWRM, to assess the existing status of integration of water and allied sectors. It assesses the different water sources and uses in the catchment and identifies whether different quality of water is used for different uses. The tool provides different integration indicators with possible responses that can reflect the situation in the catchment and each possible response has been given a score.

The Core Team should discuss and assign a score to each indicator, based on the options best suited to the catchment. For indicators where accurate data is not available, the Core Team can use broad estimates that best depict the existing situation.

This tool will give:

a. Existing status of integration through an integration score for the catchment, which is a measurement of the extent to which different quality of water is used for different uses. This score should be compared with the scoring table below to get the existing status of integration across water sectors in the catchment.

The Integration Assessment Matrix is a self-assessment tool that contains questions, based on principles of IWRM, to assess the existing status of integration of water and allied sectors.

Scoring Table

Score	Status
Above 30	Excellent
Between 25-30	Good
Between 20 – 25	Average
Between 15 – 20	Poor
Less than 15	Critical

b. Strengths, Weaknesses and Quick Improvement Areas: The tool shows that:
   - All indicators with a high score are the Strengths of the catchment.
   - Indicators with a medium score are the Quick Improvement Areas where with minimal intervention, improvements can be made in the overall level of integration.
   - Indicators with a low score are Weaknesses or critical areas that the catchment should focus on.

c. Focus issue based on Integration Assessment Matrix: The Tool will indicate the issue/s and sectors that score low that should be addressed on priority.

Exercise 3: Integration Assessment Matrix

- For your catchment, give scores to each question.
- Add the scores to get the total score
- Compare with scoring table to get the integration status
- Identify strengths, weaknesses, quick improvement areas
- Identify focus areas

Sr. No	Integration Indicators	Criteria Scoring		
		Criteria/sub criteria	Scale	Selected Score
1	Location of major water source(s) in the catchment	Main source(s) within catchment boundary	3	
		Main source(s) located at district level	2	
		Main source(s) located outside district	1	
2	Participatory process for integration of water sectors	All stakeholders and water sector departments are involved throughout planning and implementation (through stakeholder consultations)	3	
		No direct stakeholder involvement, comments invited after preparation of final plan	2	
		No involvement, plans prepared internally by government departments	1	
3	Water portfolio for supply	Practicing Reuse –Recycle and recharge - Traditional rain water harvesting (RWH) structures and systems or new policies to recycle reuse	3	
		Water security plans using different sources of water (ground water, surface water, pond)	2	
		No Plan for water security but supplies assured through single source (for next 10 to 20 years)	1	
4	Water pollution	Water quality (surface and groundwater) within permissible limits	2	
		Polluted pockets are being confined, no mitigation plan/measures yet	1	
		Critical level of surface water pollution (Coliform, BOD, DO level, eutrophication, etc.) and Critical level of groundwater pollution (Fluoride, Arsenic, etc.) – no plans for mitigation	0	
5	Link between water and energy	Link is realized and measures are taken (like use of Renewable Energy, Energy Efficiency, land use etc.)	2	
		Link is realized but measures are not taken	1	
		Link not recognized and no measure are planned	0	
6	Climate change and water resources	Impacts of climate change on water resources are recognized and adaptation measures are taken up	2	
		Need is recognized but no measures being taken	1	
		Need is recognized but no measures being taken	0	
7	Instances of water or vector borne diseases (Malaria, Typhoid, Jaundice, Hepatitis, etc	Not common	2	
		Occasional occurrence in some areas	1	
		Water borne diseases leading to fatality and outbreak of epidemic in recent past	0	
8	Capacity (skills, resources, awareness, willingness) of administrative staff and other stakeholders	Capacity related constraints are limited, addressed regularly	2	
		Addressed only in extreme cases	1	
		Capacity related constraints not addressed at all	0	

Sr. No	Integration Indicators	Criteria Scoring		
		Criteria/sub criteria	Scale	Selected Score
9	Solid Waste Management	Segregated waste collection, treatment and disposal available; no impact on water quality or drainage	3	
		Simple collection without segregation, treatment and disposal available; low impact on water quality or drainage	2	
		Simple collection without segregation, no treatment, only disposal; medium impact on water quality or drainage	1	
		Open dumping, without collection or treatment; high impact on water quality or drainage	0	
10	Waste water	Treatment system available to treat waste water at least to secondary level and septage management system available	3	
		Part sewer connection, and/or septage management available	2	
		No sewer connection, and septage management available	1	
		No sewers and no septage, link to open or natural drains	0	
11	Storm water	Water logging due to encroachment of natural drains is frequent	1	
		Water logging due to encroachment of natural drains is infrequent	3	
12	Ecosystems	More than 50% green cover and supports at least 3 types of ecosystem services	4	
		Between 35-50% green cover and supports at least 2 types of ecosystem services	3	
		Between 20-35% green cover and supports at least 2 types of ecosystem services	2	
		Less than 20% green cover and supports 1 or no ecosystem services	1	
	Total Score			

Summary Sheet for Integration Assessment Matrix

Total Score	
Existing status of integration in the city	
Weaknesses	
Strengths	
Quick Improvement Areas	
Focus systems	

Fragile Systems Assessment

This exercise helps to analyse the fragile systems identified through the Integration assessment as the focus issues or weaknesses or quick improvement areas in terms of the climate scenarios. This has the following steps:

1. Analysis of fragile systems i.e. the systems or services which are already weak or under great pressure, by looking at them through a water lens.
2. Assessment of the impact of climate change on these fragile systems.

The fragility of these systems are identified in terms of the characteristics of resilient systems - flexibility and diversity, redundancy and safe failure. This information can be obtained through discussions in meetings with the RURBAN and Core Team.

Flexibility and diversity – whether the sector is able to provide a mix of multiple options, so that key assets and functions are distributed or decentralised, and not all affected by a single event, and can function under a variety of conditions

Example: A variety of water sources used for water supply, rather than one centralised water treatment facility

Redundancy – whether the system has alternatives / back-up systems / contingency plans, capacity for contingency situations, multiple pathways and options for service delivery in case one or several options fail

Example: If the water treatment facility fails,tankers can be used to provide water for essential services.

Safe failure – whether the system has the ability to absorb sudden shocks or slow onset stress so as to avoid catastrophic failure

Example: Dikes are designed so that if their capacity is exceeded, they fail in predictable ways, channelling flooding away from populated areas

The fragility of systems are identified in terms of the characteristics of resilient systems - flexibility and diversity, redundancy and safe failure.

The systems are also analysed in terms of the impacts of this fragility on other systems and services and the overall responsibility of these systems. The information is then collated to formulate a Fragility Statement for the system to define concisely why the system is considered fragile in the catchment.

Analysis of Fragile Urban Systems

System	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Responsibility	Fragility Statement
Example: Water Supply	*Flexibility & Diversity: Traditional water sources have been lost due to urbanisation and the city depends on centralized pumping systems that transport water from significant distances to the city. Supply cannot meet the growing demand* *Redundancy: Alternatives usually include water supplied by tankers (trucks). This is an expensive and polluting fallback option* *Safe failure: in case of a disruption in water supply, individual households have to fend for themselves.*	■ *Disruption of water supply to citizens* ■ *Additional financial burden on individual households to purchase water from water tankers* ■ *Increased pollution and emissions from the plying of water tankers*	*Shared with the Irrigation & Public Health Department*	*The water supply system in the city is old and largely dependent on transporting water over large distances, whereby even minor disruptions cause significant shortages in the city in the face of an ever growing demand; alternatives are not cost effective or sustainable*

To assess the impacts of climate change on the fragile systems identified above, we have to develop a Climate Fragility Statement for each fragile system, considering the climate scenario summaries and the possible impacts of these climatic changes on the fragile systems.

Climate Fragility Statements

Urban System	Fragility Statement	Climate fragility statement	Climate fragility statement
Example: Water Supply	*Water supply system in the city is old and largely dependent on transporting water over large distances, whereby even minor disruptions cause significant shortages in the city in the face of an ever growing demand; alternatives are not cost effective or sustainable*	*Climate Risk 1: increased precipitation* *Increased precipitation disrupts / damages old water supply infrastructure*	*Climate Risk 2: Increased Temperatures* *Increased temperatures will lead to increased demand for water thereby posing additional stress on the supply system*

Risk Assessment of Climate Fragility Statements

After the climate fragility statements for the fragile systems are identified, these can be prioritized on the basis of their likelihood and consequence through a workshop with the RURBAN Platform to assess the risk status. It is important to incorporate the views of all stakeholders as well. The Risk Assessment exercise should be undertaken jointly with the stakeholders as part of a consultation process through group exercises in the workshop. Every group can present their results and debate and finalise together the outputs of the exercise.

The Risk Assessment exercise should be undertaken jointly with the stakeholders as part of a consultation process through group exercises.

The likelihood and consequence of each climate fragility statement can be assigned a score from 1 to 5 as per the tables below.

Likelihood Rating and Scoring

Likelihood Rating	Description	Score
Almost certain	Is highly likely to occur, could occur several times per year; Likelihood probably greater than 50%	5
Likely	Reasonable likelihood, may arise once per year; Likelihood 50/50 chance	4
Possible	May occur, perhaps once in 10 years; Likelihood less than 50% but still quite high	3
Unlikely	Unlikely but should still be considered, may arise once in 10 to 25 years	2
Rare	Likelihood probability significantly greater than zero. Unlikely in foreseeable future – negligible probability	1

Consequence Rating and Scoring

Consequence Rating	Impact on System	Impact on poor and vulnerable	Score
Catastrophic	System fails completely and is unable to deliver critical services,, may lead to failure of other connected systems	Severe impacts on poor and vulnerable groups in the city leading to situations of extreme destitution	5
Major	Serious impact on the system's ability to deliver critical services, however not complete system failure	Loss of confidence and criticism in city government; ability to achieve city vision and mission seriously affected Significant impacts on poor and vulnerable groups in the city that seriously affects their lives and livelihoods	4

Consequence Rating	Impact on System	Impact on poor and vulnerable	Score
Moderate	System experiences significant problems, but still able to deliver some degree of service	Moderate impacts on the lives and livelihoods of the poor and vulnerable groups in the city	3
Minor	Some minor problems experienced, reducing effective service delivery, possibly affecting certain other systems or groups	Minor impacts on the lives and livelihoods of the poor and vulnerable groups in the city	2
Insignificant	Minimal impact on system – may require some review or repair, but still able to function	Minimal impacts on the lives and livelihoods of the poor and vulnerable groups in the city	1

The likelihood and consequence scores can be multiplied to get the Risk Score. The Risk Score can be compared to the Risk Matrix to assess the Risk Status.

Risk Score = Likelihood x Consequences

Risk Matrix

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium (RS=5)	Medium (RS=10)	High (RS=15)	Extreme (RS=20)	Extreme (RS=25)
Likely	Low (RS=4)	Medium (RS=8)	High (RS=12)	High (RS=16)	Extreme (RS=20)
Possible	Low (RS=3)	Medium (RS=6)	Medium (RS=9)	High (RS=12)	High (RS=15)
Unlikely	Low (RS=2)	Low (RS=4)	Medium (RS=6)	Medium (RS=8)	Medium (RS=10)
Rare	Low (RS=1)	Low (RS=2)	Low (RS=3)	Low (RS=4)	Medium (RS=5)

RS=Risk Score

The climate risk statements **with high or extreme risks should be given priority during the solutions assessment in the later stages.**

Exercise 4: Prioritization of Climate Risks

In case of your catchment, put in a score of the likelihood and consequence of the climate fragility statement in the table. Calculate the Risk Score.

Climate Risk Statements	Likelihood	Consequence	Risk Score (Likelihood X Consequence)	Risk Status
Sudden high intensity rainfall can cause overflow in storm water drains, can dilute pollutants, cause greater runoff without recharge, and lead to water logging.				
In increased temperatures and drier climate, openly dumped waste can spread in the area, causing littering				

Vulnerability Assessment

The vulnerability assessment includes identification of vulnerable areas prone to the climate risks identified above and the social groups/ communities/ stakeholders who are impacted by these risks in these areas.

The vulnerable areas for each sector can be identified on separate maps for pictorial depiction. Superimposing all the maps will create the vulnerability hotspot map indicating which area is vulnerable to most issues so that interventions can be targeted to these areas.

The Core Team will identify the vulnerable actors (i.e. individuals, households and public/private sector organisations), that can play a critical role towards building resilience in the water sector. Their ability to contribute to resilience and adaptation is broadly dependent on the following three key capacities:

- Capacity to organise and respond – the capacity to organise and re-organise in response to threat or disruption.
- Resources – access to the resources necessary to respond (manpower, technology, funds).
- Access to information – availability of data and information necessary to develop effective plans and actions and to improve responses to disruptions.

Vulnerable areas for each sector can be identified on separate maps for pictorial depiction. Superimposing all the maps will create the vulnerability hotspot map.

The combination of these three characteristics would help determine the adaptive capacity of each of the urban actors. Adaptive Capacity Score for each actor is obtained by multiplying the scores given to each of the 3 characteristics. Actors having a 'Low' or 'Medium' level of adaptive capacity would be those that would need to be specifically targeted in the actions (or resilience strategies). Actors with a 'High' level of adaptive capacity can be engaged in the proposed actions as they have the capacity to effectively respond to the impacts of the fragile systems.

Actors' Capacities Rating and Scoring

Key Capacities of Actors	Score
Capacity to Organize and Respond - to organise and re-organise in response to threat or disruption	
– Low capacity	1
– Medium capacity	2
– High capacity	3
Resources - necessary to respond (manpower, technology, funds)	
– Low access	1
– Medium access	2
– High access	3

Key Capacities of Actors	Score
Access to Information – data and information to develop effective plans for better responses to disruptions	
Low access	1
Medium access	2
High access	3

Levels of Adaptive Capacity of Urban Actors

Adaptive Capacity Score	Level of Adaptive Capacity
1-8	Low
9-17	Medium
18-27	High

Exercise 5: Vulnerability Assessment

For the climate fragility statements, identify the areas that are vulnerable in your city. You can mention the names of places or ward numbers.

For each statement, identify four major actors or stakeholders. Think about who will be impacted or who can support you if you want to take action on water management. Think about stakeholders in the city and beyond, including government and non-government actors. Think about different users of the water resource.

Assign scores on a scale of 1 to 3 for each actor's (A) capacity to organize and respond, (B) ability to access resources and (C) ability to access information.

Calculate the adaptive capacity by multiplying A, B and C.

Vulnerability Assessment

Climate Fragility Statements	Area/ward/ village	Actors	Capacity to Organize & Respond (A)	Resources (B)	Access to Information (C)	Adaptive Capacity Score (A)*(B)*(C)	Supporting Notes
Sudden high intensity rainfall can cause overflow in storm water drains, can dilute pollutants, cause greater runoff without recharge, and lead to water logging.							
In increased temperatures and drier climate, openly dumped waste can spread in the area, causing littering							

6. Module 4: Solution Assessment and Development of CMP

General Objective

Identify solutions for water management to reduce demand supply gap using IWRM principles; prioritise interventions; preparation of action plan or Catchment Management Plan (CMP).

Training Contents

Identification and prioritisation of resilient water interventions; Development of CMP.

The Core Team will develop a list of possible actions, or "interventions" that will support integrated water resource management in the catchment. These interventions are screened and prioritised, linked to existing city plans, and assembled into a Catchment Management Plan or CMP.

Identification of Interventions

The step will be conducted by the core team and verified by the RURBAN Platform Members. The Core Team will make a list of all the climate fragility statements along with their vulnerable areas (villages, areas or city wards) and the vulnerable actors (social groups) as identified through above exercises. Based on these, interventions and solutions will be identified to address these issues by the Core Team together as part of a workshop. While selecting the interventions, it is important to remember to:

- Focus on the most vulnerable groups, sectors, neighbourhoods.
- Develop measures to address current issues and to prevent future problems.
- Aim for a mix of "hard" (e.g. infrastructure related) and "soft" (e.g. policy changes, capacity building) solutions.
- Consider links with other existing plans and processes to facilitate implementation of the Catchment Management Plan.

Interventions should identified based on the climate fragility statements along with their vulnerable areas (villages, areas or city wards) and the vulnerable actors (social groups).

Prioritisation of Interventions

Once the interventions are selected, they are first assessed for their contributions to climate resilience using a set of resilience indicators and their contribution to integrated water management through a set of integration indicators. They are then assessed for their feasibility and impact.

The resilience indicators to be used for assessing the selected interventions include:

- **Redundancy:** The intervention should support redundancy and enable the system to work in a variety of ways. A resilient system can function and achieve results through multiple paths, so that if one path fails, the others still function. In contrast, a "single best solution" is not resilient because if this single option fails, the system collapses. Back-up systems, or decentralised nodes for service delivery in a linked network, are preferable.
- **Flexibility and diversity:** The intervention should enable the system to function in different conditions and work in spite of climate stresses and shocks. Essential systems should be able to work under a variety of conditions and not be rigid or designed only for one specific situation.
- **Re-organisation and responsiveness:** Under extreme conditions, the intervention should enable the systems to respond and change to meet unexpected shocks. This requires access to different kinds of resources (information, skills, equipment, knowledge and experience) and high level of coordination among departments.
- **Access to information:** The interventions should enable the system to measure all impacts of climate change. Resilient systems have mechanisms to learn from and build on experience, so that past mistakes are not repeated and lessons from other cities can be integrated into planning. This requires procedures for monitoring and evaluating that can be shared among different departments.

A resilient system can function and achieve results through multiple paths, so that if one path fails, the others still function. In contrast, a "single best solution" is not resilient.

The contribution of the interventions to IWRM principles are assessed in terms of the following characteristics:

- **Consider all parts of the water cycle:** Whether the intervention helps to include different sources and forms of water available in the region into the water resources for the region.
- **Consider various requirements for water:** Whether the intervention helps to assign different quality of water for different uses.
- **Consider the local context:** Whether the intervention is locally relevant and addresses pertinent local issues.
- **Considers requirement of various stakeholders:** Whether the intervention addresses requirements of different stakeholders in the region.

Feasibility and Impact

Feasibility can be assessed using the following criteria:

- **Technical:** The region has the necessary technical expertise to implement the project, or can access the required skills; the project is implementable, realistic and suitable to local conditions.
- **Political:** The intervention will be seen as acceptable to city leaders and the community and is consistent with the city's values and vision.
- **Financial:** The cost is within the capacity of the region, or the region will be able to access required funds from the state or central government, and the anticipated benefits of the action will justify the cost.

Impact can be assessed using:

- **Timeframe:** Most actions should be completed within a short or medium timeframe.
- **Criticality or overall impact:** The proposed intervention will have a significant and measurable impact on the targeted climate risk.

Exercise 6: Prioritizing resilience interventions

For each climate fragility statement, identify 2 interventions.

Identify whether the intervention addresses the resilience indicators and IWRM indicators.

Count and calculate the number of instances when these indicators are addressed (marked Yes). The overall prioritization score is calculated as per the number of instances where "Yes" occurs. The score is ranked as low, medium, average or high based on rating given below:

- if yes occurs 1-2 times then the score is **"Low"**
- if yes occurs 3-4 times then the score is **"Medium"**
- if yes occurs 5-6 times then the score is **"Average"**
- if yes occurs 7-8 times then the score is **"High"**

Interventions and Solutions	Resilience Indicators (Yes / No)				IWRM Indicators (Yes / No)				Overall Prioritisation Score
	Redundancy	Flexibility	Responsiveness/Re-organisation	Access to Information	Consider all parts of the water cycle	Consider various requirements for water	Consider the local context	Considers requirement of various stakeholders	

For each intervention, identify what is the technical, financial and political feasibility.

For each intervention, identify whether the timeframe by which it can be completed is short (0-2 years), medium (2-5 years) or long (more than 5 years)

For each intervention, identify the criticality of the intervention on a scale of high, medium and low depending on the issue that it addresses and time required to address it.

Based on this assessment, identify the high priority interventions and identify if existing city plans can address or finance it.

Interventions and Solutions	Feasibility			Impact – Timeframe	Impact - Criticality
	Technical (high/ medium/ low)	Political (high/ medium/ low)	Financial (high/ medium/ low)	(short/medium/ long term)	(high/medium/ low)

Feasibility and Impact

For each intervention, identify what is the technical, financial and political feasibility.

For each intervention, identify whether the timeframe by which it can be completed is short (0-2 years), medium (2-5 years) or long (more than 5 years)

For each intervention, identify the criticality of the intervention on a scale of high, medium and low depending on the issue that it addresses and time required to address it.

Based on this assessment, identify the high priority interventions and identify if existing city plans can address or finance it.

Verification and Ratification

The interventions and solutions selected should be discussed in the RURBAN platform meeting and ratified by the RURBAN Platform so that they can be integrated into the Catchment Management Plan for implementation and eventual evaluation. The District Collector and the Municipal Commissioner should be present in the meeting to discuss potential immediate actions.

Structure of Catchment Management Plan

The catchment management plan should be developed while keeping in mind the overall fragility and vulnerability of the resources and the community. A typical structure of the integrated catchment management plan consists of the following sections.

The catchment management plan should be developed while keeping in mind the overall fragility and vulnerability of the resources and the community.

Introduction: This section introduces the concept of integration (IWRM, IUWM), the rationale of conducting an integrated catchment management and adopting integrated approaches to assess the vulnerability to climate change. Methodology and approaches used to develop catchment management plan are explained.

Catchment profile: This section describes the nature and existing situation of the catchment for which the management plan is being developed, including location of the catchment, demography, socio-economic profile and climate pattern and geomorphology of the catchment.

Integrated catchment management plan: This section provides information of the entire methodology of using the IAdapt Framework to develop the catchment management plan.

- **Engagement phase:** This section describes the engagement with various stakeholders from rural and urban areas within the catchment to discuss the issues, develop strategies to overcome the challenges and implement best possible solutions.

- **Baseline assessment:** This section outlines all data and information collected at the catchment level on water resources (water availability, water supply and water management), waste water, storm water and solid waste, demography, exposure to disasters, bio diversity and ecosystem services.

- **Assessing the climate vulnerability:** The water balance for the catchment is presented in this section, giving the current and future stress on water resources due to urbanization, population growth and other economic development activities. Information from the integration matrix, information on climate scenarios, data on the fragile systems, their climate risks and vulnerability, hotspot maps prepared and actors identified are presented in this section.

- **Solution assessment:** The list of solutions or interventions prepared to combat vulnerability of the fragile sectors are outlined in this section. The interventions are presented along with their resilience and IWRM integration priorities, their technical, financial and political feasibility and their criticality and timeframe are outlined. This section should also outline any financing sources that may be available for the implementation of the interventions.

- **Monitoring and evaluation framework:** This section outlines the monitoring and evaluation processes for the CMP implementation. The RURBAN committee will ensure a regular monitoring of the CMP and will monitor the effectiveness of the plans in achieving their stated objectives and delivering the outcomes.

The RURBAN committee will ensure a regular monitoring of the catchment management plan and will monitor the effectiveness of the plans in achieving their stated objectives and delivering the outcomes.

7. Module 5: Monitoring and Evaluation of CMP

General Objective

Enable preparation of a working and simple monitoring framework.

Training Contents

Importance of Monitoring and Evaluation; Development of Monitoring Framework.

Monitoring and evaluation processes is vital to successful implementation of the CMP. It helps to ensure that the plan is implemented and keeps a record of all targets achieved. Ideally the RURBAN Platform will ensure a regular monitoring of the catchment management plan and will monitor the effectiveness of the plans in achieving their stated objectives and delivering the outcomes. A monitoring procedure should be developed based on reporting on the implementation of the interventions and updated at regular intervals. The framework should identify the individual with responsibility of monitoring, the methods to be used for monitoring, and the frequency of monitoring of all the activities implemented. Annual discussion with the core team and RURBAN Platform members will help to understand the impact and effect of the implementation is essential.

Exercise 7: Monitoring Framework

For each intervention identified, identify a measurable indicator of success.

Identify the person/department responsible for monitoring.

Identify the method of monitoring.

Identify the frequency of monitoring required.

Monitoring and Evaluation Framework					
Intervention	**Implementing Agency**	**Indicator**	**Responsibility of monitoring**	**Method/ tool of monitoring**	**Frequency of monitoring**

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