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FUTURE PROOFING INDIAN CITIES

Madurai Action Plan for Blue-Green Infrastructure

Madurai Corporation
December 2014

Atkins in partnership with
dpu Development Planning Unit
UCL
DHAN Foundation
Building Institutions for Generations
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INDIAN INSTITUTE FOR HUMAN SETTLEMENTS

Notice

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About the project partners

Atkins

Atkins is one of the world's leading infrastructure and design companies, with the depth and breadth of technical expertise to respond to the world's most complex infrastructure and environmental challenges. These include responding to the increasing rate of urbanisation and the urgent transition to a low carbon economy. Atkins works with municipal authorities, national and regional government, development agencies, private sector companies, and other stakeholders to develop and implement strategic plans and investment projects to shape and manage the future growth of cities. With over 17,000 employees worldwide, Atkins is able to bring together its technical knowledge across a wide range of disciplines such as transport, water, energy, design, architecture, climate science, ecology, planning, and economics to help cities and those investing in them to act upon the long term opportunities and challenges of resource use and a changing climate. Our international work spans Africa, Asia, Europe, the Middle East and North America. Through our 'Carbon Critical' initiative Atkins has developed a range of bespoke tools to reduce the carbon emissions associated with major urban infrastructure programmes including a low carbon Masterplanning tool to reduce city carbon footprints.

University College London: Development Planning Unit

UCL is one of only three UK universities in the top 20 in the 2011 Shanghai Jiao Tong world rankings, and in the latest research assessment exercise UCL was rated third overall in the UK after Oxford and Cambridge. The Bartlett Development Planning Unit (DPU) is internationally recognised for its academic and professional contributions in relation to city development in the developing world in active collaboration with partner institutions and researchers in the Global South. It is concerned with promoting sustainable forms of development, understanding rapid urbanisation and encouraging innovation in the policy, planning and management responses to the economic, social and environmental development of urban areas, giving emphasis to social justice, participatory local governance and poverty reduction. The key distinctive features of the DPU are its commitment to action research and its focus on rapidly urbanising areas in the developing world. The DPU maintains a wide network of partner organisations in Latin America and the Caribbean, Africa and South and Southeast Asia working on sustainable cities.

IIHS

The Indian Institute for Human Settlements (IIHS), based in Bangalore, is a national education institution committed to the equitable, sustainable and efficient transformation of Indian settlements. IIHS aims to establish an independently funded and managed National University for Research and Innovation focused on the challenges and opportunities of India's urban transition. IIHS has also been designated a National Resource Centre (NRC) by the Ministry of Housing and Urban Poverty Alleviation.

DHAN Foundation

The Development of Humane Action (DHAN) Foundation is a professional development organisation founded in 1997. It brings highly motivated, educated young women and men to the development sector, to focus on the mission of Building people and institutions for development innovations and scaling up to enable the poor communities for poverty reduction and self-reliance. The work of DHAN is rooted in values, such as Grassroots action, Collaboration, Enabling, Innovation, Excellence, and Self-Regulation. DHAN's purpose includes the promotion of new ideas on development themes such as microfinance, small scale irrigation, dry land agriculture, and working with Panchayats; ensuring that quality benefits reach a large number of poor; and providing the opportunity for young professionals in the development sector to practice and develop relevant knowledge, attitudes and skills needed for long term work.

Foreword

Madurai shares many of the issues and challenges of other Indian cites, as the percentage of population living in urban areas rises from around 30% at present to more than half by 2030. The population of Madurai has already reached 1.4m people and the city has recently been expanded to incorporate a number of new Wards in Avaniapuram to the south of the city.

Cities have to address existing gaps to meet the needs of both existing communities and the future population who will also require the full range of urban services- water supply, sanitation, drainage, power as well as housing and urban mobility.

In addition to these immediate needs, the city is likely to be impacted by the effects of climate variability. These are slower onset changes but could impact on the water resources and food security of the city. The city may also experience a greater frequency and intensity of storm events in the future which could impact on households, businesses and the infrastructure of the city.

The scale of these challenges and emerging trends requires a new approach. The Madurai Corporation recognises this and in 2013, pledged its full support and participation in the Future Proofing Cities project in partnership with CDKN together with Atkins, University College London and Dhan Foundation.

This cooperation has helped the city take stock of the existing issues around the city and look at them in a new light. I would like to thank all those who participated in this initiative. The partnership which has developed over the course of the project has helped bring a new perspective on the issues and has been instrumental in raising awareness among the citizens of the city of the challenges which lie ahead. The role which individual citizens, civil society, academic institutions and the private sector alongside the Madurai Corporation and other Governmental bodies is increasingly being recognised.

This action plan defines a strategy and a number of constituent projects which will help to position the city to improve the quality of life for all residents as well as address long standing infrastructure gap. In the process, we can build a more resilient city better able to respond to future challenges.

The plan complements and will support many of the steps the Madurai Corporation is already taking to improve the city. The Corporation, working together with other partners in the city, will form a new city partnership and will use the plan to enhance upcoming projects, inform future plans for the city and use it as a tool to attract additional resources to address the needs of Madurai.

We are pleased with the involvement of Madurai City Corporation in this initiative and believe it represents a stepping stone on the path to a better future. We believe our experience here can be shared with other cities responding to similar issues.

Dr Kathiravan Chinnathambi I.A.S
Commissioner Madurai City Corporation


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Glossary and abbreviations

Glossary of terms

Adaptation to climate change: Adjustment in natural or human systems (e.g. cities) in response to actual or expected climate hazards or their effects. It moderates harm or exploits beneficial opportunities of climate change. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

Agglomeration economies: Relates to the benefits firms obtain when locating near each other or 'agglomerating'. This concept is related to economies of scale and network effects. As more firms cluster together they usually take advantage of declining production costs, more suppliers and more customers. Cities and specifically urbanisation promote economies of agglomeration.

Blue-green infrastructure services: represent the sum of natural and manmade infrastructure covering the hydrological cycle (blue infrastructure), natural habitat, ecosystems and urban greenspace (green infrastructure). The approach to blue-green infrastructure adopts a systems view in order to identify the links and interconnections between issues in order to avoid disbenefits and help to maximise win-wins. By taking this approach wider range of socioeconomic and quality of life benefits can be delivered.

Capacity to act: There is a wide range of definitions according to the specific context. We define this as a city's capacity and willingness to respond positively to environmental risks. This is shaped by the economic and institutional attributes of a city and its actors, which determine the degree of its capability to respond to risks.

Carbon capture and storage (CCS): Technology that attempts to capture carbon dioxide originating from fossil fuel use (power generation and other industries) and then pump underground into secure storage in rock formations.

Catalytic financing: The process whereby official financing from an agency (often the government) encourages further financing (often from the private sector).

Climate hazards: Refers to the risks posed by natural climatic processes and are often exacerbated by climate change. For example: flooding, cyclones and landslides.

Clean Development Mechanism (CDM): A flexible mechanism that provides for emissions reduction projects which generate Certified Emission Reduction units.

Climate change: The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

Compact city: A high density urban settlement with mixed land uses and access to an efficient public transports system. The efficient urban layout encourages walking and cycling, low energy consumption and reduced pollution.

Driving force-Pressure-State-Impact-Response (DPSIR): This is a conceptual framework for considering the interactions between society and the environment that is used to highlight gaps in knowledge, processes and linkages between human and environmental systems.

Ecosystem services: The benefits people receive from ecosystems including products like clean drinking water and processes such as the decomposition of wastes.

Externalities: An economic term describing a cost or benefit that is not transmitted through the price of an action and is incurred by a party who was not involved as either a buyer or a seller of the action causing the cost or benefit. An example would a non-car user suffering from the pollution caused by car users.

Geospatial: A term describing the analysis of data using a geographical base.

Greenhouse gas emissions: Emissions from the burning of fossil fuels and the manufacture of cement and include carbon dioxide produced during the consumption of solid, liquid, and gas fuels and gas flaring.

Green infrastructure: Refers to an interconnected network of natural and green man-made features, such as forests, extensive grasslands, wetlands, but in cities also parks, gardens, cemeteries, trees at streets, green walls and roofs.

Gini co-efficient: the extent to which the distribution of income or assets (such as land) among individuals or households within an economy deviates from a perfectly equal distribution.

Groundwater table: The level of the water located beneath the earth's surface. Often depleted by wells, irrigation and poor water management.

Informal settlements: Term often used to describe a slum or shanty town. Often areas where groups of housing units have been constructed on land that the occupants have no legal claim to or occupy illegally. They are often unplanned where the housing is not in a compliance with current planning and building regulations.

Lock-in: As escalating commitment to an ineffective course of action that is extremely difficult or impossible to deviate from.

Low carbon urban trajectory: An alternative development pathway that reduces carbon emissions versus a business-as-usual trajectory.

Mitigation (to climate change): An anthropogenic intervention to reduce the anthropogenic forcing of the climate system. It includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

Multi-dimensional poverty (MDP): Measure that aggregates a range of indicators (e.g. health, education, income) of human wellbeing to capture the complexity of poverty.

Natural resources: Naturally occurring resources used by humans. Natural resources can include, amongst others, air, water, wood, and fossil fuels.

Peri-urban: Land that is immediately adjoining an urban area.

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation and the capacity to adapt to stress and change.

Risk: There are a wide range of definitions of risk depending on the context reflecting the very different approaches to risk management taken in different fields. In the context of this report, we refer to risk broadly as the potential that the 'activities' of cities which drive carbon emissions and pressure on natural resources and 'events' in the form of climate hazards and external pressures on the resources used by cities will have an undesirable impact.

The Global South: A generic term generally used to describe countries with a medium or low Human Development Index score, which is a comparative measure of life expectancy, literacy, education, standards of living, and quality of life for countries worldwide.

'Triple-win' solutions: In the context of this report, policies and programmes that deliver multiple environmental benefits by (1) reducing carbon emissions and energy use; (2) responding to climate hazards; and (3) reducing pressures on regional support systems such as water and food systems and natural habitat.

Urban: Used as a collective term to fit with the different country specific definitions of cities and towns.

Urban catchment: Area surrounding a city that supplies water, food, and other ecosystems services.

Urban densification: Is a term used to describe the number of people living within an urbanised area. Often measured in the number of people in a given area. Concept closely linked to urban sustainability in theories such as New Urbanism, Transit-oriented development and smart growth.

Urbanisation: Is the physical growth of urban areas as a result of rural migration and even suburban concentration into cities. Often linked with modernisation, development and industrialisation.

Urban Heat Island (UHI) effect: The increased temperature of the urban air compared to its rural surroundings. The difference is particularly stark at night.

Urban sprawl: The outwards spreading of a city through the expansion of low-density development that increases car usage.

Vulnerability: A variety of definitions exist according to the specific context. In the context of this report we define vulnerability as the degree to which a city and its inhabitants are susceptible to and are likely to be detrimentally impacted by the stresses and shocks associated with climate change, resource scarcities, and damage to vital ecosystems. The United Nations International Strategy for Disaster Reduction defines vulnerability as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. The Intergovernmental Panel on Climate Change defines vulnerability to climate change as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

'Win-win' solutions: In the context of this report, policies and programmes they deliver multiple environmental benefits by contribution to two of the three out of the following objectives: (1) reducing carbon emissions and energy use; (2) responding to climate hazards; and (3) reducing pressures on regional support systems such as water and food systems and natural habitat.

Abbreviations used

BAU Business As Usual

BEE Bureau of Energy Efficiency

BRT Bus Rapid Transport

BWSESMP Bangalore Water Supply and Environmental Services Master Plan

BWSSB Bangalore Water Supply and Sewerage Board

CAC Command and Control

CDM Clean Development Mechanism

CER Certified Emission Reduction

CMA Chennai Management Authority

CNG Compressed Natural Gas

CO_2e CO_2 Equivalent (Impact of greenhouse gases expressed interns of CO_2)

CMCs City Municipal Corporations

CGC City Coordination Group

CDP City Development Plan

CVTC City Volunteers Technical Corps

CTAG City Technical Advisory Group

CMA Commissionerate of Municipal Administration

CSR Corporate Social Responsibility

DPR Detailed Project Report

DTCP Directorate of Town and Country Planning

ECBC Energy Conservation Building Code

EE Energy Efficiency

ESCO Energy Service Company

FAR Floor Area Ratio

FSI Floorspace Index

GDP Gross Domestic Product

GEF Global Environment Facility

GHG Greenhouse Gases

GRIHA Green Rating for Integrated Habitat Assessment

Ha Hectares

HPEC High Powered Expert Committee

IGBC Indian Green Building Council

IHSDP Integrated Housing and Slum Development Programme

INCCA Indian Network for Climate Change Assessment

INR/Rs Indian Rupees

IPCC Intergovernmental Panel on Climate Change

ITS Intelligent Transport System

IT Information Technology

IDFC Infrastructure Development Finance Corporation

ICF International Climate Funds

JNNSM Jawaharlal Nehru National Solar Mission

JNNURM Jawaharlal Nehru National Urban Renewable Mission

KWh KiloWatt hour

LEED Leadership in Energy and Environmental Design

LPA Local Planning Authority

LPG Liquefied Petroleum Gas

MoEF The Ministry of Environment and Forests

MMC Madurai Municipal Corporation

Mw Mega Watts

MNRE Ministry of New and Renewable Energy

MLD Million Litres per Day

MLPA Madurai Local Planning Authority

NAPCC National Action Plan on Climate Change

NMT Non-Motorised Transport

NTAG National Technical Advisory Group

NRW Non-Revenue Water

PV Photo Voltaics (Solar panels)

PWD Public Works Department

SPV Special Purpose Vehicle

SEZs Special Economic Zones

TERI The Energy and Resources Institute

TNDE Tamil Nadu Department of Environment

TNEB Tamil Nadu Electricity Board

TNHB Tamil Nadu Housing Board

TNSTA Tamil Nadu State Transport Authority

TNSCB Tamil Nadu Slum Clearance Board

TNUDF Tamil Nadu Urban Development Fund

TNUIFSL Tamil Nadu Urban Infrastructure Financial Services Limited

TNWSB Tamil Nadu Water and Sanitation Board

TMC Thousand Million Cubic Feet

TCE Thiagarajar College of Engineering

UIDSST Urban Infrastructure Development Scheme in Satellite Towns

UIDSSMT Urban Infrastructure Development Scheme for Small and Medium Towns

UFW Unaccounted for Water

ULB Urban Local Body

01

INTRODUCTION

Introduction

Background

In March 2013, Atkins, supported by the Development Planning Unit of University College London and the Indian Institute of Human Settlements, were commissioned by the Climate Development Knowledge Network (CDKN) to undertake action planning with the city authorities of Bangalore and Madurai, focussed on developing future proofed urban strategies in the cities. In Madurai, we have been working closely with Madurai Municipal Corporation who has been the client for the project as well as Dhan Foundation who are delivery partners for the project.

The key objective of the project is to help both cities to develop an action plan which charts a clear way forward, via the development of policies and other interventions, to help them respond to climate hazards and promote a transition to a low carbon economy while reducing poverty and catalysing economic development. A special emphasis is placed on supporting and enhancing locally owned policy processes.

Overall approach to the project

The project has been undertaken over two key stages at the city level, which is consistent with the future proofing approach developed by Atkins and UCL, with later stages disseminating the lessons learned (see Figure 1.1 on page 4).

This report is the final action plan for Madurai which provides a basis to address the climate risks and development needs of the city.

At the conclusion of the urban diagnostic stage, stakeholders in the city converged on the view that the plan should focus on future proofing Madurai's blue-green infrastructure to build resilience to climate change impacts facing the city. This is essentially a plan for managing an interconnected set of challenges relating to water resources management (surface and ground water), water supply, water quality, sanitation, waste management, flooding and preservation of natural ecosystems in the context of the urban development trajectory of the city and its changing climate.

The plan develops a series of city wide proposals as well as showing how such a plan could be developed at the local level (refer to Appendix A on page 86).

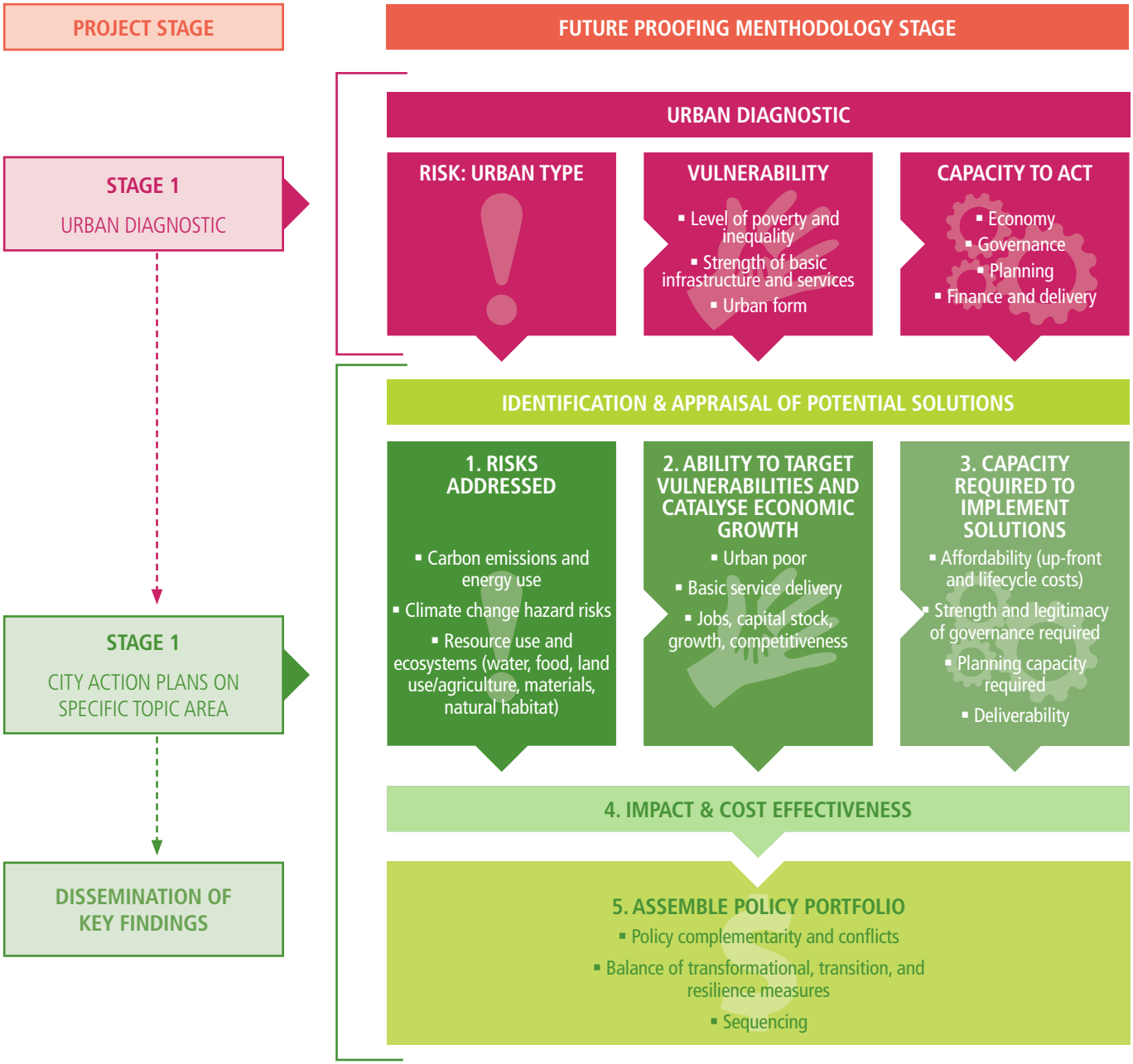


Figure 1.1 Overall approach to this project

The diagnosis of the present and future challenges for Madurai now needs to be mobilised into action that can deliver change on the ground.

Purpose of the plan

The purpose of the action plan is to provide a mechanism for building the city's current and future resilience, as well as the capacity to act among communities, institutions, and government. The aim is to foster collaboration between sectors and communities, in order to arrive at an integrated approach and to generate momentum for early action around the priority issue of blue-green infrastructure.

The aim of the action plan is to:

- mobilise action, target specific vulnerabilities and deliver change on the ground that will benefit a wide range of stakeholders, including those in multidimensional poverty
- address identified risks, including multiple risks to generate 'win-win' and 'triple win' environmental benefits
- catalyse economic development.

Action in Madurai will be driven through the setting and implementation of projects. Some projects relate to spatial interventions in neighbourhoods, while others relate to systemic issues. The action plan will:

- make the case for the mobilisation of resources to address issues and infrastructure gaps in Madurai
- define a programme of interrelated actions to help unlock currently stalled projects in Madurai
- contribute to the forthcoming revision to the CDP and masterplan
- link to and reinforce other planning interventions and existing policies
- be implementable, in the context of other existing plans, capacities and incentives
- to identify those organisations, departments and institutions who have the responsibility for implementing each element of the action plan
- to identify potential sources of investment, funding, and delivery vehicles for key interventions and projects.

The action plan for Madurai charts a clear way forward. It helps the city respond to climate hazards and promote a transition to a low carbon economy while reducing poverty and catalysing economic development. It supports and enhances the local creation and ownership of policies, interventions and projects aimed at future proofing Madurai.

The frame of reference for the plan is to cover the period up to 2031 which aligns with the upcoming revision to the Madurai Master Plan. The plan considers ongoing actions required over the whole plan period together with actions required to build resilience and tackle vulnerability over the short term while preparing for measures to tackle slow on-set climate change risks which would be fully implemented post 2020.

The structure of this document

This document is structured in four sections following this introduction.

Section 2 provides a summary of the diagnostic for Madurai and the underpinning rationale for its focus on blue-green infrastructure.

Section 3 outlines the overall strategy for Madurai focusing on how the components should be integrated and sequenced. The chapter also contains project plans for 14 projects across six themes relating to sanitation; solid waste management; rehabilitation of channels and tanks; flood and surface water management; water resources supply demand balance and governance and future proofing planning.

Section 4 focuses on delivery and implementation of the plan including three projects addressing the arrangements for improved governance and proposals for future proofing planning to provide the regulatory framework for implementing the other proposals contained within the plan. This section also includes a preliminary of the cost of implementing the plan. A range of financing options are also explored.

Appendix A provides the results of a pilot to develop more detailed future proofing proposals at the neighbourhood level.

Action planning in Madurai

The approach

Over a period of around one year, a series of action plan proposals have been shaped and supported by a range of stakeholders in the city.

Initial discussions took place early in the project about the issues and challenges Madurai is facing which provided the impetus for collective action.

The process of action planning has been used to develop, deepen and share understanding between different stakeholders, as well as exploring and initiating discussion of what the opportunities could be for the city to address its existing vulnerabilities and adapt to climate risks which are expected to impact the city.

The project timeline in Figure 1.2 opposite highlights the key phases of the project and of the turning points and milestones which were pivotal to the goals below.

- **Building platforms for engagement -** state level dialogues were essential in gaining commitment to address the project. In addition, multiple mechanisms were used during the action planning process to engage local stakeholders.
- **Reviewing the current position and creating an urban diagnostic** allowed for the first time the critical issues to be seen as interlinked, rather than a collection of sector focused issues and initiatives which previously have proved difficult to implement in isolation from each other.
- **Using the action planning process to clarify and examine the implications of the existing situation for vulnerable communities** through a multifaceted programme of research, interviews and visits to hotspot areas around the city where the climate risks and vulnerabilities are most evident including an in depth case study of the Kiruthumal corridor.
- **Bringing together stakeholders to engage and consider the priority issues.** The process provided a safe place for debate and discussion to between community organisations and government bodies.
- **Exploring and selecting the range of different actions which can be mobilised to reduce vulnerability and adapt to climate risks** - developing the social capital of the city can help deliver early results and complement policy-legal and government actions regarding infrastructure projects which may take longer to realise.

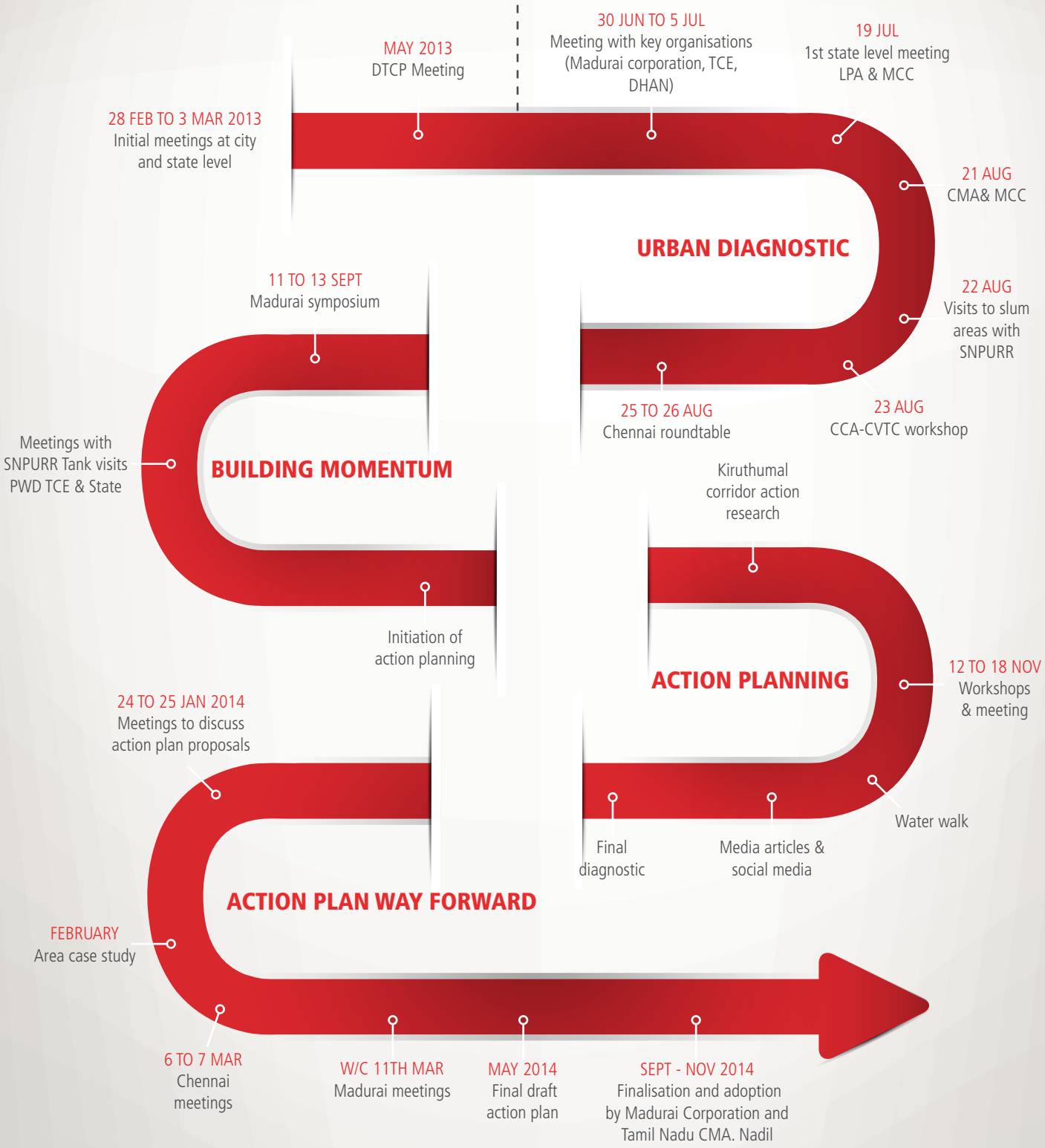


Figure 1.2 - Action plan timeline

02

DIAGNOSTIC AND PLAN FOCUS

Future proofing

What is the 'Future proofing' approach?

In order to tackle the risks to its future growth, as well as to meet the demand for adequate infrastructure and basic services, Madurai could benefit from a new approach to urban development: a 'future proofing' approach.[1] Future proofing is about identifying and developing solutions which can respond to the risks associated with issues such as climate change, resource scarcities, and damage to vital ecosystems but in a way which catalyses broader economic development, improves access to basic services, and tackles urban poverty.

Future proofing is about taking an integrated approach to tackling some of the city's deep rooted urban problems. For example, water supply issues are generally approached solely from the perspective of identifying water engineering solutions, with the potential impacts on vulnerable groups, patterns of development, food security and flooding poorly understood. When urban problems are approached in this narrow way, solutions can sometimes be ineffective, opportunities for generating wider benefits are missed, or significant unintended negative consequences can occur.

The future proofing approach considers the growth dynamics of the city in parallel with the range of potential risks which may impact its future development. The approach involves looking at three groups of interrelated issues:

- climate risks e.g. flooding, extreme heat events
- resource and ecosystem risks within the city and its wider catchment e.g. water scarcity, food security, and damage to vital ecosystems due to urban growth
- energy use and carbon emissions e.g. from transport, domestic and commercial consumption, industry and waste.

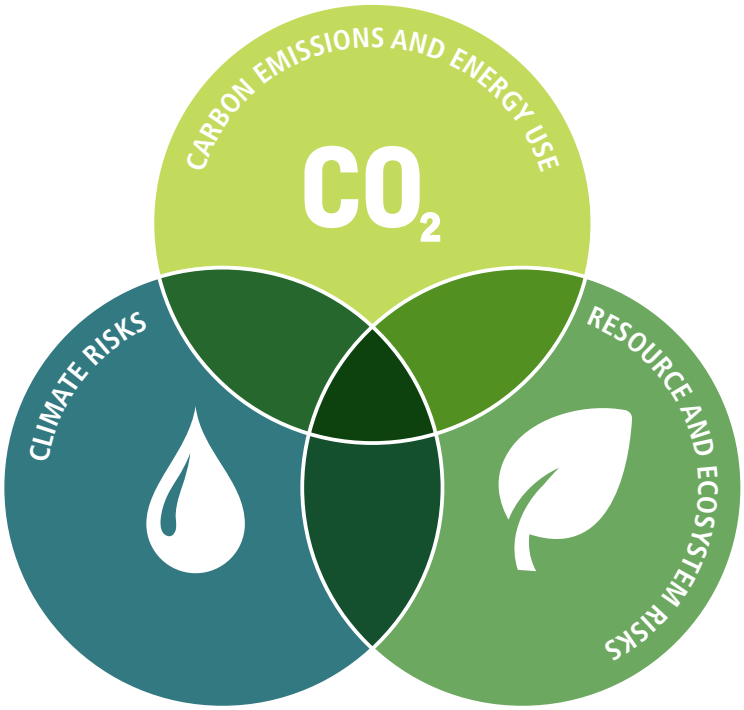


Figure 2.1 - Future proofing approach: integrated assessment framework

Source: Atkins

1 Future Proofing Cities (2012), Atkins in partnership with DFID and UCL

Benefits of a future proofing approach

Building a profile - or urban diagnostic - of these key risks, in conjunction with assessing the vulnerability and capacity of local institutions and stakeholders to respond to them can help to identify implementable solutions which can deliver multiple economic, social, and environmental benefits. This differs from most current approaches to urban development which tend to focus on targeting one or a few narrowly defined objectives (e.g. city competitiveness, green cities) rather than looking at packages of complementary policies which can meet multiple objectives. The benefits for Madurai of developing this approach include:

- An explicit focus on how the city can respond to four long run challenges - resource security (e.g. water), resilience to climate impacts, the move to a low carbon economy, and protection of ecosystems
- The identification of packages of complementary policies in these areas which can generate multiple environmental, social, and economic benefits, crucial in the context of limited financial resources
- A focus on measures which respond to the needs of the urban poor
- The identification of measures which can be implemented and driven forward by stakeholders within the city given current capacities.

This action plan reflects the needs and aspirations expressed by Madurai Corporation stakeholders and communities during action planning in Madurai. This is a shared vision of how Madurai could be in the future.

Key objectives for the plan

- That Madurai becomes a healthy city with functioning public infrastructures and a low incidence of water and vector borne diseases.
- That the blue-green networks and ecosystems restored - with a balance between natural systems and communities the strong historical relationship with the water networks.
- That the needs of a community are addressed in terms of service provision and green spaces leading to a high quality of life for all.
- That mechanisms are defined to support sustainable growth and expansion of the city.
- That Madurai is better able to respond to the risks climate change through strong partnerships local and city partnerships.

Why Madurai?

Madurai is the second largest city in Tamil Nadu. One of the oldest continuously inhabited cities in the world, Madurai developed on the fertile plain of the River Vaigai and has been a major religious centre and settlement for two millennia.

Today it is an important educational, industrial and tourism hub, but retains many remnants of its historic origins. The intricate network of rivers, channel, canals, tanks and groundwater forms the city's essential blue-green infrastructure, providing water, drainage and sanitation for domestic, agricultural and industrial use. The city is growing rapidly, and is expected to rise from 1.4m in 2011 to over 2 million people by 2031 (the end date for the upcoming Madurai Master plan). This will lead to further pressures on infrastructure, housing, and basic services.

Madurai is also facing a wide range of risks that will hinder future economic growth and quality of life unless action is taken soon to future proof Madurai's development. These are risks such as water scarcity, climate change, growing traffic congestion and damage to important natural habitats. The city is likely to be particularly impacted by climate change. Madurai lies in a warm-humid climatic zone, which is hot and dry with intermittent and irregular rainfall. Increase in average temperatures and rainfall variability will lead to wide ranging effects on many sectors, including food and water systems, human health, buildings, transport, energy and ecosystems.

The first phase of this Future Proofing Cities India project - the urban diagnostic is summarised on pages 13 to 21. It has highlighted the criticality of Madurai's blue-green infrastructure. In order to improve and secure the long term resilience of the city, there is a need to integrate the issues of water resources management with the management of urban growth. This means looking at ground and surface water management, water supply and distribution, sanitation, drainage and storm water management as well as links to natural habitat and urban development and energy use - all in the context of a changing climate.

A quarter of households inside the Madurai Corporation Boundary live in slum areas, some of which are located directly in the Vaigai River channel. While the Madurai Corporation are committed to providing universal water supply, underground sewage system and ensuring the city becomes slum free, these communities are currently on the front line of the increasing demand for water resources, poor water distribution infrastructure, and contamination of existing supplies. Future pressures on the blue-green infrastructure will also have a disproportionate impact on those living in multi-dimensional poverty. Slum areas will be increasingly prone to flooding, and the lack of effective sanitation is likely to lead to the spread of communicable diseases.

Madurai needs an approach to future development which is both climate compatible and improves the lives of all the residents including the poorest. By adopting a future proofing approach to managing development, Madurai can demonstrate that interventions which are targeted, integrated and developed through a partnership of government, business and communities, can be the essential catalyst for transformational and long term change.

Summary of the urban diagnostic for Madurai

Risks facing Madurai

Madurai faces a range of climate hazards - particularly flooding - which already impacts its people and physical infrastructure. Madurai is located in a warm-humid climatic zone, and experiences a hot dry climate with intermittent and irregular rainfall. In recent years, high volumes of rain during the monsoon has caused parts of the city to flood. Areas particularly impacted are the Periyar Bus Stand Area, Railway Colony, and the area close to Madura Coats on the northern bank of the Vaigai River. Other flood prone areas include Simakkal, the area near to Amirtham Theatre, the area near to Tallakulam Perumal Kovil temple, Kattabomman Nagar, Narimedu and the Meenakshipuram-Bibikulam area.[1]

The areas which are particularly prone to flooding include parts of the city which lie within the natural floodplain of the river and drainage channels. Often slums have become established in these areas which are usually owned by public bodies and lack appropriate flood protection or flood resilient infrastructure. Moreover, much of the network of natural water bodies and tanks which play a key role in storm water drainage and runoff within the city have been encroached upon by development which leads to these areas flooding during heavy rainfall events.

Climate change is likely to exacerbate these existing hazards: Existing national and regional level climate studies indicate that climate change could result in: (i) an increase in average temperatures and increase in the number of extreme 'hot days' (with increased risk of drought); (ii) an increase in the unpredictability of the summer monsoon with potential for rainfall variability, and (iii) an increase in the frequency of heavy rainfall events (with increased risk of flooding) in Madurai.

The availability and management of water resources available to Madurai is one of the most significant issues facing the city. The situation has partly resulted from underinvestment in water supply and storage infrastructure within the Vaigai catchment and partly due to the poor quality of the water distribution network within the city and newly expanding areas.

Madurai's water supply is dependent on rain from the monsoon which is stored in the reservoirs and water bodies and replenishes groundwater resources. Within the Vaigai catchment in which Madurai is situated there is a water balance deficit in surface water and groundwater sources. Water shortages are an issue within the catchment during drought periods. The city's rainfall is concentrated with much of the annual rainfall arriving in late summer. Climate projections indicate that variability could increase.[2] The city receives piped water from dams located upstream of Madurai linking with the piped water network within the Corporation boundary. However, this network serves only around half of households within the previous Corporation boundary. It is unclear what options may be feasible to increase water storage in the Vaigai catchment.

The situation relating to water supply storage infrastructure within the Vaigai catchment has placed additional pressure on groundwater resources. The rest of the city draws their water from groundwater (where this is available) or from tankered deliveries. Both of these sources are problematic.

1 Madurai CDP
2 World Bank Climate Change Portal

3 Madurai CDP
4 ibid
5 Water Poverty in Urban India: A Study of Major Cities.
6 A leak detection study conducted by WAPCOS/NEERI in 1998 undertaken in the West Zone by TWAD, revealed a 30 % loss in the transmission and distribution of water.
8 http://timesofindia.indiatimes.com/city/madurai/Vaigai-water-reaches-Madurai-outskirts/articleshow/21321680.cms

Abstraction rates are not sustainable evidenced by a significant lowering of the water table in many areas and drying up of some wells (despite drilling of deeper boreholes).

In addition, the groundwater serving the city is of poor quality due to inadequate sanitation infrastructure and seepage of pollutants into the water table with significant health implications. Ground water has high rates of faecal contamination and nitrate content in many parts of the city.

It is estimated that only 52% of households in Madurai have a connection to the water supply network, with large sections on the periphery of the city not connected. The frequency of supply is also poor and averages once in every two days outside of the summer season.[4] As a result, average daily water supply is just 67lpcd compared to a national standard of 110lpcd. The problem is not confined solely to low income areas, with the proportion of water deficient households relatively evenly spread throughout the high, medium and low income group areas.[5]

Figure 2.2 - Many of the water bodies which could play a role in providing water for the city are polluted from untreated sewage and pollutants from dumping

Estimates of leakage also suggest high losses in the transmission and distribution of water, although reliable recent estimates are challenging to find.[6] The Corporation has identified a need for a comprehensive programme of works to repair the existing water distribution network in the core area of the city (which is now over 50 years old). Treatment capacity of wastewater is also inadequate, with some estimates putting the amount of wastewater eventually treated at just 25%. There are issues reported in terms of gaps in sewerage network pipes and pumps, lack of connections as well as the network not serving slum areas. Septic tanks play an important role but pollution of groundwater and informal disposal of waste is a problem as it often finds its way into stormwater and drainage systems and ultimately the Vaigai River or the city's lakes.[7]

Many of Madurai's lakes and surface water bodies have been seriously degraded or even built upon reducing the capability of the city to deal with heavy rainfall events. Climate change represents an additional stress factor which will exacerbate the situation. A network of natural and manmade water bodies and tanks within the city collect runoff with the tanks providing a stormwater detention role. Many of the tanks are used for irrigation with some of the tanks also playing a role in water storage for the city.

The management of surface water bodies, especially the lakes, influences how the city can respond to droughts and climate variability as they have the potential to provide a buffer of supply. There are a number of pressures which have eroded the effectiveness of this system over time. This year, it was reported that the drinking water shortage was acute in parts of the city-region including Avaniapuram, Thiruparankundram, and Thirunagar,[8] and the productivity of local agriculture was heavily impacted. The system of lakes and water bodies are a significant feature of the city, as well as providing potential significant future amenity and tourism value. However, Madurai's ability to store rainwater for irrigation and water supply has fallen over time for a variety of interconnected reasons:

- development pressures in the city and the shortage of land has led to loss of some of the tanks to development. These areas are prone to flooding during rainfall events due to lack of provision of alternative storm water storage or drainage infrastructure
- sand mining in the Vaigai River channel has disrupted the water flow replenishing a number of tanks leading to them falling into disuse
- some of water bodies and connected channels have been abandoned or have silted up as a result of changes in agriculture including the emergence and development of energised well irrigation, reducing the incentive of farmers to participate in common work for tank maintenance as well as migration of labour from rural areas into the city.[9]

Figure 2.3 - An example of one of the water bodies which has fallen into disuse from sand mining which is disrupted the flow of water which would replenish the tank. The tank has then been encroached upon by development which is at high risk of flooding

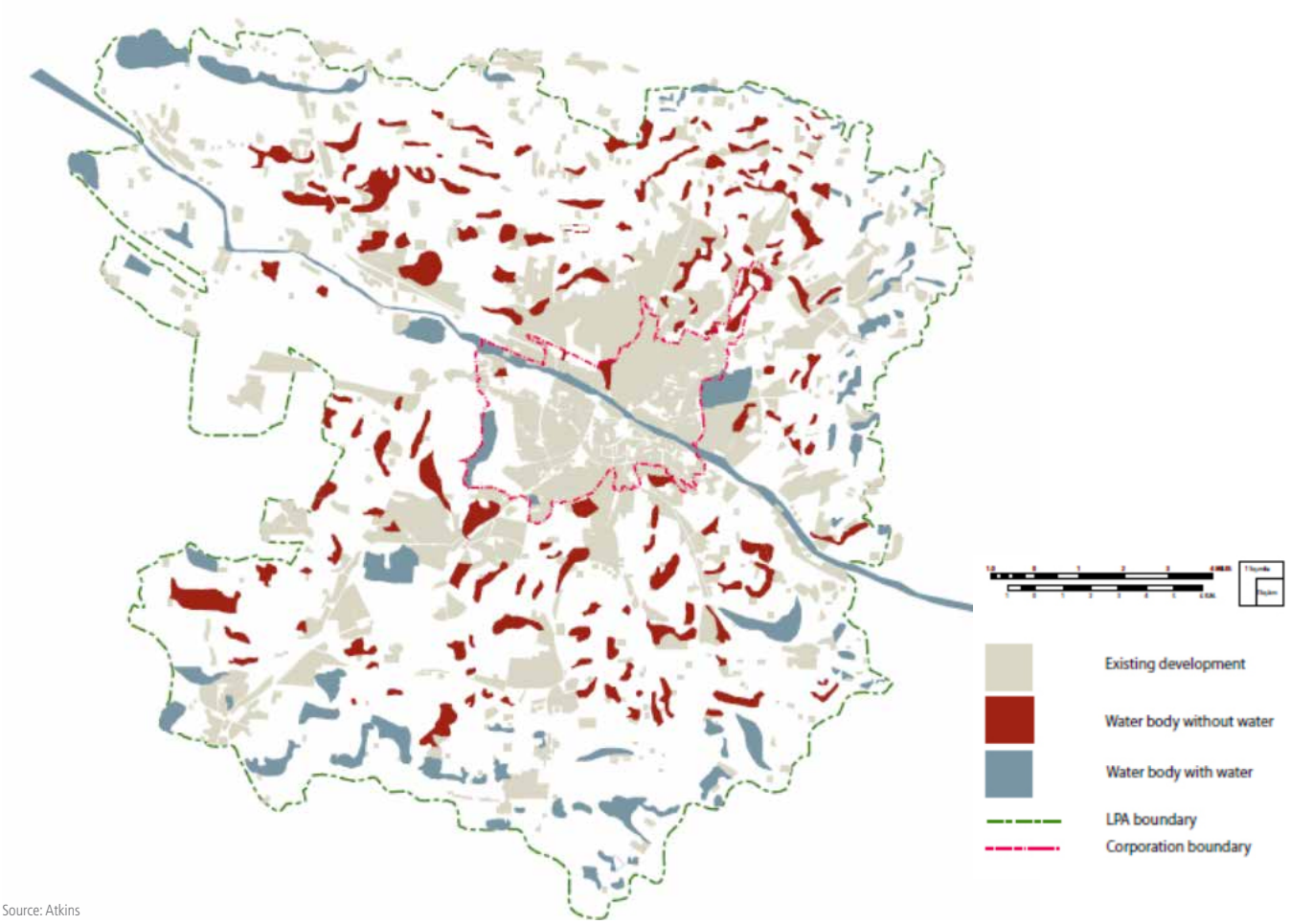
Degradation of the water bodies has led to water quality issues and increased the exposure to health risks which could be further exacerbated by climate change. The lack of sanitation infrastructure and solid waste management collection in many parts of the city has led to unauthorised discharge of raw sewage and waste into channels and water bodies on a widespread basis. This has polluted water in the channels, the lakes the channels flow into, as well as the Vaigai River. Contaminated water has also percolated into the groundwater. This has led to health issues due to water borne and vector borne diseases as well as diseases resulting from ingestion of food irrigated by contaminated water. Madurai District has the highest rate of dengue fever of all districts in Tamil Nadu as well as above average rates of cholera, typhoid and jaundice.

This issue is compounded by deficiencies in existing wastewater treatment facilities and sanitation infrastructure. Madurai has challenges in terms of its wastewater disposal infrastructure with a significant quantity of sewage flowing through open channels and rainwater drains into the Vaigai River and open water bodies with negative effects on the environment and health of the local population. Due to capacity constraints of the two existing wastewater treatment systems, less than 50% of the collected wastewater in Madurai is routed towards 'treatment' facilities - about one quarter of the wastewater generated within Madurai Corporation limits.[10] This problem is especially acute within informal settlements. The same applies to adequate sanitation infrastructure with the urban poor living in informal settlements which are largely not provided with adequate sanitation infrastructure.

The degradation of Madurai's wetland and aquatic ecosystem is reducing the availability of vital ecosystem services such as oxygen production, carbon storage, natural filtering of toxins and pollutants, and protection from other storm-related disasters. Aquatic systems dilute and transport pollution away from human settlements, maintain the quality of freshwater sources, and, in some cases, permanently remove pollutants from the atmosphere. Unsustainable water resources management and excess pollution are eroding these services in Madurai, compromising clean water supplies and food production.[11]

Actual water availability within the city of Madurai is a function of rainfall within the Vaigai catchment (fed predominantly by monsoon rains); pipeline systems linked

9 Madurai CDP
10 City Communiqué
11 Institute of Water Management



Source: Atkins

Figure 2.4 - Distribution of water bodies in Madurai including those with and without water

with water storage and replenishable groundwater resources within the city boundary. However, the current hydrological scenarios and models used in national studies are of a scale which means that conclusions for Madurai cannot easily be drawn. Further work is needed to understand the needs of the city and implications of climate change on water resources.

However, the combination of increasing demand for water resources, poor water distribution infrastructure, and contamination of existing supplies could constrain the ability of Madurai to grow and prosper in the future as demand in the city and wider region continues to grow. Development is already constrained in areas of the city without a piped network where there is only limited access to ground water. Urbanisation, population growth, economic development and increasing demand for water from agriculture and industry are all likely to aggravate the situation further. Domestic water requirements alone are projected to increase by more than 50% in Tamil Nadu from 2,222 MCM in 2001 to 3,460 MCM in 2050.

Given the severe water stress the city and wider region are already experiencing, the interconnectedness of Madurai's blue infrastructure to other challenges such as managing the impacts of climate change and spread of communicable diseases, along with concerns about the environmental quality of water, addressing water security represents an urgent system-wide priority for Madurai.

Figure 2.5 - Location of slum areas inside Madurai Corporation area

There is an important opportunity for Madurai to consider an integrated urban water management approach to address its water security challenges. The current strategies employed by the city have not been able to keep pace with demand for drinking water, sanitation, wastewater treatment, and other water-related services. The Government of Tamil Nadu has already indicated that improving access to water will be the highest priority of the regional government.[12] Madurai has an opportunity to consider an integrated urban water management approach which offers a set of principles that underpin better coordinated, responsive, and sustainable resource management practices. It is an approach that integrates water sources, water use, water services, and water management.[13]

Vulnerability of the city

Not only does Madurai face a wide range of environmental risks, but segments of Madurai's population - especially the urban poor - are particularly vulnerable[14] to those risks. For example, the urban poor can be expected to be hit first and hardest by climate hazards such as flooding - they do not have the assets to protect themselves against stresses and shocks and poor residents tend to be located in the most vulnerable areas and in poor quality housing as well as in low paid jobs that can be impacted by flooding. Equally, rising resource prices affect the urban poor disproportionately because they spend a larger share of their income on energy, water and food. When parts of the city experience intermittent power outages, many businesses and households rely on fossil fuel powered backup generators but which are unaffordable for the poorest households.

12 Tamil Nadu Environment Report
13 Integrated Urban Water Management Report
14 We define vulnerability as the degree to which a city and its inhabitants are susceptible to and are likely to be detrimentally impacted by the stresses and shocks associated with climate change, resource scarcities, and damage to vital ecosystems. At the heart of all definitions of vulnerability is the notion of 'lack of means to cope' with the adverse impacts associated with shocks and stresses.

Figure 2.6 - Many slum areas are built on land along rail and river corridors and experience multiple vulnerabilities. Water is drawn from channels which are polluted by raw sewage

Around a quarter of households inside the Madurai Corporation boundary live in urban slums. There are 310 slums within the recently expanded Madurai Corporation boundary[15]. Data available from the CDP indicates that there is a slum population recorded in every ward of the city, although the proportion varies from a maximum of 69% in Ward 31 to 3% in Wards 39 and 36. Many of these slums are located along the riverbanks and adjacent to transport corridors, encroaching both private and municipal land. Around 85% of the slums in the city are on Government land and 9.2% are on Corporation land.[16]

Madurai's slum dwellers are particularly vulnerable to changes in the availability of critical resources, particularly water supplies. As development is largely unauthorised, the slum areas are not connected to city water supply and sanitation networks unless they have been regularised, leading to dependency on ground water or tankered water which may be of poor quality. The needs of some slum areas are met through hand pumps and public stand posts (PSPs) as a stop-gap measure. The slums at Gandhipuram - Pandian Nagar, and Ramavarma Nagar have approximately 70 water outlets serving populations of around 7000 and 4000 respectively. Dependency on the stand posts is high, and varies between a maximum of approximately 1000 persons per PSP to a low of approximately 20 persons per PSP in approved slums. Average dependency is approximately 120 persons per PSP against the standard norm of 75 persons per hand pumps or PSPs.[17] Despite the dependency on hand pumps, the majority of all households in slum areas also get at least some of their water from a tap (76.6%), 28.1% uses a tube well or hand pump, and 17.8% uses a tank or reservoir. Even though the majority of the households uses a tap, the vast majority of the households shares at least one source with other households (85.6%).

A lack of adequate waste disposal and sanitation facilities is a significant issue impacting slum dwellers. Public toilets are provided in 28 of 64 approved slums and 46 of 144 unapproved slums. Those residents in slums without toilets use nearby public toilets and urinals, or resort to open defecation. On average each public convenience seat serves approximately 300 persons and each urinal serves approximately 200 persons, against prescribed norms of 30 to 50 persons per public convenience seat / urinal.[18] There are no designated solid waste collection points or waste bins provided in slums. As a result, in most of the slums, the waste is disposed in nearby vacant areas with significant public health risks.[19]

Many residents are particularly vulnerable to climate hazards such as flooding - the problems are most acute within slum areas. Many of Madurai's informal settlements and most vulnerable residents in Madurai are located in vulnerable locations close to the River Vaigai and are often located in housing using poor quality construction materials. Slums in the city are not provided with pucca storm water drains. Although, there are kutcha drains, these are often damaged or clogged due to solid waste dumping. Because many of the slum areas are located along the banks of the River Vaigai, these areas face the twin threat from the river flooding, as well as from high rates of surface water runoff from poor drainage infrastructure.[20] Areas which have been

15 Including 208 within the former Madurai Corporation area
16 Slum upgrade report
17 Slum upgrade report
18 Slum upgrade report
19 Ibid
20 ibid

Figure 2.8 - Many of Madurai's slums are located near to river banks vulnerable to flooding

Figure 2.7 - Open disposal of waste in water bodies and channels is commonplace in Madurai's slum areas due to lack of adequate waste and sanitation facilities

developed on former water bodies and tanks as well as development which has taken place in flood plains is also highly vulnerable to flooding as there is a lack of drainage and resilience to flooding. Table 5 provides a summary of the risks facing selected slum areas in Madurai, illustrating the complex confluence of issues facing slum dwellers.

Existing action and gaps to be bridged

The capacity of Madurai to respond to the environmental risks to its growth and prosperity will be shaped by the strength of its governance and planning structures, and its ability to access, mobilise, and structure financing to respond to identified risks.

The Madurai Municipal Corporation is the key organisation that manages and/or coordinates most of the city level services. The Corporation has recently been expanded to include a further 28 Wards around the edge of the city and now has responsibility for meeting the deficit in infrastructure and services to this area. Unlike Bangalore and many other larger cities in India, all of the service provision organisations are managed by the Corporation. This implies that any specific organisational arrangement for sustainable urbanisation and future proofing must recognise that the Madurai Municipal Corporation has an important role to play.

Capacity available within the Corporation has not kept pace with the additional demands the Corporation has to address. The Corporation has identified a need to scale its internal staffing and technical capabilities to match the plans and programmes Madurai wishes to implement. However, a lack of funding has prevented progress being made.

Lack of coordination between state and local level bodies responsible for funding, provision and expansion of infrastructure has contributed to inadequate provision. Whilst the governance structures within Madurai

21 The update to mapping and survey work is soon to be completed and work is expected to begin on planning during 2014.

are not as fractured as some of India's larger cities, there are still a large number of agencies involved in the planning, regulation, management, funding and delivery of infrastructure and urban development and a relative lack of co-ordination between them on complex technical issues.

Fragmentation of responsibilities for management of water supply and distribution, groundwater and surface water drainage between State and Corporation Departments have represented a barrier to take up of best practice. The Tamil Nadu Water Supply and Drainage Board (TWAD) is responsible for creation of water and sewerage infrastructure in the state and the Municipal Administration and Water Supply Department (MA & WS) is responsible for managing water resources. At the city level, the Madurai Corporation is responsible for the day to day governance, maintenance and delivery of services within the city. Lack of coordination and aligned agendas has prevented implementation of an integrated water management approach although the benefits are well known. During the stakeholder engagement process, the Corporation expressed a desire to explore how steps can be taken to move towards solutions which can be implemented.

Mechanisms to support multi-stakeholder consultation and co-ordination to support long term planning and tackle the development needs of the city are not formalised. The city has made progress in setting up formal structures to co-ordinate cross-cutting issues. The City Technical Advisory Group (CTAG) is envisaged as an integral part of programme implementation at city level with autonomy in offering advice to JNNURM related activities. CTAG is constituted by Madurai Corporation as a formal structure within the guidance of National Technical Advisory Group. CTAG provides advice on city governance and management, enlisting community participation in service delivery, governance and on measures to reduce urban poverty. CTAG guides the city in its development and renewal process with concrete technical and development inputs and by involving all the stakeholders in the development process of the city, including making the City Development Plan a living document to guide programme implementation.

The City Volunteer Technical Corps (CVTC) is being constituted by City Corporation to enable people participation in JNNURM implementation and to ensure accountability and transparency. It is guided by CTAG. CVTC comprises of a number of thematic cells namely, urban governance, urban infrastructure and engineering, urban planning, urban poverty and financial and legal services. CVTC will trigger the development process by sensitising the different stakeholders of their rights, roles and responsibilities and be the watchdogs of the development process. CVTC facilitates the exchange of information and will be a conduit for reaching the common person about the information on schemes.

Opportunities for strengthening partnership between the public, private sector and civil society were highlighted by city stakeholders during consultation events. The opportunity for a Special Purpose Vehicle which could help support the coordination, planning and delivery of new expansion areas was flagged during the project consultation process which could serve as a pilot for future proofing through data integration on a common platform and knowledge sharing between different stakeholders.

A range of efforts have been taken to improve the living conditions and reduce the vulnerability of Madurai's slums including relocation away from areas at risk of flooding, most recently through the RAY slum upgrading programme. However, despite the positive momentum behind the slum upgrading programme, significant challenges are arising in relation to finding suitable land for resettlement away from vulnerable locations. Due to financial constraints, finding land to resettle away from vulnerable lands (e.g. public land next to river banks, water courses) can often only be found on the outskirts of the city. Residents often refuse to move from their existing location due to proximity to employment. For example, of the 1,800 units that have already been constructed at Rajakkur - about 10 kilometres from the city centre - less

Source: Project team visits

Figure 2.9 - New housing developed for relocated slum dwellers on outskirts of city

than 10% of slum dwellers have taken possession after a year. Even plans to run special bus routes between Rajakkur and the city centre have not incentivised residents to move into their new homes. A lack of social infrastructure such as schools in the resettled locations has also made relocation more challenging. Since a previous Supreme Court judgement prevented tenure regularisation on objectionable lands, the requirement to resettle vulnerable communities in slum areas has slowed down the whole RAY programme implementation.

The focus of the project and city action plan was confirmed as part of the discussions.

- There is an opportunity for the action plan to closely link with current and upcoming initiatives in the city. This includes the RAY slum areas programme, UNDP programme addressing disaster risk reduction as well as the update to the Madurai Masterplan. This provides an opportunity to formalise some of the policies and proposals included in the action plan. In addition, sources supporting the further development and implementation of the State Climate Change Action Plan could also be linked to support implementation of initiatives in Madurai.
- Addressing city priorities and commitment to change - a strong focus of the discussions with the service beneficiary (Madurai Corporation) was that the outcome of the action plan should be a tangible series of solutions and actions defined to a level which can directly translate into a detailed project report which can be discussed with state, national and international agencies
- The city has found making the case for funding and securing resources to address its needs and priorities challenging, and the need was felt to be urgent. The service beneficiary and city stakeholders expect that an action plan will help to demonstrate the case for a more transformational series of interventions to address the blue-green infrastructure system. The city will be more able to lever in finance and provide a longer term solution than past attempts to address the issues of the city. The City Corporation has shown a desire to leverage funding from established national and State level programmes to help deliver improvements (including JNNURM). In Madurai, programmes such as the DFID-ADB Urban Climate Change Resilience Programme and the World Bank Low Carbon Liveable Cities Initiative could also play a role in supporting the city meet its existing and future needs by providing technical, financial and capacity building support.

Blue-green infrastructure: a way of integrating

The focus of the Action Plan on future proofing blue-green infrastructure emerged through the process of developing the urban diagnostic and setting priorities for the city (described in Section 1). This approach enables the city to address the priority climate and resource risks (especially water security) by reducing the vulnerability of Madurai's population, infrastructure and urban form.

The blue-green infrastructure approach is essentially about demonstrating how to manage the interconnected set of challenges relating to water resources management (surface and ground water), water supply, water quality, sanitation, solid waste management, flooding and conservation of natural ecosystems in the context of the urban development trajectory of the city and its changing climate.

Understanding water as a system has helped to identify Madurai's vulnerability and exposure to climate risks.

Water is a system - it flows across the city, it is used for drinking, cooking, washing, fishing, agriculture and industry and then discharged. Seeing Madurai through this lens has been key to reforming the issues and solutions for the city identified in the urban diagnostic. It has helped to identify the importance of two aspects: the role and condition of tanks and channels which have become part of the sewerage system of the city; and the malfunctioning of sewerage and sanitation. The case study of communities along the Kiruthumal River exemplified the interactions of these two issues and how they are intrinsically intertwined and linked to the third issue of water resources - pollution of the river and groundwater means that communities in many areas cannot access clean water, causing a range of health issues.

The green dimension of the blue-green infrastructure concept relates to the issue that polluted water used to irrigate agriculture along the corridor is in turn consumed in the produce. The water flowing into the system of natural lakes also impacts on the natural habitat and biodiversity of the city.

The issues highlighted in the urban diagnostic were identified as being complex and systemic in nature. The problems and vulnerabilities experienced within communities were often traceable and linked with natural river and drainage system networks as well as physical infrastructure.

This way of seeing was powerful to stakeholders in the discussions and interactions because it helped to link local challenges with the systems and risks operating at city and regional scale.

Action planning for Madurai focused on blue-green infrastructure as the mechanism to unlock and address the climate risks and vulnerabilities facing the city.

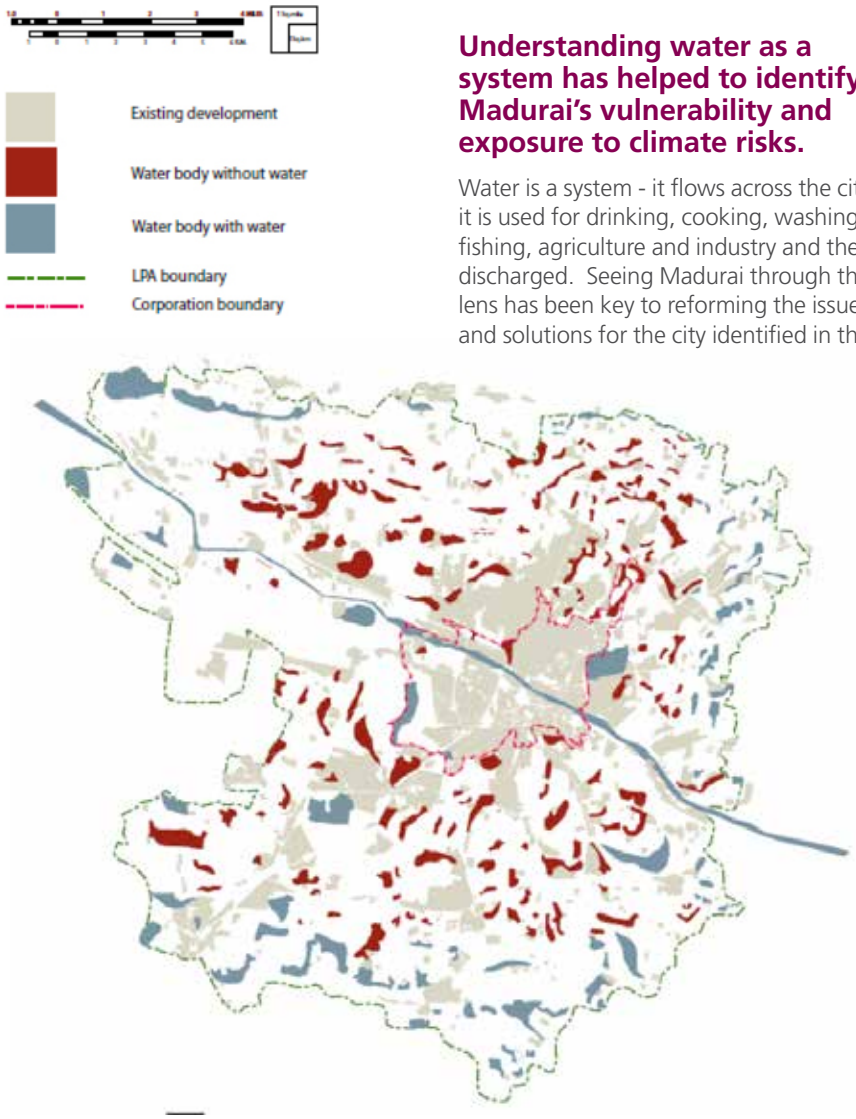


Figure 2.10 - Distribution of water bodies in Madurai including those with and without water.

The historical sustainable relationship with water has become stressed

The urban diagnostic revealed particular vulnerability to water issues. Madurai has historically had a sustainable relationship with water, but this has become stressed due to over-abstraction, sand mining of the Vaigai River, and pollution. The infrastructures of the city have not been extended or developed in an effective way, hindering the alleviation of the pressures which have grown as the population of the city has increased.

Sustainable solutions must be holistic

Considering the systemic nature of water and blue-green systems, it is vital to have holistic solutions. This was emphasised in the workshops and discussions. For example:

- rehabilitation of tanks and channels provides multiple benefits - cleaner water, enhanced capacity to deal with flood risk, biodiversity and amenity, with secondary benefits in terms of incomes and health. If these water resources can be better utilised, the need to pump water long distances may be reduced in the long term
- dealing with the sewerage system and having appropriate sanitation ensures channels are not polluted. It also provides a resource via re-uses with secondary benefits in terms of health and resource efficiency
- solutions would only be effective if they involve the communities who live alongside channels, as well as the institutions who are charged with managing different parts of the system.

Sustainable solutions must meet immediate and future needs

In the short term, water solutions will underpin poverty reduction, through saving time and avoiding illness (i.e. medical costs). In the longer term, they can drive tourism income and reduce the risk of extreme events (e.g. flood, drought). The solutions would also build capacity, in infrastructure, governance and communities, to deal with changes in climate and resource scarcity and price increases.

For community stakeholders in the city, health benefits would be highly valued and would build support for other link initiatives where the benefits may be less visible or be felt in communities in other parts of the city.

The Kiruthumal River case study

The Kiruthumal River was adopted as a case study of the complex interactions between the water network, the ecological infrastructure, institutional governance as well as the future environmental and urban development challenges. The fieldwork identified the relationship with land use patterns and clarified how the risks and vulnerabilities change according to the social geography of the city. More than 100 people in 25 locations across the city were interviewed and there were focus group meetings with communities who live and work alongside the river. This deep engagement ensures that the projects and interventions in the action plan are fully relevant to the lived experience and challenges of daily life on the river, as well as the systemic causes of the current problems and future vulnerabilities. (Refer to Appendix A).

03

THE FUTURE PROOFING STRATEGY FOR MADURAI

Introducing the strategy themes

The actions and projects reflect the range of issues which stakeholders in the community identified as priorities.

Figure 3.1 sets out the six themes which form the framework for 14 proposed future proofing projects focussed on the blue-green infrastructure of Madurai. The section on page 34 provides details on the methods of how the projects were selected and developed using future proofing techniques of evaluation and selection. Figure 3.1 also shows how the six themes will be integrated across four dimensions.

Enabling infrastructure improvements

Sanitation, including sewer system rehabilitation within the existing urban area, is the issue which needs to be tackled most urgently because sustainable change on the other issues cannot be delivered without it.

Action to address solid waste management so that channels and sewerage infrastructure does not become blocked can be addressed in parallel.

As these two actions take effect for different branches of the network, it will be possible to make sustained progress in rehabilitating channels and tanks. Without separation of sewage, any action will have a limited impact.

As the channels and tank system are restored, it will strengthen drainage systems which will lead to protection from localised flooding during the monsoon, as well as less frequent floods. Action can then shift towards physical interventions to address flood risk along the Vaigai.

Actions to directly address the water resources supply-demand balance in the Vaigai feature lower down the list of priorities. This is because action to address sanitation and sewer system rehabilitation and restoration of green infrastructure corridors will have the effect of increasing the efficiency and effectiveness of water supply and enable the city to improve its resilience by becoming more self sufficient for its water resources needs over time. For example, decentralised water treatment can provide water which can then be reused within the city. Replenishment of tanks by clean groundwater and surface water could enable these to become water resource reservoirs for the city.

Strengthening social capital

While capital improvements will take time to be fully delivered in the city, social capital can be used to initiate action, deliver improvements and change behaviour norms on an ongoing basis across the themes. The action plan proposals identify how community-based organisations and initiatives are an essential part, not only of coping with and managing the issues and gaps, but can complement and work alongside government driven initiatives which are capital intensive in terms of finance.

Policy and regulation improvements

Spanning the six themes are improvements to policy, legal and regulatory mechanisms and systems which are needed to help sustain change and align incentives between different interests within the city. Measures extend from enforcement of development permits through to fines and penalties relating to dumping of waste for example.

Governance and future proofing planning

Governance and institutions to support future proof planning is one thing which can be strengthened immediately. Improvements are a necessary enabling factor to unlock and strengthen infrastructure delivery. The proposed actions extend across governance mechanisms and partnerships for infrastructure coordination and delivery. In addition, a green city plan linking to the CDP/masterplan update which can ensure that appropriate policies and safeguarding are in place to reduce exposure to risk.

Standards, guidelines and funding mechanisms for new development areas are identified which would be effective in ensuring that history is not repeated and that infrastructure can be phased as an integral to development as the city expands.

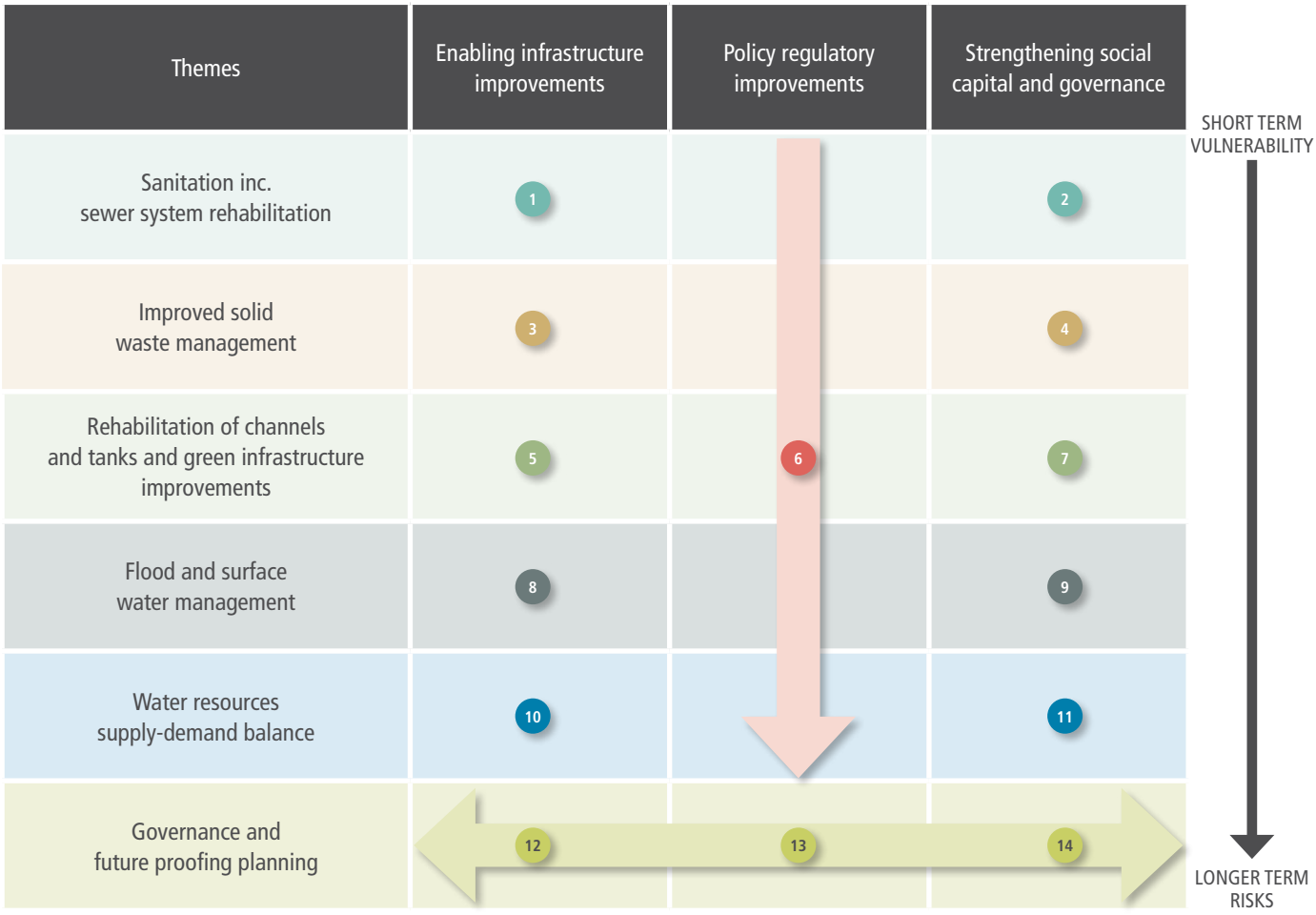


Figure 3.1 - Tackling risk and vulnerability together in Madurai
Tacking risk and vulnerability together in Madurai requires integration action across sectors (see project key on page 32)

Future proofing to 2031

The strategy for future proofing the blue-green infrastructure for Madurai is to build up a programme of projects and actions which reduces vulnerability and address, climate and water security risks, while delivering multiple benefits to the community.

Improving adaptive capacity and focussing on critical system links before addressing slower moving long term risks.

The range of measures in the plan has been viewed over a 17 year period to 2030, which is also closely aligns with the upcoming city development plan for Madurai.

The early years of the action plan to 2020 would be focused on strengthening adaptive capacity and infrastructure deficits of the city, focusing on critical linkages and hotspots which can deliver the most significant immediate benefits. These measures would make an immediate impact to vulnerable communities and in terms of infrastructure provide a necessary foundation for future measures.

From 2020 to 2031, the plan would include a broader range of projects to enable the city to future proof its expansion and to address longer term risks such as climate impacts within the water basin catchment of the city as well as flood risk.

Short, medium and long term actions

The following pages contain the details of the 14 proposed projects. Figure 3.2 shows how the individual future proofing projects build up over time, the dependencies and relationships between individual projects and highlights how social capital building provides a foundation and adaptive capacity needed to deliver more complex infrastructure programmes and initiatives.

Figure 3.2 shows how further studies and data gathering can lead to identification, design and engineering of physical solutions. It can be summarised into five key clusters of actions.

1. **Bottom left** - Social capital building and community led initiatives.
2. **Middle left** - Enabling actions for sanitation, sewer rehabilitation and solid waste management.
3. **Top left** - Enabling actions for channel and tank restoration, flood risk mitigation and water resources management.
4. **Bottom middle** - Government and future proofing planning actions.
5. **Top right** - Implementation of more capital intensive infrastructure improvements.

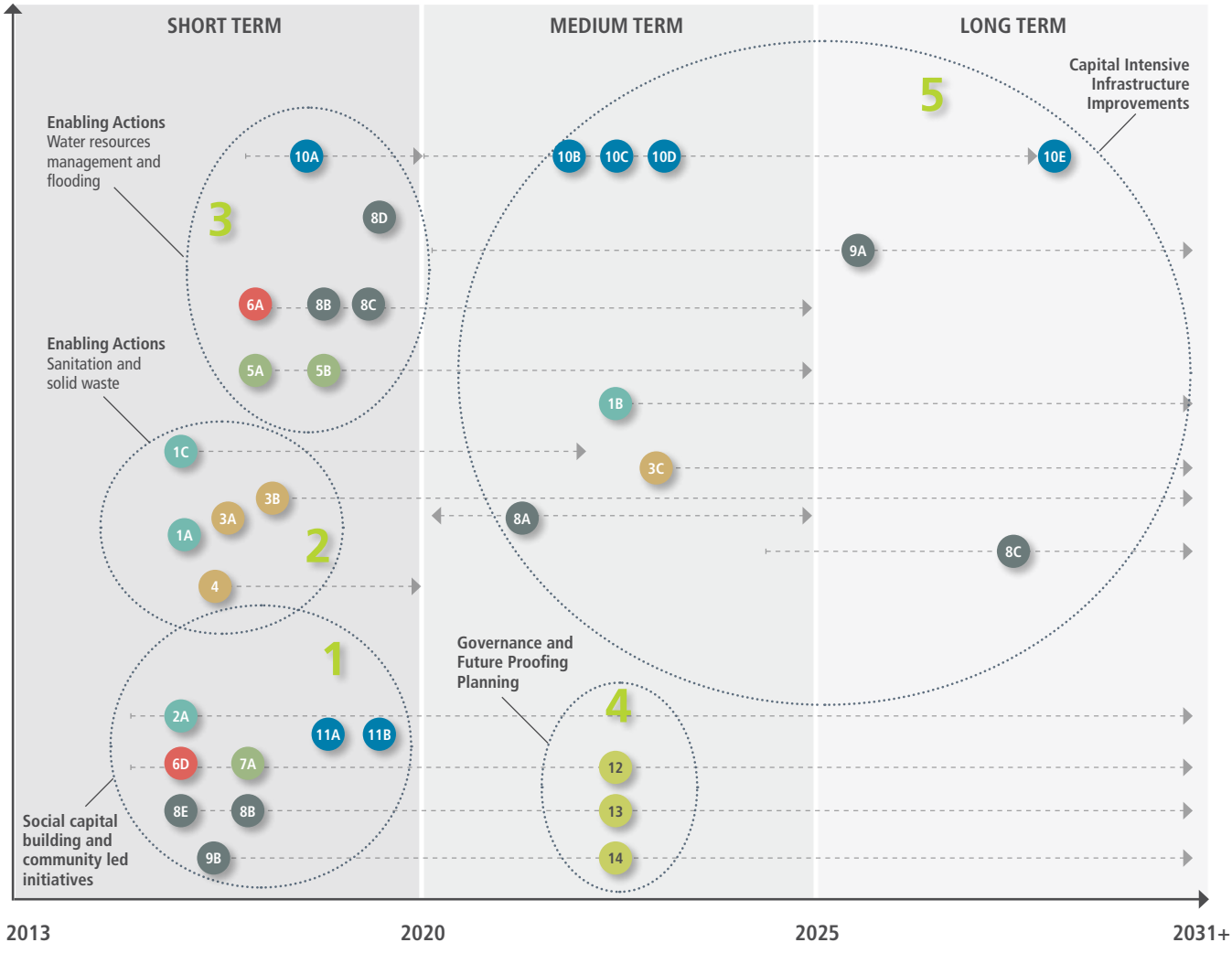


Figure 3.2 - Indicative schedule of actions

How the future proofing projects were selected and developed

The projects in the action plan have been developed through an iterative process of discussions and dialogues on the interventions needed to address the needs and risks facing Madurai city.

Action planning was used to explore, identify, and extend ideas and proposals for future proofing the city. The Kriuthumal corridor case study provided a platform to show how considering the opportunities along a corridor can identify future proofing actions which combine interventions across a range of sectors and in doing so begin to align public, private and civil society stakeholders.

The process was participative and qualitative in nature as limited detailed technical information was available for specific local areas to inform discussions - defining what was needed to address this issue was an important outcome of the process.

This approach to action planning was helpful in both capturing and clarifying the possibilities of what future proofing interventions could be, blending a variety of perspectives based on lived experience within vulnerable communities and slum areas as well as city level civil society, government and technical perspectives.

A key issue which emerged was that gaps can be experienced in the follow through and implementation of projects and programmes. An effective partnership to combine and align financial and no financial resources and capacities in the city was a possible solution to this issue and is likely to be necessary to maximise the outcomes and range of benefits which the action plan could deliver. A draft structure of such a partnership is included in this plan.

Using activities and actions to develop social capital, combined with government driven action was identified as a mechanism to maximise the effectiveness of projects and could increase the support and buy from communities and other stakeholders.

Combining technical knowledge to structure the action plan proposals

A review of the future proofing blue-green infrastructure project from a technical perspective was undertaken in parallel with the community and stakeholders action planning.

The selection and prioritisation of future proofing actions for blue-qgreen infrastructure was not based upon filtering and sorting processes to arrive at a preferred set out measures. Instead, it followed a process of developing an integrated package by combining, linking and sequencing initiatives to address the needs and problems identified by stakeholders.

Benefit / Impact Scorecard

A benefit / impact scorecard was developed to provide a preliminary assessment of how each project would address the range of future proofing dimensions defined as follows.

Climate risk: Initial assessment on whether the measure would be effective in addressing climate risk along one or more dimensions. Effects of increased temperatures, variability in monsoons, extreme precipitation events/flooding; 5 = very high, 4 = high, 3 = medium, 2 = low, 1 = very low / no impact.

Community needs: Initial assessment of how the measure would reduce vulnerability of communities and reduce multidimensional poverty e.g through provision of basic services, health improvements etc.. 1 - 5 scale.

Resource efficiency: Initial assessment of whether the project would address resource efficiency along one or more dimensions water scarcity, food security, natural habitat, 1 - 5 scale.

Prioritisation: An initial assessment was made for the prioritisation which should be given to each policy to help inform the approach to phasing and sequencing within the overall strategy.

The scorecard was used to help inform and develop the programme of actions for blue-green infrastructure improvement which would address climate risks.

At this early stage of planning, there is uncertainty as to the scale of impact and effectiveness of options and whether the financial cost of options would be significantly greater than the averted damage costs from climate change, combined with the wider poverty reduction and co-benefits. While quantification of costs and benefits cannot take place until the action plan proposals have been defined, figure 3.3 (p33) shows the illustrative benefits which the proposed measures may deliver in the context of uncertainty.

'High regrets' options are where the extent of the impact of projects is less certain and/or where the associated socioeconomic co-benefits may be low. 'Low regret' options are those where the likely impact is more certain as the effect of the action is more direct and/or the measure delivers socio-economic co-benefits.

What can be seen is that most of the actions included within the plan are no or low regret options. Many are social capital building or planning related initiatives which build resilience and adaptive capacity.

Figure 3.3 - Maximising impact and value for money (see project key on page 32)

There is a further cluster of actions where the opportunity to avert climate impacts is higher, but where there is greater uncertainty over the effectiveness until feasibility and technical studies to develop and structure the proposals have been completed. In the long term, these could deliver a high impact, however some of the options such as flood storage schemes are potentially high regret options unless it can be proven that the solution would be effective.

As well as addressing climate risk, many of the proposals also have the potential to deliver climate change mitigation benefits as well as addressing climate risks. For example implementation of the sewer rehabilitation project will enable greater use of gravity fed conveyance of effluent and reduce the energy and emissions associated with pumping. Addressing leaks in the water supply network and enabling greater use of local water resources following restoration of tanks could also reduce the energy intensity of water from pumping.

Further definition of many of the actions will be needed following data collection, surveys and technical investigations and feasibility studies will be needed to enable decisions on hard infrastructure to be taken. This will avoid too early selection of options to avoid being locked into a high regret approach.

The approach has enabled the action plan to link across sector boundaries and to consider solutions from the bottom up shaped from discussions of the needs, gaps and opportunities.

Future proofing projects for the blue-green infrastructure of Madurai

1 Project 01: **Sewer system rehabilitation**

RATIONALE:

Outcome: The sewer system is a contained system, collecting all sewer waste and delivering it to the treatment works without contamination of the environment. Future capacity and related infrastructure constraints are understood and considered as part of rehabilitation works; this will also consider the implications of climate change e.g. on capacity.

Proposal: Three sub components are required:

1. a study to better understand the current infrastructure condition and to identify future capacity requirements
2. completion of the sewer infrastructure
3. building of improved toilets to avoid water pollution and to minimise health risks

Issues addressed: Pollution of watercourses including River Vaigai, health risks, under-utilisation of treatment works and outputs.

KEY ACTIONS:

- Better understand the current infrastructure condition and future capacity requirements and constraints through mapping and analysis.
- Complete the sewer infrastructure.
- Build community toilets to serve slum communities and ensure these are resilient and serviced.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
1A **Mapping of sewer system.** To include location, capacity and condition. Perhaps involving CCTV survey with findings integrated in a GIS. To include understanding of relationship with groundwater levels and potential for infiltration and exfiltration. To review chemical dosing requirements to avoid septicity problems. Also to identify future foul capacity requirements and constraints, considering population growth, land use change and climate change. Consideration should be given to the potential benefits of decentralised treatment.	Up to US$1m	**5** **Comment:** risks can be incorporated in study. **4** **Comment:** in particular it will improve health outcomes, in conjunction with community capacity building (Project 2). **4** **Comment:** can be built into study outcomes. **5** **Comment:** will provide evidence to underpin sewer improvements.	▪ Corporation-led study - could be undertaken by Technical College of Engineering ▪ Delivery issue will require significant primary data collection (this could be prioritised) ▪ Could benefit from some international technical assistance e.g. leak detection ▪ Could be financed via IFI technical assistance.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
1B **Completion of the sewerage infrastructure.** This will include ensuring sewers are connected and are securely closed (including wider sewer infrastructure, such as collection chambers, and to avoid easy access); that pumping stations are functioning, thus ensuring delivery of sewerage to the treatment works (not via watercourses); that there is system resilience (e.g. to enable continued pumping in power outages).	Up to US$100m	**5** **Comment:** will prevent ingress of storm water; risks can be incorporated in design. **5** **Comment:** in particular it will improve health outcomes and avoid expenditure on medical treatment. **3** **Comment:** there will be a need for physical infrastructure including likely to be concrete. **5** **Comment:** early win.	▪ Corporation-led via DPR ▪ Delivery issues; potentially significant construction required ▪ Capacity building required to ensure sewers are connected ▪ Possibility of a loan but to ensure use of system a direct charge is not preferable.  Figure 3.4 - Sewer system rehabilitation
1C **Building of improved toilets, including community toilets in slum areas.** Three improvements are recommended: conversion of dry latrines into water seal toilets; construction of new latrines with super structures; and proper sewage facilities for the disposal of excreta. It is important the toilets are resilient to extreme weather, in particular flooding.	Up to US$1m	**4** **Comment:** will prevent contamination of water possible with other sanitation practices; resilience can be built into design. **5** **Comment:** in particular will improve health outcomes and avoid expenditure on medical treatment. **4** **Comment:** construction required, but choice over materials. **5** **Comment:** early win.	▪ Awareness raising and buy-in is an important first step ▪ It is important that users in the community and particularly women are involved in the design of the toilets. The design must be in keeping with the local cultural practises e.g. regarding anal cleansing. There should also be a private space or a toilet with a wash basin in it for menstrual hygiene. The location of toilets should allow rapid, safe and secure access at all times, day and night ▪ The management arrangements are very important. Toilets should be cleaned and secure, especially at night. There are good examples of successful community toilets including those which do and do not charge ▪ Would need to link to community capacity building on sanitation (see Project 2A) ▪ There will be challenges associated with community participation and adequate space for construction. ▪ Could attract grant financing from e.g. the Corporation / philanthropists / commercial banks, to fund construction; maintenance can be funded via user charging or ongoing institutional or community investment.

Climate risk | Community needs | Resource efficiency | Prioritisation

2 Project 02: **Sanitation community capacity building**

RATIONALE:

Outcome: The whole population of Madurai understands the benefits of sanitation and makes use of toilets (private or community).

Proposal: To support the use of toilets including community toilets (see Project 1), this project will deliver capacity building for communities that have existing or new toilets.

Issues addressed: Pollution of local watercourses; health risks, poverty (reduced income spent on health services).

KEY ACTIONS:

- Build capacity to maximise use of existing and new community toilets.
- Build capacity to ensure toilets are adequately serviced.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
2A **Community capacity building**. This is likely to involve the following steps: • rapid consultation with the affected population on safe excreta disposal and hygienic practices • concerted hygiene promotion campaign • consult and secure the approval of all users (especially women and people with limited mobility) on the siting, design and appropriateness of sanitation facilities (linking to Project 1C) • provide the means, tools and materials to construct, maintain and clean toilet facilities • provide an adequate supply of water for hand washing and for toilets with flush and/or hygienic seal mechanisms.	Up to US $1m	**4** **Comment:** will prevent contamination of water enabling effective protection of water resources . **5** **Comment:** in particular it will improve health outcomes and reduce vulnerability to climate hazards. **5** **Comment:** low resource implications. **5** **Comment:** early win; ongoing initiative.  **Figure 3.5 - Waste water from the channels being used for livelihood activities and household uses. Kiruthumal at Melevasal.**	This project could be delivered by local NGO Partners (such as Dhan Foundation). There would be a need for several strands: ▪ **Stakeholder awareness raising:** regular awareness building programmes and interaction meetings conducted at different levels of each institution ▪ **Community mobilisation:** implemented through people institutions where poor people have a stake and ownership ▪ **People institutional leaders training:** capacity would be built to facilitate the progress and monitoring of projects at community level and ensure to sustain the project even after funding ▪ **Health / hygiene / environmental education:** behavioural change communication through materials such as flash cards, flip charts, posters, pamphlets; cultural campaign would be prime focus for disseminating messages among the public using street theatres and exhibition booths; demonstration units on model toilets, water harvesting structures, water filters, tap connections; individual counselling for selected target audience on installation and connections ▪ **Community / client training:** client training will be conducted with each client/client family and will be focussed on financial aspects; water, sanitation and hygiene (WASH) training will be conducted among target households to disseminate WASH related issues and its implications, precautions to avoid the implications and solutions ▪ **Government engagement:** e.g. via total sanitation campaign programme. Could attract grant financing via government subsidy or international donors.

Climate risk | Community needs | Resource efficiency | Prioritisation

3 Project 03: **Improved solid waste management**

RATIONALE:

Outcome: Improved solid waste management in Madurai would mean that channels and tanks within the city would not become blocked reducing the impact of flooding events. Effective solid waste management would also reduce pollution and contamination of surface and ground water resources. Utilisation of water resources from within the city boundary will increase the resilience of the city to droughts enhancing food security through enhancing the resilience of the urban agriculture sector, as well as safeguarding surface and groundwater resources. The development of an anaerobic digestion facility would provide a means to recycle waste in the city and reduce the proportion of waste going to landfill. As well as providing a source of clean energy.

Proposals: The solid waste infrastructure of the city would be extended and enhanced to complement the existing landfill facility in operation. The measures would encompass
1) a comprehensive system of primary and secondary waste collection;
2) Development of an Anaerobic Digestion facility for managing organic waste;
3) Development of a recycling facility.

Issues addressed: Increased community outreach and collaboration and improvements in sanitation through reduction of wild dumping and informal scavenging. Production of renewable energy from organic waste and compliance with MSW 2000 Handling Regs.

KEY ACTIONS:

- Waste Collection.
- Anaerobic Digester.
- Recycling Infrastructure.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
3A **Introduce PPP approach** for both primary and secondary waste collection: ▪ understand who and how the collection system can be improved ▪ encourage collaboration between the private and informal sectors ▪ undertake extensive outreach program to share mission and goals of the programme and interact with community awareness and IWMP development ▪ develop mechanism for funding the system (and agree service fee, etc).	Up to US $500k	**4** **Comment:** Improved solid waste management in Madurai would mean that channels and tanks within the city would not become blocked reducing the impact of flooding events. Effective solid waste management would also reduce pollution and contamination of surface and ground water resources. Establishment of an Anaerobic Digestion facility would help mitigate climate risk and provide a source of renewable energy. **3** **Comment:** Provides an increased level of service and engages community and private sector. Improves sanitation and flood and surface water management ability. **4** **Comment:** rehabilitation of channels could conserve water resources. **5** **Comment:** Early win.	Madurai Corporation have prepared a Draft Detailed Project report which would be updated and resubmitted to the State level agencies with a view to securing National Urban Renewal Mission (NURM) Funds: ▪ letting of a concession to the private sector to undertake waste collection services ▪ concession supported by a service fee payable by the Corporation ▪ Potential for IFI funding to support the Corporation in finding the capital for a service fee ▪ the service fee needs to be set at an affordable level (~$5-8 per tonne) ▪ opportunity for private sector to collaborate with informal sector ▪ would enable wide spread source segregation to be implemented.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
3B Development of anaerobic digestion facility for managing organic waste: ▪ determine whether plant should co-digest waste and sewage sludge - size appropriately ▪ identify land/ site ▪ develop mechanism for implementing source segregation of organic waste (through waste collection) ▪ develop mechanism for developing AD facility (PPP, funding, grants or direct by Corporation) and identify opportunities/ impacts of CDM ▪ develop the facility and secure end markets are available - for electricity and for digestate on agricultural land.	$5-10m	4 **Comment:** Can generate renewable energy as well as producing usable fertilizer for agriculture Reduces methane production in the landfill. 3 **Comment:** Meets requirements of MSW 2000 Regs and diverts organic waste from landfill Will enable targeted implementation of IWMP and community awareness and education. 4 **Comment:** Improves energy resilience and use of biofuels - possible to co-digest with sewage sludge. Opportunity for CDM. 3 **Comment:** project.	Madurai Corporation have prepared a Draft Detailed Project report which would be updated and resubmitted to the State level agencies with a view to securing National Urban Renewal Mission (NURM) Funds: ▪ letting of a concession to the private sector to develop a facility on a long term concession ▪ loncession supported by a service/ gate fee payable by the Corporation ▪ potential for IFI funding to support the Corporation in finding the capital for a service/ gate fee ▪ the service fee needs to be set at an affordable level (~$15-20 per tonne) ▪ opportunity for revenue to offset the service/ gate fee from sale of electricity and digestate to agriculture and CDM credits.
3C Developing basic recycling infrastructure. Construction of a simple recycling facility at the landfill/ extension of a transfer station to enable informal sector to recycle safely: ▪ determine level of investment and secure funding (IFI, grant, PPP or direct by Corporation) ▪ identify land/site ▪ engage with informal sector and CBOs.	Up to $1m	3 **Comment:** Contributes to renewable energy 2 **Comment:** Will enable integration of CBOs and community into the waste management sector. 4 **Comment:** Reduced resource depletion and improved sanitation. 5 **Comment:** Early win - but need to make sure that markets for recyclate are available and established.	Madurai Corporation have prepared a Draft Detailed Project report which would be updated and resubmitted to the State level agencies with a view to securing National Urban Renewal Mission (NURM) Funds: ▪ development of formalised recycling infrastructure (e.g. reprocessing facility, picking line and area of hardstanding for safe storage) ▪ could be funded through IFI grants or loans or through private sector partnership.

Climate risk | Community needs | Resource efficiency | Prioritisation

4 Project 04: Straightening social capital to improve sanitation and and solid waste management

RATIONALE:

Outcome: Strengthening social capital and governance to improve sanitation and solid waste management across the city.

Proposal: Increased governance and awareness of solid waste management activities.

Issues addressed: Improved data collection to improve understanding of waste management and to facilitate development of a city-wide integrated waste management plan. Engagement with community at various levels.

The project would run in parallel with project 3.

KEY ACTIONS:

- Waste data collection
- Community awareness and education
- Formalising the informal
- Integrated waste management plan

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
4A **Waste data collection** to improve understanding of key waste generators, waste types being produced and how and who is managing it: ▪ undertake data gap analysis ▪ collate data on software ▪ liaison between CBOs and private sector.	> US $250k	**3** **Comment:** Improved solid waste management in Madurai would mean that channels and tanks within the city would not become blocked reducing the impact of flooding events. Effective solid waste management would also reduce pollution and contamination of surface and ground water resources. **4** **Comment:** Will enable targeted implementation of IWMP and community awareness and education. **4** **Comment:** Will enable more effective management of waste. **4** **Comment:** Ongoing initiative.	This initiative would be taken forward by Madurai City Corporation but delivered as a partnership with Community based organisations in the city to scale existing practices: ▪ Implementation of periodic auditing system of waste management in the City ▪ Development of simple waste software to update, store, track, review waste data - could incorporate some element of GIS to enable spatial planning for waste infrastructure and best identify needs ▪ Needs to be an ongoing process that links directly with policy/ strategy formulation and infrastructure needs.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
4B **Community awareness and education especially in slum areas** to provide a forum for educating the public on key problem areas to improve awareness and participation: ▪ identify key stakeholders/ communities ▪ prioritise campaigns and align with IWMP ▪ target schools and community groups.	< US $100k annually	3 **Comment:** Improved solid waste management in Madurai would mean that channels and tanks within the city would not become blocked reducing the impact of flooding events. Effective solid waste management would also reduce pollution and contamination of surface and ground water resources. 5 **Comment:** Will enable targeted implementation of IWMP and community awareness and education. 4 **Comment:** The initiative would lead to more effective management of waste streams in the city through increased rates of recycling. 4 **Comment:** Ongoing initiative.	It would follow on from the development of an IWMP and would focus on two specific issues/ subjects each year. Close liaison and integration with CBOs and schools will help to ensure targeted audiences.
4C **Formalising the informal** - integrating the role of the informal sector into the Corporation's strategy. Encouraging Community Based Organisations to form operational partnerships with private waste collectors ▪ Identifying roles in line with IWMP ▪ Maintain dialogue and interaction ▪ Maintaining employment.	>US $100k annually	4 **Comment:** This measure builds climate resilience. The coordination and integration of solid waste management activities between Madurai Corporation, the informal sector and private organisations would enable reduction of dumping of solid waste in the surface water and drainage systems of the city. Channels and tanks within the city would not become blocked reducing the impact of flooding events. Effective solid waste management would also reduce pollution and contamination of surface and ground water resources. 3 **Comment:** Provides an increased level of service and engages community and private sector. Improves sanitation and flood and surface water management ability. 3 **Comment:** Can assist in achieving higher recycling rates if informal sector allowed to formally pick from waste at source. 4 **Comment:** Potentially Early win but requires ongoing Initiative	This initiative would be taken forward by Madurai City Corporation but delivered as a partnership with Community based organisations in the city to scale existing practices: ▪ in support of the introduction of PPP into waste collection effort needs to be made to maintain dialogue and integration between the informal sector and private contractors.  **Figure 3.6 - Kiruthumal River near Kaja Theru filled with solid waste.**

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
4D **Development of an integrated waste management plan (IWMP) for the city:** ▪ identify key goals and outcomes for the plan ▪ collate, review existing data, policies, current practices and undertake gap analysis ▪ link existing views and objectives together to provide a clear way forward ▪ engage with other departments within the Corporation and wider stakeholders.	> US $500k initial set up and development Ongoing internal annual costs	**3** **Comment:** This measure would contribute to climate mitigation. Managing waste flows and enhancing re-use and recycling would reduce the proportion of waste going to landfill and embodied energy in materials used in the city. The plan includes a proposed waste management centre and energy recovery facility which would provide a renewable source of energy which would displace fossil fuels. **4** **Comment:** Will enable targeted implementation of IWMP and community awareness and education. Enables identification of goals and objectives for the city. Facilitates spatial planning of waste management infrastructure and to help with sanitation improvements and improved sustainability. **4** **Comment:** Reduction of wild dumping and clogging of water course will help to conserve water. **3** **Comment:** Ongoing but important in facilitating delivery of common vision.	This initiative would be led by Madurai City Corporation. It: ▪ would formalise a clear and integrated approach linking waste initiatives and policies to infrastructure ▪ could be developed by a consultant with ongoing monitoring and review undertaken in house by Corporation staff ▪ would require agreement across all departments within the Corporation.

Climate risk | Community needs | Resource efficiency | Prioritisation

5 Project 05: **Channel and tank restoration**

RATIONALE:

Outcome: The channels and tanks are restored to in order to function more naturally, thus providing a number of supporting services to the city. Restoration of channels and tanks addresses drought and water scarcity risk the most significant climate risk to the city through enabling Madurai to utilise its surface and ground water resources more effectively as a source of supply. Pollution and lack of infrastructure prevent this happening at present. The project would also mitigate the issue of flooding from surface water run-off which occurs every one-three years in certain parts of the city (see diagnostic).

Proposal: This project contains two sub components. Firstly, a mapping exercise will be undertaken to provide a common understanding of the interaction of the channels and tanks. Secondly, a programme of restoration will be designed and implemented in order to maximise the supporting services.

Issues addressed: Pollution of watercourses; water resource deficits; groundwater recharge; flood risk; health risks; opportunities for local agriculture; under-utilisation of treatment works; provision of high quality open green space.

KEY ACTIONS:

- Map and document a common understanding of the operation of the tanks and channels.
- Restore the tanks and channels, taking into account operational practice and climate change impacts.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
5A **Further mapping of channel and tank system, and improved understanding of interactions and operations.** This should include community participation including community mapping. Mapping to include channel boundaries and catchment, and to extend beyond former Corporation boundary. Also to include documentation of flow sources, flow paths, water uses, existing operational rules and practices. This should include identifying users and tanks status (usufruct or privately owned). Study to examine implications of climate change for flows and ecology.	US $1-5m	**4** **Comment:** The mapping exercise would quantify the benefits and technical feasibility of the channel and tank restoration and quantify the potential role the system could play in addressing water scarcity and drought risks to the city as well as mitigating the risks associated with flooding from surface water run-off. **4** **Comment:** Water scarcity, ground water depletion and lack of 24/7 supply which this project would help to address is an issue which effects all communities. Communities who experience flooding from surface water run off would no longer incur the losses involved with flood events. **5** **Comment:** This project contributes to water resources management and efficiency. **5** **Comment:** This will provide evidence to underpin restoration.	▪ Corporation to initiate mapping study; could be undertaken by Technical College of Engineering and should involve communities. ▪ Corporation to initiate climate change study ▪ Delivery issues: System is complex and extends beyond former Corporation boundary. May require significant primary data collection e.g. flow monitoring. ▪ Could benefit from some international technical assistance e.g. climate change study. ▪ Could be supported via IFI technical assistance.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
5B **Restoration of channels and tanks, especially south of the River Vaigai.** To include: source protection and connection (e.g. from River Vaigai); establishment of appropriate bed gradients (that maintain flow) and bed and bank materials. To incorporate potential climate impacts.	US $10-100m	**5** **Comment:** The mapping exercise would quantify the benefits and technical feasibility of the channel and tank restoration and quantify the potential role the system could play in addressing water scarcity and drought risks to the city as well as mitigating the risks associated with flooding from surface water run-off. **5** **Comment:** Water scarcity, ground water depletion and lack of 24/7 supply which this project would help to address is an issue which effects all communities. Communities who experience flooding from surface water run off would no longer incur the losses involved with flood events. **4** **Comment:** This project contributes to water resources management and efficiency. **5** **Comment:** Ongoing initiative.	▪ Corporation to set up multi-stakeholder programme led by new programme board. Will need to initiate technical studies, engineering reviews and to gain support of communities for delivery and legacy. ▪ Phased approach required, focused first on areas of high vulnerability and more generally upstream. Delivery issues: ▪ May require land/channel remediation and reversal of previous engineering works. ▪ Requires technical and community capacity building (see Projects 6 and 7 respectively). ▪ Finance through DPR; possibility of external grant or IFI support.

Climate risk | Community needs | Resource efficiency | Prioritisation

6 Project 06: **Channel and tank protection and management**

RATIONALE:

Outcome: The restored channels and tanks are actively managed and protected from future deterioration.

Proposal: This project contains four sub components:
(1) Establishment of operational rules to regulate abstraction and use of water from channels and tanks for irrigation, commercial and domestic use to effectively manage the water balance. Regulation of discharges to improve water quality and control pollution;
(2) Abstraction management;
(3) Discharge regulation and management;
(4) Encroachment management.

Issues addressed: Pollution of watercourses including River Vaigai; water resource deficits; health risks; opportunities for local agriculture; under-utilisation of treatment works; provision of high quality open green space.

KEY ACTIONS:

- Establish or refine operational rules.
- Manage abstraction through enforcement of appropriate existing allocation rules and further regulation.
- Regulate and manage discharges.
- Limit encroachment.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
6A **Establishment or refinement of operational rules to regulate abstraction and use of water from channels and tanks for irrigation, commercial and domestic use to effectively manage the water balance.** Regulation of discharges to improve water quality and control pollution. This would build on Project 5 (especially sub component A) and cover: channel inputs from upstream tanks and the Vaigai; connections and flows between tanks and channels; potential for / ability of groundwater recharge from tanks and channels (Thengal and Vandiyur tanks as possible recharge structures). This will link closely with sub components B and C, so that water balances can be established.	$1-10m	**4** **Comment:** climate risks cannot be thoroughly evaluated without this. **4** **Comment:** will help establish allocation rules and will improve water quality and flood risk. **5** **Comment:** requires few physical resources. **5** **Comment:** early win to underpin sub components B and C.	▪ Corporation Public Works Dept (PWD) to initiate study to answer technical questions; could be undertaken by Technical College of Engineering ▪ PWD to set up new programme board, which should include multi-stakeholder committee to agree and oversee operational rules (including abstraction and discharges - see sub components B and C). Delivery issues: ▪ Refinement of operational rules is likely to be complex, especially given recent drought. ▪ Could benefit from some international technical assistance e.g. leak detection. ▪ Study could be financed via IFI technical assistance.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
6B **Abstraction management.** Enforcement of existing allocation rules where appropriate. Consideration of how best to manage abstraction to protect water quality and quantity e.g. limits to well depths.	US $1-10m	**4** **Comment:** climate risks cannot be managed without this. **5** **Comment:** will improve water quality and allocation. **5** **Comment:** requires few physical resources. **4** **Comment:** ongoing initiative.	▪ New operational committee to re-evaluate existing allocation rules in light of operational rules and water availability. ▪ New operational committee to consider which types of abstraction could be regulated e.g. large industrial abstractors, and to implement related decisions e.g. through licensing and monitoring. ▪ Delivery issues: Refinement of allocation rules is complex, especially given recent drought events. ▪ Could be financed via IFI technical assistance.
6C **Discharge regulation and management, to prevent discharge of sewerage and industrial effluent into channels and tanks.** Planning permission and issue of building permits should be dependent on the quality of proposed waste water / effluent disposal, which may require on-site treatment. Consideration of regulatory requirements, with a focus on key sites / types of discharge.	US $1-10m	**4** **Comment:** climate risks will be harder to be managed without this. **5** **Comment:** will improve water quality and reduce health risks. **4** **Comment:** May require further treatment, but environment will benefit. **5** **Comment:** ongoing initiative.	▪ Corporation PWD to alter rules associated with planning permission and building permits. ▪ New operational committee to introduce / implement discharge regulation for particular sites. ▪ Industry etc to consider need for additional treatment. ▪ Delivery issues: Further treatment likely. Enforcement can be complicated. ▪ Capacity building required to ensure sewers are connected and that industrial plant owners are aware of their responsibilities and potential solutions. ▪ Could be supported by IFI technical assistance. Possible IFI loans to improve industrial processes.
6D **Encroachment management.** To include protection of channels and tanks from alterations to natural boundaries, including damage via animals (e.g. bank erosion) and temporary or permanent settlement or development. This might require a combination of measures: land-use policies; realistic alternatives for people using these areas; capacity building to improve understanding of the importance of protection; and physical protection measures.	US $1-10m	**4** **Comment:** avoids exacerbating climate risks. **4** **Comment:** will help protect watercourses but land-use alternatives required. **3** **Comment:** Some physical measures required. **4** **Comment:** ongoing initiative.	▪ New programme board to work with planners, slum clearance board and community organisations. ▪ Delivery issues: Need to provide realistic alternatives for people using these areas. ▪ Capacity building required to ensure protection occurs. ▪ Possibility of IFI technical assistance.

Climate risk | Community needs | Resource efficiency | Prioritisation

7 Project 07: **Channel and tank community involvement**

RATIONALE:

Outcome: The community is fully engaged in the protection of channels and tanks and benefits from them for local water supply, amenity and tourism Enhancing community awareness was highlighted as a key component of addressing climate risks at a practical level and to enhance the sustainability and effectiveness of other projects within the action plan.

Proposal: A continuing programme of engagement, involving residents, school children, professionals and tourists.

Issues addressed: Pollution of watercourses including River Vaigai; water resource deficits; health risks; opportunities for local agriculture; under-utilisation of treatment works; provision of high quality open green space.

KEY ACTIONS:

- Invoke a set of programmes to engage school children, residents and tourists.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
7A **Community involvement** will be achieved through: ▪ mass awareness campaign through radio programmes, newspapers, and internet; ▪ school campaigns through raising understanding about the immediate environments including the tanks, channels and rivers; ▪ training programmes (separate) for volunteers, professionals and cultural enthusiasts.	Up to US $250k	**4** **Comment:** Builds adaptive capacity. Enhancing community awareness was highlighted as a key component of addressing climate risks at a practical level and to enhance the sustainability and effectiveness of other projects within the action plan. **5** **Comment:** Community involvement is the purpose of the project **5** **Comment:** requires few physical resources **5** **Comment:** ongoing initiative	▪ As the channels and tanks are so interlinked with each other across the city it is desirable to deal with all places at the same time. A management structure will required including Government bodies, private organisations and civil society organisations. Implementation will be supported via various fora. ▪ Delivery issues: ▪ will need to be coupled with regulation (and enforcement) and practical alternatives to current (mis-)uses of tanks and channels (e.g. adequate waste disposal facilities). ▪ Could be financed from within the community and CSR initiatives.  **Figure 3.7 - Waste water blocked and stored in the water channel to pump out for vegetable cultivation. Kiruthumal river at Thanathavam.**

Climate risk | Community needs | Resource efficiency | Prioritisation

8 Project 08: **Flood & surface water infrastructure improvements**

RATIONALE:

Outcome: Existing & future risks of flooding from rivers and surface water is reduced, particularly in the most vulnerable areas.

Proposal: Several sub components are included:
(A) Separation of sewers and storm drains;
(B) Construction of adequate surface drainage;
(C) Flood storage;
(D) Flood defences;
(E) Green infrastructure improvements.

Issues addressed: Pollution of watercourses including River Vaigai; water resource deficits; flood risk; health risks; provision of high quality open green space.

KEY ACTIONS:

- Separate sewers and storm drains.
- Construct adequate surface drainage, taking into account downstream requirements.
- Assess and potentially add flood storage upstream and within Madurai.
- Implement flood defences for vulnerable areas.
- Designate and protect areas around water bodies.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
8A **Separation of sewers and storm drains.** This will avoid pollution of watercourses and ensure that treatment works are not dealing with excessive loads	US $1-10m	**4** **Comment:** Improves resilience to climate risks. Addresses drought and water scarcity risk the most significant climate risk to the city through enabling Madurai to utilise its surface and ground water resources more effectively as a source of supply. Separation of waste water flows into a piped network will avoid pollution of the groundwater and enable the surface water system to be effective during storm events reducing the risk of flooding. **5** **Comment:** will reduce flood risk and improve water quality, reducing disease. **3** **Comment:** This project contributes to water resources management and efficiency. **4** **Comment:** Ongoing initiative.	▪ Corporation to undertake study to identify locations of combined or mis-connected systems; then to implement phased construction programme involving new channel and tank programme board. Delivery issues: ▪ Identifying combined drains and engineering separation complex where many connections. Also will require ongoing enforcement. ▪ Capacity building required to help identify locations and to ensure continued separation. ▪ Study could be financed via NURM / IFI technical assistance. Works financed via DPR.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
8B **Construction of adequate surface drainage.** There is an ongoing programme of works to install additional drainage infrastructure under highways across the city. This will need to be extended to cover the 100 ward boundary of the city and integrated into the construction of new roads. Also there is a need to ensure that downstream infrastructure is appropriate and adequate e.g. suitability of discharges to channels and storage in tanks (including recharge structures).	US $10-50m	**4** **Comment:** Improves resilience to climate risks. Addresses drought and water scarcity risk the most significant climate risk to the city through enabling Madurai to utilise its surface and ground water resources more effectively as a source of supply. Separation of waste water flows into a piped network will avoid pollution of the groundwater and enable the surface water system to be effective during storm events reducing the risk of flooding. **4** **Comment:** Reduced flood risk and losses. **4** **Comment:** This project contributes to water resources management and efficiency. **4** **Comment:** Ongoing initiative.	▪ Corporate to lead, linked to committee overseeing management of channels and tanks (e.g. relating to discharge regulation). ▪ Study to consider downstream infrastructure adequacy. ▪ Study could be financed via NURM / IFI technical assistance. Works financed via DPR.
C. **Flood storage.** 8C Consideration and possible implementation of flood storage upstream of Madurai and within Madurai e.g. use of Vaigai and channel floodplains and tanks.	US $10-50m	**4** **Comment:** Improves resilience to climate risks. Addresses drought and water scarcity risk the most significant climate risk to the city through enabling Madurai to utilise its surface and ground water resources more effectively as a source of supply. Separation of waste water flows into a piped network will avoid pollution of the groundwater and enable the surface water system to be effective during storm events reducing the risk of flooding. **4** **Comment:** reduced flood risk and disruption. **3-4** **Comment:** Integration of flood defences and storage will not have a significant direct effect on water or food security. Flood storage could contribute to groundwater recharge. Indirectly the financial resources used by the Corporation and the community to address flood events could now be used for other purposes. **3** **Comment:** project	▪ Corporation to initiate study; could be undertaken by Technical College of Engineering. Then to work with committee overseeing management of channels and tanks on possible implementation within Madurai; Tamil Nadu state upstream of Madurai. Delivery issues: ▪ Will need to integrate with operation of channels and tanks; health risks from stagnant water will need to be assessed. ▪ Study could be financed via IFI technical assistance. Works financed via DPR.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
8D **Flood defences.** Evaluation and implementation of flood defences to protect vulnerable areas (e.g. Periyar Bus Stand Area, Railway Colony, and the area close to Madurai Coats on the northern bank of the Vaigai River); this also needs to consider groundwater levels / flooding.	US $10-50m	**4** **Comment:** Improves resilience to climate risks. Addresses drought and water scarcity risk the most significant climate risk to the city through enabling Madurai to utilise its surface and ground water resources more effectively as a source of supply. Separation of waste water flows into a piped network will avoid pollution of the groundwater and enable the surface water system to be effective during storm events reducing the risk of flooding. **5** **Comment:** reduced flood risk, health risk and disruption. **3** **Comment:** Integration of flood defences and storage will not have a significant direct effect on water or food security. Flood storage could contribute to groundwater recharge. Indirectly the financial resources used by the Corporation and the community to address flood events could now be used for other purposes. **4** **Comment:** Ongoing initiative.	▪ Corporation to initiate study; could be undertaken by Technical College of Engineering. Then to work with committee overseeing management of channels and tanks on possible implementation within Madurai; Tamil Nadu state upstream of Madurai. Delivery issues: ▪ Needs to consider objectives associated with improving channels and tanks for water quality and resource purposes. The geomorphology of the River Vaigai and channels needs to be considered e.g. need for de-silting and role of sand mining. ▪ Study could be financed via IFI technical assistance. Works financed via DPR.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
8E **Green infrastructure improvements.** Establishing new publicly accessible spaces for recreation and biodiversity linked with components D-E above as well as in flood risk areas which are protected from development. These would be designed to align with natural processes following a Sustainable Urban Drainage Systems (SUDS) approach. The spaces would include tree planting and vegetation to support flood mitigation and provide usable spaces for informal recreation. Spaces would also provide shade mitigating the impact of the urban heat island effect addressing climate risks relating to extreme heat events. Key projects include Vaigai linear park, channel and tank side spaces and community pocket parks.	US $1-10m	4 **Comment:** Improves resilience to climate risks. By incorporating sustainable drainage enables addresses drought and water scarcity risk. Establishing publicly accessible areas green space within areas the most significant climate risk to the city through enabling Madurai to utilise its surface and ground water resources more effectively as a source of supply. Establishing a formal recreation use for flood safeguarding areas will prevent encroachment and provide a sustainable use when not required for flood storage. 5 **Comment:** Madurai is a densely developed city with a lack of urban greenspace. Provision of space will provide an amenity and recreation resources providing a health and quality of life benefits to the community. Green spaces will also enhance the attractiveness and image of the city which could help strengthen Madurai's role as a tourism centre. 4 **Comment:** Designation and provision of greenspace will help to conserve and enhance natural habitat and biodiversity especially within wetland areas which are recognised of being of national importance (refer to diagnostic). 4 **Comment:** Phased improvements linked with projects B-D above.	▪ A network of public space provision would be defined as part of Project 13. ▪ The Corporation would be responsible for mobilising land for use as publicly accessible. The land could remain in private ownership with access rights or be formally acquired. ▪ Improvements would be delivered as an integral component of channel and tank restoration and flood and surface water management projects. ▪ Improvements could be financed from Corporation resources, State- national funding. Philanthropic and CSR funds could also be utilised. ▪ The Corporation public works department would coordinate and oversee works. However civil society and community could play a role in helping to establish spaces as well as well as ongoing management and maintenance.

Climate risk | Community needs | Resource efficiency | Prioritisation

9 Project 09: **Flood & surface water capacity building**

RATIONALE:

Outcome: A greater understanding by land managers on ways to minimise runoff and by those vulnerable to flooding on how to manage flood risk.

Proposal: This will involve two sub components (A) Rural soil erosion management, upstream of Madurai (B) Flood risk awareness-raising, particularly in the vulnerable slum communities.

Issues addressed: Flood risk; pollution of watercourses; health risks.

KEY ACTIONS:

- Manage soil erosion in the upstream Vaigai catchment.
- Increase flood risk awareness, especially in the slum communities.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
9A **Rural soil erosion management.** Promotion of land use and management practices that reduce runoff and conserve soil and nutrients. Examples include contour ploughing, buffer strips near watercourses, afforestation.	Up to US $1m	**4** **Comment:** Improved agricultural management practices will reduce runoff and conserve soil nutrients during storm events. This will serve to lessen the effect of storm events and run off into the Vaigai and its tributaries reducing flood risk to Madurai and other communities along its banks. Improved soil management would improve resilience of agriculture and food provisioning systems which is of benefit to producers as well as end consumers including those in Madurai. Climate variability is expected to lead to place additional pressures on agriculture in the Vaigai basin. In additional storm and flood events are expected to be more frequent. **4** **Comment:** reduces water pollution and flood risk. **4** **Comment:** requires inputs but benefits may be larger e.g. reduced need for fertilisers, water; carbon sinks. **4** **Comment:** ongoing initiative.	▪ The geographic focus of action would be focused outside of the Madurai Corporation boundary in rural areas. ▪ Action would be co-ordinated by the Tamil Nadu Water Supply and Drainage Board (TWAD) and form part of their wider programme to manage water resources and flooding within the Vaigai basin. ▪ Action would be funded by a combination of State level grants. There could also be potential for linking with water resources catchment management programmes. Several in Tamil Nadu have been developed in co-operation with the Asian Development Bank.

Climate risk | Community needs | Resource efficiency | Prioritisation

9B **Flood risk awareness.** Improvements to awareness of slum communities regarding flood risk and what actions can be taken before, during and after an event to reduce risks.	Up to US $500k - US $1m	**4** **Comment:** Builds adaptive capacity and resilience to flood events which are expected to increase in scale and frequency as a result of increased climate variability. **5** **Comment:** Reduces flood and health risks **5** **Comment:** Requires few physical resources **5** **Comment:** Ongoing initiative	▪ These would be linked to the current UNISDR programme in Madurai linked to Disaster Risk Reduction and disaster management. ▪ Madurai Corporation would play a coordinating role. However, programmes would need to be delivered within the Wards identified as being at particular risk. ▪ Community based organisations could be delivery partners to deliver awareness raising and training the programmes.

Climate risk | Community needs | Resource efficiency | Prioritisation

Figure 3.8 - The vegetable and grass cultivation in wastewater at Keerathurai.

10 Project 10: **Water resources infrastructure improvements**

RATIONALE:

Outcome: A secure, safe and cost effective water supply system.

Proposal: Several sub components are included: (A) Study to examine the feasibility of re-using treated waste water (B) Provision of local water treatment facilities (C) Mains replacement (D) Pressure management (E) Metering.

Issues addressed: Water resource deficits; health risks (e.g. from mis-connections).

KEY ACTIONS:

- Examine the feasibility of re-using waste water.
- Provide local water treatment facilities for tanks and groundwater.
- Replace leaking distribution mains.
- Manage pressure to ensure adequate supply.
- Meter water users to protect revenue and manage demand.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
10A **Study to examine the feasibility of re-using waste water.** With the waste water treatments works operating effectively, and given the lack of water supplies, there is an opportunity to consider if and how treated water, and other by-products, could be used. This would include municipal re-use (e.g. via river augmentation, or artificial recharge), industrial re-use and agricultural re-use (some local agriculture currently depending on raw sewerage). Paramount will be safety requirements and related treatment levels e.g. to avoid contamination via parasites and intestinal worms. The cost and location of re-use will also be relevant.	Up to $1m	**5** **Comment:** would displace need for new resources. **5** **Comment:** potential to meet growing demand. **3-5** **Comment:** study will not require many physical resources; potential schemes can be resource intensive but this has to be considered against alternatives. **4** **Comment:** building momentum.	▪ Corporation to commission research to consider alternatives e.g. involving Technical College of Engineering. Delivery issues: ▪ Depending on the study outcomes, scheme delivery may have issues associated with public acceptability, cost and environmental impact. ▪ Capacity building maybe required e.g. international experience from Australia, UK, USA. ▪ Study could be financed via IFI technical assistance.  **Figure 3.9 - The vegetable and grass cultivation in wastewater at Avaniapuram.**

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
10B **Provision of local water treatment facilities.** This will consider the need for and potential location of local treatment facilities, to treat water from non-Vaigai sources including tanks and groundwater. It is envisaged that such facilities will be outside the city centre (which is covered by the Vaigai scheme) and in areas of new development. Treatment levels may vary depending on the source e.g. as at present, groundwater is treated more simply.	US $10-$100m	4 **Comment:** supports diversification of sources. 4 **Comment:** helps secure good quality water supply. 4 **Comment:** requires construction, but of small works. 4 **Comment:** ongoing initiative.	▪ Corporation to lead but could devolve to new programme and committee overseeing management of channels and tanks (subject to quality. ▪ inspections), with support from Technical College of Engineering and local groups. Delivery issues: ▪ Defining and connecting areas that benefit from new facilities and charging mechanism. ▪ Study could be financed via IFI technical assistance. Works financed via loan if security over income.
10C **Mains replacement.** The original system is old and there are many leaks. A leak detection programme is required to determine the locations and size of the leaks, following which a programme of replacement can be implemented. This may also help identify and eliminate illegitimate connections. Reducing leakage will improve pressure (see sub component D).	US $10-$100m+	4 **Comment:** reduces 'demand'; should be designed to increase resilience of infrastructure. 4 **Comment:** facilitates security of supply; reduces cost. 4 **Comment:** requires re-construction but avoids unnecessary treatment. 3 **Comment:** project.	▪ Corporation to initiate leak detection programme. Delivery issues: ▪ A programme of enforcement to prevent illegal connections would be beneficial. Will be more efficient if it dovetails with other infrastructure improvements (e.g. where roads are dug up for access). ▪ Study could be financed via IFI technical assistance. Works financed via DPR.
10D **Pressure management.** Consider ways to ensure adequate supply pressure, including reviewing the status of over head tanks.	US $1-$10m	1 **Comment:** does not specifically address 4 **Comment:** will help ensure water supply is more regular and covers distribution zones. 3-4 **Comment:** depends on actions. 3 **Comment:** project.	▪ Corporation-led study; could be undertaken by Thaiarajar College of Engineering Delivery issues: ▪ Madurai Corporation to deliver. ▪ Capacity building maybe required e.g. international experience. ▪ Study could be financed via NURM or with IFI technical assistance. Works financed via DPR.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
10E **Metering.** Metering of water users in order to protect revenue and to manage demand. Currently 40% of supplied water is counted as non-revenue water. It may also help identify illegitimate connections.	US $10-100m+	4 **Comment:** Promotion of more efficient water use will enhance water security and build resilience to climate risks associated with drought water scarcity. 3 **Comment:** will facilitate fuller revenue collection, thus allowing re-investment. 4 **Comment:** requires infrastructure but should help reduce demand. 3 **Comment:** project.	▪ Corporation to develop metering strategy. Delivery issues: ▪ Would be useful to dovetail with a programme of managing demand, including free or subsidised pipe and tap repairs. ▪ Metering is expensive. Consideration will need to be given to the type of meter and how and how often they are read. ▪ Capacity building e.g. international metering experiences. Also, community capacity building associated with role of meter. ▪ Study could be financed via IFI technical assistance. Meters could be financed via loan if security over related income.

11 Project 11: **Water resources capacity building**

RATIONALE:

Outcome: Greater involvement of the community in managing water resources and understanding the importance of water resources protection and good hygiene.

Proposal: This will involve three sub components (A) Water safety planning (B) Rain water harvesting (C) Education on water sources and hygiene.

Issues addressed: Water resource deficits; health risks.

KEY ACTIONS:

- Develop a water safety plan.
- Scale up rainwater harvesting.
- Provide education on water sources and hygiene.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
11A **Water Safety Plan**. Development of a water safety plan involving official bodies and people institutions. This will characterise the ways in which different groups receive water supply and identify relevant hazards. This will improve understanding and provide evidence to support other projects, both those dealing with hazard removal and with new water sources and supply infrastructure.  Figure 3.10 - Everyday living conditions along side the Kiruthumal for informal settlements.	US $1-5m	4 **Comment:** Will help build resilience. 4 **Comment:** Will help identify hazards and test proposed projects. 5 **Comment:** Requires few physical resources. 4 **Comment:** Early win.	▪ Could be initiated via various routes (including IFI) but will need buy-in from people institutions. Delivery issues: ▪ Requires a mixture of inputs; can focus on key areas e.g. slums. ▪ Could be financed via IFI technical assistance or a grant.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
11B **Rain water harvesting.** This is mandatory (Tamil Nadu state) for new property but demonstration projects need to be scaled up and consideration given to huge potential on existing properties. Rain water harvesting should help supply buildings during the wet season (thus avoiding abstraction from other sources) and could be used to facilitate groundwater recharge. (Note that rain water harvesting is not a dry season or drought measure).	Up to US $10m	4 **Comment:** Reduces demand; recharge benefits. 4 **Comment:** Provides cost-effective water on-site during wet season. 4 **Comment:** Requires some infrastructure but avoids/reduces need for other infrastructure. 4 **Comment:** Ongoing initiative.	▪ Local scheme developed by corporation and civil society partners targeted at areas of highest ground water depletion. ▪ Social enterprise for construction and maintenance. Delivery issues: ▪ Installation and maintenance. ▪ Requires support of property owners. ▪ Grant / incentive scheme linked to water billing.
11C **Education on water sources and hygiene** (linked with sanitation training). To promote the best available sources of water, the importance of protecting all water sources, water storage in the home, hand washing, household treatment of water and demand management. More broadly to demonstrate choices available, to create access to micro-finance products and to provide technical support on the construction and maintenance of rain water harvesting and tap connections (as well as household toilets).	Up to US $250,000	4 **Comment:** Builds adaptive capacity. 5 **Comment:** Helps protect water supplies and reduces health risks. 5 **Comment:** Requires few physical resources. 4 **Comment:** Ongoing initiative.	▪ People institutions (existing and created) would create the awareness among the targeted member households via behavioural change communication materials, demonstration units and individual training. Delivery issues: ▪ Requires supporting infrastructure including toilets. ▪ Could be financed via IFI technical assistance, banks (to support micro-finance) and via the Corporation.

Projects continue on page 63

Climate risk | Community needs | Resource efficiency | Prioritisation

04

DELIVERY AND IMPLEMENTATION

Doing things differently: Cross-cutting actions to support implementation

Action planning has galvanized and brought together stakeholders in Madurai to address the problems of the city. To enable implementation of the action plan are proposed a number of structures to support the co-ordination and management of the projects.

A description is provided of the institutional and governance arrangements to support a future proofing planning approach. These include:

- an enhanced city partnership;
- improved co-ordination and delivery including Project 12 (page 64). These will span government, academic institutions, civil society and community based organisations, the private sector and other organisations and institutions in the city. The proposed structures will evolve and build from existing co-ordination arrangements;
- policies and regulations to support Blue-green infrastructure including Project 13 (page 67). Linking them to the CDP and Masterplan would enable them to be enforced;
- a strong bridge to the community by establishing and enhanced platform for community participation in plan making (Project 14, page 73).

These cross-cutting proposals underpin all of the preceding projects.

City partnership model

A Madurai city partnership would be formally established and provide a forum to coordinate and collectively agree on the urban development, infrastructure and environmental priorities.

The partnership would include advisory bodies for channelling the comments and inputs from all stakeholders with interests in the planning and implementation of projects and initiatives in the city.

The partnership would provide a platform for Madurai Municipal Corporation (MMC) to facilitate more effective cross agency co-ordination between urban local and state level bodies.

In addition, it would provide a platform for groupings such as the City Coordination Group (CGC) and City Volunteers Technical Corps (CVTC) and other organisations to play a greater role in advising on and monitoring development in the city providing additional links and communication channels between the community and government organisations.

A target oriented work plan could be jointly developed spanning the different organisations. The budgets of different organisations would be coordinated linking the City Development Plan (CDP), plans from State level agencies and other institutions including the civil society sector to enable delivering of the action plan and potentially other projects and initiatives in Madurai.

An efficient framework for inclusive decisions would align the differing roles of individual city departments (i.e. PWD, TNSCB, TNHB, etc) and community stakeholder (i.e. CGC-CVTC, Dhan Foundation, etc) at different stages of the project cycle; from city level planning, sector and area specific proposals through to individual projects.

The stakeholders can be clustered to three forums consisting of Madurai City Partnerships, Tamil Nadu State level administrative bodies and Community stakeholders with their respective forums.

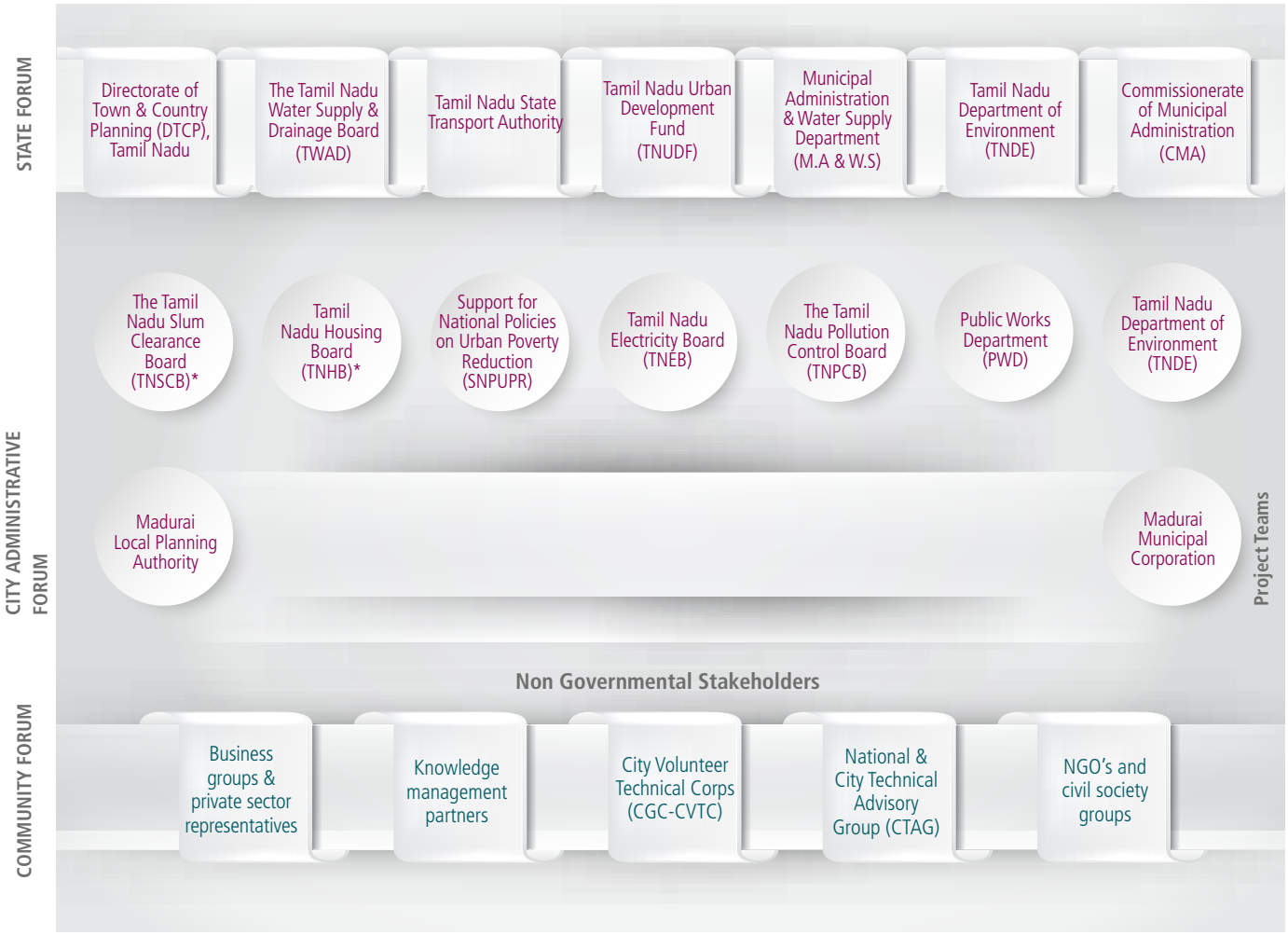


Figure 4.1 - City partnership model

REGULATOR / DECISION MEMBER
Core Authority 'functional responsible for delivery and execution

ADVISORY ROLE
Contribute to decisions through analysis of issues and options

The contributions of each forums are elaborated as below:

- **Madurai City Administrative Forum:** The city partnership platform led by Madurai Municipal Corporation (MMC) and supported by individual departments and delivery bodies would enable Madurai to deliver more integrated projects and to coordinate the actions of individual agencies. The platform would be an advisory body of senior level technical staff which would make recommendations back to the constituent bodies who have the legal powers to approve and implement actions. MMC would be the secretariat for the body and support of project teams and collate contributions from individual department function's and community stakeholders through the entire planning and development process. Dedicated programme and project managers and follow up staff would be attached to the group to ensure the effectiveness of the actions agreed.
- **Tamil Nadu State Forum:** The State forum would include nodal representatives of state level authorities who would be invited to city administrative Forum meetings when the topic relates to their area of responsibility in order to strengthen communications across State level bodies at project and programme level Plans and projects would still require formal approval processes to be followed (e.g. through DTCP and CMA). However, the involvement of state level bodies would have taken place earlier to smooth the process. As a result the process will be more streamlined as discussions can be jointly-agreed or can be considered in parallel rather than sequentially.
- **Community forum:** The community stakeholders would serve in an advisory capacity as well as facilitating platforms for wider community engagement around projects and proposals:
  - Advisory forum: The CGC-CVTC, CTAG are already established and can serve as advisory bodies to ensure effective dialogue with the city administrative forum. CTAG would serve a technical advisory role of disseminating best practices.

- Madurai is unique as it has offers a strong involvement from academia in assisting in research and analysis of key issues and options the forum as knowledge management partners to the forum to allow this information to inform policy and project development and implementation.

- Community dialogue: The CGC-CVTC together with C-TAG would act as a nodal point for coordinating feedback and dialogue between various community groups (refer to Project 14, page 72). The action planning working groups established to develop the action plan could be maintained to track and develop initiatives to address particular issues.

Thematic project teams and working groups

The city partnership would establish working groups/project teams drawn from representatives from government and community stakeholders to develop particular actions and projects and track implementation who would then report back to the city partnership on say a quarterly basis. The city partnerships can open dialogue to the public on initiatives and proposals, apart from regular dialogue every quarter with the public and state level bodies.

Improving delivery

The cycle of delivering change within the city will go through a transition phase as the city administration and frameworks are aligned to help support implementation of the action plan.

The systems would need to be practiced, monitored and reviewed regularly to ensure that results are achieved and administrative challenges are addressed. During the process of change discussions through the city partnership will encourage transparency and accountability in infrastructure delivery.

As the city partnership becomes established, the partnership should be able to move to a process of shared learning leading to further performance improvements.

Achieving delivery efficiency

The Madurai City Partnership should be an effective measure which can help to deliver cost efficiencies and reduce wasted efforts by reducing overlap between individual sector infrastructure plans. Stakeholder meetings and collective decisions would improve parallel working and be used to pro actively anticipate and eliminate bottlenecks as well as reduce delays and cost escalations. The MMC could use dedicated project teams to coordinate between departments at the planning stage to ensure accountability for timely and cost effective delivery (see Figure 4.2 on this page).

A cost efficient and timely delivery mechanism can aid shorter periods for infrastructure investment recovery. The multiple-benefit of savings in time, costs and shorter-timeframes for investment recovery, would enable the city to move towards using revolving approach to fund future projects and initiatives to reduce the burden from borrowing.

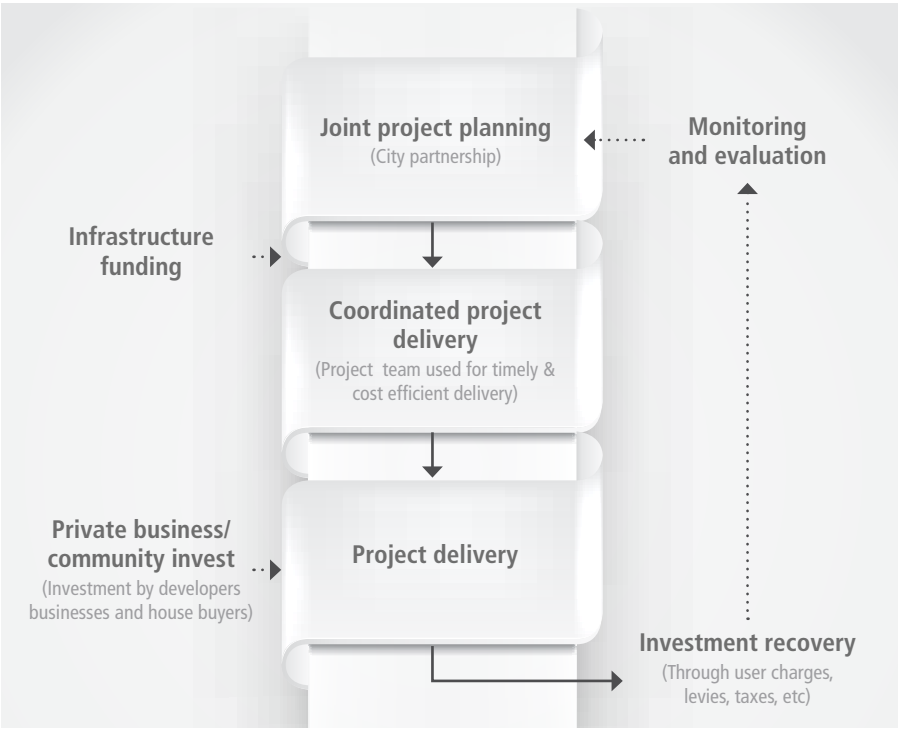


Figure 4.2 - How the city partnership model could enhance delivery

Policies and regulations

The schedule of proposals summarised Table 4.3 shows where policy changes and additional guidance and regulation have been identified as part of the Projects and as a necessary component of ensuring the long term effectiveness and sustainability of the actions identified.

There are three projects which include significant changes to the policy and regulatory framework.

Projects 12 and 13 provide the overall co-ordination and planning framework for enabling the delivery of the other projects contained in the action plan.

Project	Action	Responsibility	Mechanism
6 **Channel and tank protection and management**	Establishment and refinement of operational rules	PWD with TWAD and TNPCB.	Guidelines adopted by State level bodies and Madurai Corporation in parallel.
	Abstraction management - enforcement of existing rules	TWAD	Additional resources deployed.
	Discharge regulation and management	TNPCB Madurai Corporation (linking to development permits)	Co-ordination and enforcement between the two bodies. Additional penalties may be required.
	Encroachment management	PWD (management), TNPCB (enforcement) and Madurai Corporation and DTCP (policies)	Improved policies in CDP. Capacity building and resources for follow up (PWD and TNSCB with community organisations).
12 **Infrastructure coordination**	(A+B) Enablement of proposed co-ordination structures	Madurai Corporation	Through local byelaw
	(C) Infrastructure standards and co-ordination procedures to enable appropriate phasing	Madurai Corporation	Through local byelaw
13 **Green city plan linking to the City Development Plan and masterplan**	(A) Policies on channel and tank protection	Developed by Madurai Corporation planning team and DTCP LPA team with PWD, TWAD, TNPCB and TNDE.	City Development Plan.
	(B) Identification of zoned areas/overlays for flood protection areas and supporting policies.	Policies developed jointly by Madurai Corporation Planning team, DTCP LPA team with PWD and TWAD.	Areas shown on city masterplan. Policy approach with criteria for development linked to design standards to regulate development Adopted via CDP/masterplan.
	(C) Identification and zoning for protection of natural habitat areas and establishment of management norms.	Developed by Madurai Corporation planning team and DTCP LPA team with support from Department of Environment and PWD).	Developed and adopted through CDP/ masterplan process.
	(D) Identification and planning of urban green space with design and management standards.	Developed by Madurai Corporation planning team and DTCP LPA team and PWD.	Developed and adopted through CDP/ masterplan process.
	(E) Planning policies and design standards for new communities/ Eco neighbourhoods	Developed by Madurai Corporation and DTCP LPA team.	Locations identified and policies and standards developed through CDP process. Local byelaw needed to supplement State level Planning standards.
	(F) Land consolidation and management measures to enable - Town Planning schemes. Compensation and incentive structures to enable effective protection of safeguarded land and appropriate management and stewardship.	Developed by DTCP	State legislation and guidelines building upon frameworks at national level.

Table 4.3 - Suggested changes to policy and regulatory framework

12 Project 12: **Proposals for blue-green infrastructure coordination**

RATIONALE:

Outcome: Structures enabling coordination of relevant stakeholders with interests in providing, managing and utilising blue-green infrastructure at a state, city and local level.

Proposal:
(A) The creation of a integrated co-ordination framework with a process to facilitate informed and joined up decision making;
(B) Governance to support implementation of the projects identified within the action plan;
(C) Infrastructure standards & coordination procedures.

Issues addressed: The lack of coordination between individual departments and institutions; gaps in management and implementation to support delivery.

KEY ACTIONS:

- Establishment and enablement of city partnership co-ordination structures.
- Refinement and formalisation of city partnership body and decision frameworks.
- Workplan for the city partnership body prepared.
- Formation of Madurai City Corporation Project Teams.
- Strengthen project and programme management systems and procedures including appointment of a city co-ordinator / resilience officer
- Establishment of knowledge management and project preparation partnership.
- Define technical assistance and capacity building activities to strengthen governance and institutions.
- Develop a resourcing and funding strategy.
- Infrastructure standards and co-ordination procedures to enable effective infrastructure delivery.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
12A **Establishment and enablement of city partnership coordination structures.** ▪ Refinement and formalisation of City Partnership body and decision frameworks. ▪ The framework outlined in the section on "doing things differently" provides a basis to establish a partnership and its terms of reference. Formation of a partnership would support the engagement necessary to plan, design and enable the opportunities and interventions needed to deliver plans for blue-green infrastructure for addressing climate risks and reducing vulnerability and through building resilience. Notes: ▪ The City Partnership would be guided by the vision of consolidating a plan for blue-green infrastructure focused on delivering the projects in this action plan. ▪ The City Partnership would help establish priorities for infrastructure provision. ▪ The partnership would coordinate how plans are delivered linked to a phased approach for development and infrastructure investment. ▪ A workplan for the City Partnership body would be prepared	$250,000-$500,000 Excludes annual staff resourcing costs relating to implementation of the plan.	3 **Comment:** The City Partnership is necessary for strengthening resilience and adaptive capacity to respond to climate risks. 4 **Comment:** A strengthened governance framework help address community needs. 5 **Comment:** Effective planning and delivery decisions will help address water security issues. 5 **Comment:** An enhanced governance framework is a necessary first step to making progress on the other projects identified.	▪ A suggested framework for governance is outlined in Figure 15 on page 78. ▪ Madurai Municipal Corporation (MMC) would lead the initiative with all relevant stakeholders involved. ▪ The framework should be formalised adoption by Madurai Corporation and other bodies.

12B **Strengthen project and programme management systems and procedures including appointment of a city coordinator / resilience officer.**
▪ Madurai City Corporation Project Teams would be formed.
▪ Establishment of knowledge management and project preparation partnership.
▪ Define technical assistance and capacity building activities to strengthen governance and institutions.
▪ Develop a resourcing and funding strategy including:
▪ Social capital building strategy
  ▪ voluntary support
  ▪ grant funding opportunities
  ▪ improve capacity to access and secure funding
▪ Identify and explore financing options for revenue generating capital programmes
▪ Identify and explore financing options for non-revenue generating capital programmes
	Included in cost	3
		Comment: The City Partnership is necessary for strengthening resilience and adaptive capacity to respond to climate risks.
		4
		Comment: A strengthened governance framework help address community needs.
		5
		Comment: Effective planning and delivery decisions will help address water security issues.
		5
		Comment: An enhanced governance framework is a necessary first step to making progress on the other projects identified.
			▪ Linked with component A. Madurai Municipal Corporation would lead this initiative.

Climate risk | Community needs | Resource efficiency | Prioritisation

12C **Climate smart infrastructure standards and co-ordination procedures to enable effective infrastructure delivery.** A design manual of climate smart planning and design standards and procedures would be developed to be used by all public bodies and implementing bodies linking to the City Partnership review structures. The manual would include: ▪ design principles for blue-green infrastructure, streets and wayleaves (planning for multiple infrastructures together rather than individually) ▪ points of coordination with relevant bodies ▪ phasing and programming ▪ approval and review procedure.	US $250,000-US $500,000	3 **Comment:** Improved Climate Smart infrastructure planning approaches will enhance resilience to climate risks. 4 **Comment:** The standards would be applicable to upgrading of existing infrastructure as well as new communities to plug significant existing gaps. 4 **Comment:** Effective policies would enhance water and food security as well as help avoid lock in to energy intensity pathways. 5 **Comment:** Developing the framework is an important early priority. Implementation would be ongoing.	▪ Preparation of the standards would be led by Madurai Municipal Corporation (MMC) and Madurai Local Planning Authority. ▪ The State Department for Town & Country Planning (DTCP) would be consulted on and approve the standards and plans. The following bodies would also play a strong role in helping to formulate the standards: ▪ Madurai Corporation Public Works Department (PWD), Support for National Policies on Urban Poverty Reduction (SNPUPR)-Rajiv Awaz Yojana, Basic Services for Urban Poor, Regional Transport Office. ▪ Tamil Nadu State institutional support including Municipal Administration & Water Supply Department (MA & WS), Tamil Nadu Water Supply and Drainage Board (TWAD), The Tamil Nadu Slum Clearance Board (TNSCB), Tamil Nadu Electricity Board (TNEB),Tamil Nadu State Transport Authority, Department of Environment and other relevant bodies. ▪ Other local stakeholders particularly local and State Universities.

Climate risk | Community needs | Resource efficiency | Prioritisation

13 Project 13: **Green city plan linking to the city development plan and masterplan**

RATIONALE:

Outcome: Green city masterplan plan and policies adopted covering the whole city to enable effective management of development to protect communities and maintain and enhance blue-green infrastructure and the associated benefits to the community.

Proposal: The city wide blue-green infrastructure masterplan and policies would provide a spatial dimension to this action plan and contain the policies and guidance identified within action plan projects. It would be developed in parallel with the city development plan and updated masterplan as a supporting document to acknowledge and address the specific climate risks and green blue infrastructure needed to protect the city and its residents.

Issues addressed:

- Linked to city development plan and masterplan.
- To provide a mechanism for formal adoption and budgeting.
- Limited basis for urban growth management with inadequate control of undeveloped land leading to encroachment on blue-green infrastructure and agricultural land. Increased resilience and ecosystem benefits available to the city and its residents as a result.
- High proportion of existing city residents are exposed and vulnerable to climate risk and are not provided with adequate infrastructure. No policy framework to safeguard environmental risk and natural hazard areas from development. No policies to protect or provide for natural habitat, biodiversity and urban greenspace. Number of residents living in areas at risk to climate and natural hazards is reduced. Quality of life is enhanced by improved access to urban greenspace and natural habitat.
- Avoid lock in to unsustainable patterns and replicating damage to blue-green infrastructure systems. Reduces multidimensional poverty through increased access to services and improved housing compared with current trends.
- Enables management and stewardship of undeveloped land and delivery of new development areas.

KEY ACTIONS:

City wide blue-green infrastructure plan including:

- Policies on channel and tank protection.
- Identification of zoned areas/ overlays for flood protection areas and supporting policies.
- Identification and zoning of natural habitat areas and establishment of management norms.
- City greenspace plan with design and management standards
- Policy, planning standards and design code developed and applied in masterplans for new communities.
- Land management policies.

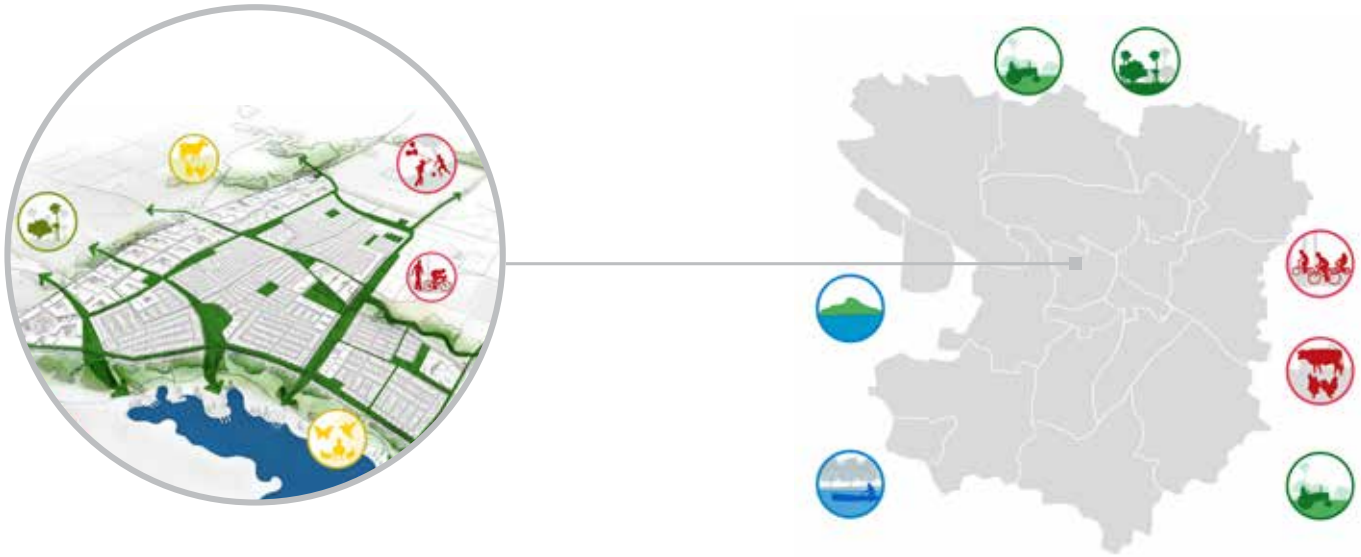


Figure 4.3 - City Plans for infrastructure delivery. Blue-green Corridor City Projects

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
13A The city wide blue-green infrastructure masterplan would provide a regulating plan (map) to enable moves towards a sustainable model for city expansion. Development policies and standards for application to new development areas which are zoned. These would incorporate eco-neighbourhood planning principles and topics not covered by State level guidelines used at present identifying: ▪ Protection policies: zoning designations and safeguarding areas for areas to be protected from development or which can only be developed if particular criteria are met. ▪ Site level proposals: for land and facilities relating to new blue-green infrastructure required to address the existing and needs of the city. ▪ The plan would need to be informed by further more detailed evidence based technical assessments.	Refer to components below	4 **Comment:** Protection policies reduce exposure to flooding. Green space and natural habitats enable resilience to climate risks and preserve ecosystem services. 4 **Comment:** Integrated plans fundamental to meeting community needs. 4 **Comment:** Planning of new communities to enable water and energy efficiency and reduce loss of productive agricultural land. 5 **Comment:** Plan should be developed as a priority to link with CDP and masterplan update. Implementation would be ongoing.	▪ The city plans would need to involve a core team that includes Madurai Municipal Corporation (MMC), Madurai Local Planning Authority, the State Department for Town & Country Planning (DTCP) and Commissionerate of Municipal Administration (CMA). ▪ Support from National Policies from Urban Poverty Reduction (SNPUPR)-Rajiv Awaz Yojana, Basic Services for Urban Poor could help to align and apply the same approach to planned housing and slum improvement areas. Delivering Issues ▪ There would also need to be close engagement with other agencies for particular components and policies. ▪ Support to develop and strengthen capacities while the plans are developed at a practical level is likely to be needed. ▪ A participatory process to inform and shape the plans should be implemented to ensure the proposals align with the needs of different communities.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
13B **Policies on channel and tank protection** There is a need for policies to retain and protect the lake system, tanks and natural drainage systems (rivers, streams and nallas/drainage channels from development and encroachment. ▪ Identification and mapping of the channels and lakes. ▪ Identification of a green zone or buffer zone around channels and tanks which could double as public greenspace/habitat areas. ▪ Provision of infrastructure /receptor points to avoid pollution/unauthorised discharges. ▪ Stewardship/management approach to enable effective management this could be a community managed approach involving those who depend on the channels or more formal and approach linked to licensing and penalties. ▪ Establishment of an effective management and maintenance regime delineating responsibilities for TNWSDB and PWD and other stakeholders and organisations who may be involved in these activities (farmers and small holders, community based organisations etc.).	US $250,000 - US $500,000	4 **Comment:** Tanks can play an important role in addressing water scarcity risks and enabling food security. 4 **Comment:** Tanks used for irrigation of agricultural land and storm water run off. Connected to groundwater resources. 4 **Comment:** Tanks can play an important role in addressing water scarcity risks and enabling food security. 5 **Comment:** High priority to establish policy framework - implementation would link with Projects 1 and 6.	In addition to the above the following would need to be involved: ▪ State Department of Environment - Ecology/ Climate change. ▪ Tamil Nadu Water Supply and Drainage Board. ▪ Madurai Public Works Department. ▪ Farmers/irrigation collectives and other tank users. ▪ Local Universities.
13C **Identification of zoned areas/overlays for flood protection areas and supporting policies.** ▪ Flood risk assessment informed by accurate topographic data to identify areas at risk of flooding supplemented. ▪ Identification of policy designations and criteria for development reflecting the level of risk. UNISDR community based disaster risk mapping project findings should help inform the approach.	US $500,000- US $1,000,000	4 **Comment:** Flooding is a key climate risk in Madurai. 4 **Comment:** Many communities are exposed to the risk of flooding and development is continuing totake place in these areas. 3 **Comment:** Action to address flood risk links with an integrated approach to addressing water management issues. 4 **Comment:** Flooding while occurs on a frequent basis is changing relatively slowly. Early action is needed to prevent exposure through planning and build resilience among existing communities that are exposed.	In addition to the above the following would need to be involved: ▪ State Department of Environment - Climate Change. ▪ Tamil Nadu Water Supply and Drainage Board. ▪ Madurai Public Works Department. ▪ UNISDR. ▪ Local Universities. ▪ Land owners.

Climate risk | Community needs | Resource efficiency | Prioritisation

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
13D **Identification and zoning of natural habitat areas and establishment of management norms.** ▪ The lake and wetland system at Madurai is noted to be of national and State significance but at risk from climate change as well as urbanisation pressure ▪ Assessment of the extent, condition and significance of areas natural habitat areas and flora and fauna ▪ Assessment of vulnerability of these habitats to climate change and development pressure ▪ Identification of areas to be rehabilitated or established to restore/extend the city green infrastructure network ▪ Identification of policy designations for those areas which require protection and preparation of a management plan. ▪ Criteria established for development located close to natural habitat areas.	US $250,000 - US $500,000	3 **Comment:** Natural habitat areas alleviate extreme heat and the urban heat island effect. 5 **Comment:** There is a deficiency in access to natural areas within the Core city which has a high population density. 3 **Comment:** Provision of shading and shelter from wind and rains can help to reduce energy demand and manage run off. 5 **Comment:** Plan should be developed as a priority to link with CDP and masterplan update. Implementation would be ongoing.	In addition to the above the following would need to be involved: ▪ State Department of Environment - Climate Change/Ecology. ▪ Madurai Public Works Department. ▪ Local Universities. ▪ Land owners.
13E **City greenspace plan with design and management standards.** ▪ Develop a strategy for providing open space to meet the needs of the city. Establishing appropriate standards of provision, design and management. The strategy should align and incorporate opportunities to surface water management and sustainable drainage as well as retention of agricultural areas/local food production in recognition that land can sometimes accommodate multiple functions at once if managed carefully. ▪ The provision should be viewed as a network and can link and coincide where possible with water channels. Linear routes can provide opportunities for walking and cycling routes.	US $250,000 - US $500,000	3 **Comment:** Natural habitat areas alleviate extreme heat and the urban heat island effect. 5 **Comment:** There is a deficiency in access to urban greenspace throughout the city. Provision would enhance quality of life of residents and provide an amenity linking with tourism which is important to the economy of Madurai. 3 **Comment:** Provision of trees and shading and shelter from wind and rains can help to reduce energy demand and manage run off. 5 **Comment:** Plan should be developed as a priority to link with CDP and masterplan update. Implementation would be ongoing.	In addition to the above the following would need to be involved: ▪ State Department of Environment - Ecology. ▪ Tamil Nadu Water Supply and Drainage Board. ▪ Madurai Public Works Department. ▪ Farmers and other tank users. ▪ Local Universities. ▪ Stakeholders linked to temples and religious monuments. ▪ Land owners.

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Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
13F **Policy, planning standards and design code developed and applied in masterplans for new communities.** Newly zoned areas and communities should be planned as integrated communities (with adequate infrastructure) as well as improved energy and environmental performance. The guidelines and proposals would cover the following topics: ▪ Location criteria to guide the location of development. ▪ Water resources and supply. ▪ Water efficiency measures including rainwater harvesting. ▪ Sewerage and waste water collection and disposal. ▪ Storm water drainage. ▪ Building performance and energy efficiency (linked to building rating system accreditation). ▪ Microgeneration of renewable energy including solar water heating and photovoltaics. ▪ Solid waste collection and management. ▪ Transport strategy including public transport and non motorised modes. ▪ Eco-neighbourhood design guideline features to provide resilience to future climate change risks - shaded streets, resilient infrastructure and buildings. ▪ Provision of urban greenspace. ▪ Mixed use approach with local employment opportunities and community facilities. ▪ Urban design guidance to accommodate public transport routes and standards for Street network planning and block size to promote walkability. ▪ Design code and plot development guidelines mix and density of land uses underpinned by level of infrastructure available and services. ▪ Wider range of development and procurement options. ▪ Resident and community engagement including long term community management model.	US $250,000 - US $1,000,000 per plan depending on area.	3 **Comment:** New communities would be located in areas not exposed to risks and provided with infrastructure which reduces vulnerability. 4 **Comment:** The growth of the city and demand for houses provided with infrastructure is high. 5 **Comment:** Establishing Eco neighbourhoods will reduce lock in to energy and water intensive patterns of development. 4 **Comment:** Ongoing with plans developed in a phased way linked to infrastructure delivery. Early win to develop proposals for the first project which can act as a demonstrator.	▪ Preparation of the policy, standards and codes would be best accomplished through a number of pilots rather than as general guidance. ▪ This would build capacity for extending the approach. ▪ The plans would be led by Madurai Municipal Corporation (MMC) (for areas within the MMC boundary and Madurai Local Planning Authority for those outside. ▪ The State Department for Town & Country Planning (DTCP) would be consulted on and approve the standards and plans. ▪ To enhance institutional capacity and collective enforcement there would be stakeholder engagement during the plan planning process. ▪ Madurai Corporation the Public Works Department (P.W.D), Support for National Policies on Urban Poverty Reduction (SNPUPR)-Rajiv Awaz Yojana, Basic Services for Urban Poor, Regional Transport Office and stakeholders affected by the plan. ▪ Tamil Nadu State institutional support including the Municipal Administration & Water Supply Department (M.A & W.S), Tamil Nadu Water Supply and Drainage Board (TWAD), The Tamil Nadu Slum Clearance Board (TNSCB), Tamil Nadu Electricity Board (T.N.E.B),Tamil Nadu State Transport Authority and other relevant bodies ▪ Community stakeholder engagement and inputs to shape the plans through a participatory process (see Project 14).

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Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
13F **Land management policies** ▪ Use made of Tamil Nadu legislation allowing for Town Planning Schemes requiring land consolidation and compensation to enable infrastructure provision. ▪ Development of compensation and incentive structures to enable effective protection of safeguarded land which should be protected from development ▪ Phasing plan for the provision of infrastructure and designation/release of zoned land. ▪ Enactment of land conversion charges more closely reflecting the costs of infrastructure provision incurred by public bodies.	US $500,000 - US $1,000,000 for development of the detailed approach.	3 **Comment:** Policies are required to enable effective protection against risks. 4 **Comment:** Provision of serviced land and housing is necessary to enable resilience to climate risks. 4 **Comment:** Effective policies applied and enforced would enhance water and food security. 4 **Comment:** Developing the framework is an important early priority. Implementation would be ongoing.	▪ The project would be developed by Madurai Municipal Corporation (MMC), Madurai Local Planning Authority with the support of state Department for Town & Country Planning (DTCP). ▪ Output would include local byelaw to complement and enhance State level law and guidelines. ▪ Results would inform infrastructure plans/CDP and support effective implementation. ▪ As this is a new approach external support to help build capacity and shape the approach would be required. ▪ Stakeholder engagement would need to take into consideration affected members of the public.

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14 Project 14: **Platform for community participation to develop and deliver city plans**

RATIONALE:

Outcome: Action Groups linking to City Co-ordinating Group (CCG) and City Voluntary Technical Corps (CVTC) are used as an advisory platform linking with wider City Partnership identified in Project 12.

Proposal: Create Action Groups

Issues addressed:

- lack of understanding of role, rights and responsibilities of urban local bodies and people to ensure the ownership, contribution and management of City development process
- facilitation of community building processes and initiatives at grassroots level through continuous interaction with city corporation
- voice citizen concerns and to take responsibility for constructive actions by the corporations
- ensure equity and fairness in the implementation of infrastructure programmes and resource allocation based on the needs and viability
- social audit of development and infrastructure programmes which will become a monitoring tool of the society
- technical support in governance, planning, finance, poverty and heritage.

KEY ACTIONS:

- Establishment and enablement of agreed City Partnership co-ordination structures.
- Identify anchor NGO to act as secretariat.
- Workplan for the Action Groups prepared including community outreach and engagement activities.

Description of sub component	Cost	Benefit / Impact Scorecard	How it would be delivered
14A **Create Action Groups. Establishment and enablement of agreed community participation platform.** ▪ Identify anchor NGO who would provide secretarial support for the CCG / TAG The tentative terms of reference could include the following: ▪ To advise City steering group, urban local bodies on enlisting community participation, securing transparency and accountability, ways and means of involving citizens in service delivery and governance ▪ To facilitate the functioning of the City Coordinating group and Technical Advisory groups ▪ To help mobilise support of civil society and elected representatives for reform in urban governance ▪ To help enlist involvement of citizens at grassroots level through Nagar sabhas and Technical advisory groups.	For facilitation and coordination of the CCG / CVTC, senior coordinator and Support staff for documentation, finance and administration. The costs will be $100,000 per annum which would be required for three years and later it will manage on its own by generating its own resources.	3 **Comment:** The participatory platform is necessary for strengthening resilience and adaptive capacity to respond to climate risks. 4 **Comment:** A strengthened governance framework help address community needs. Impacts could include: ▪ Green City Development Plan with community buy in. ▪ Input to relevant Detailed Project Reports and proper networking with the anchors. ▪ Legitimate legal entity with self-supportive nature mooting multiple initiatives for the development of the city. 5 **Comment:** Improved co-ordination and links between the government and civil society sector should enhance the effectiveness of city initiatives. 5 **Comment:** An enhanced governance framework is a necessary first step to making progress on the other projects identified.	**Coordination and Facilitation:** The coordination and facilitation of the CCG / CVTC will be done by the anchor NGO with the following activities: ▪ Integrating CCG /CVTC, Nagar Sabhas and city level networks of NGO's and maintaining a continuous interaction with these network partners. ▪ Organising the seminars and workshops and in city consultations for cross learning among the stakeholders. ▪ Documentation of the CCG / CVTC activities. ▪ Support CCG / CVTC in facilitating cross learning among stakeholders and cities. ▪ Interacting with Corporation on CCG / CVTC activities. ▪ Coordination of logistics and administrative actions of CCG/ CVTC. ▪ Planning, Budgeting and accounting of CCG / CVTC on advice of Chair. **Frequency of meetings** ▪ The groups will meet once in a month to share. However, the respective action groups can meet based on the needs and call of the city. **Chair** ▪ City Coordinating Group Chairman will chair the meeting in the presence of Municipal Commissioner, Mayor and Deputy Mayor. **Legal status** ▪ This structure / body comes in to shape by the authorisation and notification of the Municipal Corporation. Over a period, these will become a legal entity which will be self managed.

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Financing for future proofing

In order to implement the Future Proofing Action Plan for Madurai, stakeholders will need to develop a funding and finance business plan which matches the sources of funding and support necessary to enable the projects and opportunities identified within the plan.

The level and type of support and funding and support needed to deliver the plan

Table 4.2 (on page 78) shows the broad level of funding needed to develop and deliver the 14 Projects. A range of costs is identified for each project to provide an indication of the funding needed.

More detailed cost estimates for particular projects and actions would need to be defined for capital programmes after the technical feasibility and concept design options are developed. Madurai Corporation has developed a budget plan which includes a budget estimate for providing infrastructure for the additional Wards which have recently been brought within the Corporation boundary.

The 14 projects include a range of actions which require different types of support. The table highlights the range of possible sources of funding and types of funding relevant for particular projects.

It will be necessary to blend and combine a range of different sources of financial and non-financial support. Funders have specific eligibility criteria for commitment and investment which means that only projects which meet their criteria will be fundable.

Outlined below are the types of support and funding sources relevant to the action plan projects:

Social capital building and catalysing community action

Voluntary support

Many of the social capital building actions identified within Projects 2, 4, 7, 9 and 11 can be supported through mobilising volunteers and community organisations to develop and implement projects. The human and social and capital resources can be mobilised for actions where there is a direct and visible relationship between the action and the benefits.

Grant funding

Grant funding is also an option to support the development and administration of projects and their implementation where materials and financial support is required to complement the social capital.

Philanthropic and NGO grant funding could be leveraged through initiatives such as the Rockefeller 100 Resilient Cities programme. Initiatives such as the recently introduced requirement for businesses to dedicate 1% of profits to corporate social responsibility (CSR) initiatives is an opportunity for the city to involve businesses with interests in Madurai to jointly support projects.

Securing co-funding by linking initiatives with Corporation, State and national level programmes and initiatives

Co-funding from Urban Local Body (ULB), State and national funds (e.g. as part of JNNURM, RAY) as well as International Financial Institutions/donors can also support projects with a social capital building component.

Developing capability to access and secure funding

In order to access funds the city stakeholders could develop fund and finance raising capacities to develop and leverage funds further and in a more coordinated manner. Capacities already exist within the city evidenced by successful initiatives already developed and implemented by organisations such as Dhan Foundation and partnership projects such as Future Proofing Cities India.

Project preparation assistance and capacity building

Almost all of the 14 projects require further definition and project preparation activities to develop and assess options for implementation. An outline of the studies required is defined within projects 1A, 5A, 10A, 12 and 13.

There are a number of existing sector specific initiatives in Madurai where Detailed Project Reports have been completed, such as for solid waste management, transport and sewerage system improvement. However these studies are generally out of date (some more than 10 years old) and they do not take an integrated view of the needs or the solutions which could run the risk of maladapted infrastructure solutions being implemented or opportunities to combine investment with poverty and climate risk reduction to be missed.

Knowledge management and project preparation partnership

Developing a consolidated project preparation and monitoring capability in Madurai is a priority for the city and is important to assist implementation of a number of action plan projects. The corporation has very limited in house human and financial resources to develop, manage and implement projects and programmes.

More coordinated programming of State and City expenditure

The state tends to pay for expenditure on infrastructure provisions through individual departments linked to particular sector improvements. This sometimes does not take into consideration the overlap of department functions and links with programmes of other agencies which may be necessary to implement an integrated approach.

The coordination and linking of sector programmes between water resources, sanitation and drainage more effectively is likely to enable delivery of more multidimensional projects (able to deliver wider range of social, economic and environmental benefits. It could also lead to opportunities for cost savings and expenditure efficiencies. These funds can be reinvested in programmes as well as institutional capacity development which could help to bridge human resources gaps.

The City partnership framework described in this action plan would offer the ability to collectively pool together state financial resources to implement projects. A collective agreement of state and city nodal representatives within the City partnership would align programme objectives and delivery. Accountability and financial management would be retained by the respective agencies in order to minimise impediments to the introduction of the partnership.

A mechanism for pooling the revenues from municipal services and charges (e.g. for water services) could be explored. In the future this could be extended to include solid waste collection/management and infrastructure services to new communities and other provision.

At present there is a significant capability, research expertise and academic and applied knowledge relating to blue-green infrastructure issues in the city clustered at Thiyagarajar College of Engineering (TCE). At present it is not possible for Madurai Corporation to procure the college to contribute to their programmes although informal advice is provided. Establishment of a partnership body could enable services to be procured from academic, voluntary sector bodies and the private sector more easily.

As part of the formulation of the Tamil Nadu State Climate Change Action Plan Anna University has established a knowledge management centre housing data and studies relating to climate risks as well as sector studies on vulnerability and implications of a range of climate risks. It is not possible for Madurai Corporation to commission the university to provide advice/expertise from the centre.

Tamil Nadu Water and Sanitation Board (TNWSB) has expertise in water resources management and modelling having completed models for a number of other river basin catchments in the State. Their expertise could be called upon to contribute to the analysis of drought and water resources risks in the Vaigai catchment. TNWSB do not have resources available to commit to analysis of river basin issues in Madurai.

Again, if it were possible for Madurai Corporation to develop a partnership body it could provide a vehicle to enable procure services from TNWSB as another public body. The establishment of a partnership could also enable links to be strengthened from the bottom up with international agencies and development banks in support of the development and implementation of plans for the city.

Combining external advisory and technical assistance would enable the gap to be bridged between academic, government, private and civil society sectors. The benefit would be improved evidence based decision making and co-ordination of programmes and projects to strengthen delivery and effectiveness of implementation. It would enable improvements to infrastructure planning, integration and the investibility and delivery of projects. In turn the poverty reduction and climate risk reduction benefits could be enhanced as a result.

Technical assistance and capacity building to support governance and institutional strengthening

In addition to knowledge management and project preparation there is also a need to develop and enhance the governance and institutional frameworks and capacity of the city.

Projects 6, 12 and 13 include proposals for enhanced regulatory, policy and follow up/ enforcement mechanisms. There is a need for specialist expertise to be drawn upon to establish and develop these frameworks working alongside the Corporation other Urban Local bodies as well as State Level Bodies.

In parallel, as frameworks are formalised and agree there is a need to develop the human resources to implement the frameworks. As there is very limited resources available recruitment and training of a new cadre of technical and professional staff will be needed.

Project and programme management capacities

Given the scale of projects and programmes in the city to be developed and implemented over a sustained period of 10-15 years or more there is a need to enhance the project and programme management and co-ordination capacities in the city. Linking with project 12 a locally based programme and project implementation manager and team would be needed to link across different programmes being funded and delivered by the responsible agencies.

A number of different types of funding sources are relevant to the delivery and implementation of project preparation and capacity building programmes including funds from the Ministry of Urban Development National Urban Renewal Mission (NURM) fund as well as programmes such as the Ministry of Environment and Forest programmes including those relating to Missions under the National Climate Change Action Plan. Programmes from international and bilateral development agencies such as the World Bank, Asian Development Bank, GIZ and UK DFID also have programmes which could be drawn upon in order to source financial support for the types of initiatives described under the action plan projects and summarised above.

Possible finance sources which could support revenue raising projects

Municipal bond market

The Indian municipal bond market has not been looked at as a serious option for financing projects. Small and medium sized Municipal Corporations face hurdles of low ratings, reluctant investors and unclear regulations. With emerging national guidance and regulatory support in the pipeline, Madurai in partnership with State level bodies could take advantage of the Bond market to raise capital to service some of its infrastructure projects.

In order to make projects investible and gain the trust of investors, the city would need to demonstrate transparency in responsible governance and target oriented delivery, above the mandatory regulatory compliance. The bond market could be used to fund projects that require a delivery horizon and offer a lower return.

Blended funding and public private sector partnership through TNUDF

The evolution of Tamil Nadu Municipal Urban Development Fund (TNUDF) into a public private entity with the private sector equity participation to form Tamil Nadu Urban Infrastructure Financial Services Limited (TNUIFSL) offers debt for civic infrastructure and is tasked with improving the living standards of urban population.

TNUIFSL can support Madurai city in facilitating private sector participation in infrastructure through joint venture and public-private partnerships, and the City's ability to access debt finance from the market where required. The integration of city partnership can offer flexibility in packaging certain projects and services through the bond market and PPP routes. Projects could be packaged to offer a return on investment which would be attractive for private sector participation. The range of projects which may be suitable could include solid waste collection service with a recycling centre or energy from waste centre or integration of renewable energy with affordable housing provision.

Land based finance and levies to enable cost recovery of public infrastructure investment

The City could develop pooled funding vehicles to enable area based land development and infrastructure projects (for Greenfield areas) as well as schemes for regeneration and renovation of infrastructure and urban development within established areas of the city.

Proposals could be developed through land consolidation/readjustment and Town Planning Schemes. The increase in land value created through providing infrastructure and developing land. Schemes should be developed with full consultation with all existing land owners and others with interests in the identified area. Land based finance could be linked to for example a Municipal bond to fund the planning and delivery the integrated infrastructure for a new eco-neighbourhood including procurement of land, construction of infrastructure and the recovery of investment through land sale, levies and user charges.

Funding to support revenue generating capital programmes

The remaining projects require significant capital investment some of which may not be possible to recoup directly. Projects include 1B - completion of sewage infrastructure; 5B Channel and tank restoration; 8 A, B, C, D - Separation of sewers and storm drains, construction of adequate surface drainage, flood storage and defences; 10B,C,D and E Reuse of waste water, local water treatment facilities, mains replacement, pressure management and metering.

Established national programmes such as NURM have been established to enable ULBs and State level bodies to leverage funds to co-fund capital investment.

In addition to attracting support from national (NURM) and international programmes of the development banks, projects which provide a stream of revenue which can be used to repay loans for capital projects could be suitable for sourcing all or part of their finance from a wider range of funders.

These may include national development banks and funds such as Tamil Nadu Urban Development Fund and IDFC (Infrastructure Development Finance Corporation) who may in turn be able to access and draw upon private sector finance or help to develop and structure public-private partnership arrangements.

The range of projects which could be eligible relate to water resources and supply projects, sewer and sanitation projects as well as solid waste management projects. Plans for new land development including future proofed infrastructure may also be attractive to a range of finance providers including the private sector.

Funding to support non revenue generating capital programmes

Capital programmes which include components which are non revenue generating such as social and environmental actions which may be necessary to maximise the poverty reduction and climate risk reduction benefits. They may even be required to make investment in hard infrastructure effective in achieving its intended outcomes. Funding could be sourced from international donors and/or funds linked to International Climate Funds (ICF) or other green finance mechanisms. Programmes include:

- World Bank Low Carbon Liveable Cities
- ADB-DFID-Rockefeller Urban Climate Resilience Partnership
- GIZ Urban Nexus and Eco Cities programmes.

Revolving credit and guarantee mechanisms operated by a number of international development institutions may also be available and be provided in return for delivery of enhanced socioeconomic and climate change related benefits.

The table below provides a summary of the costs of all of the projects included in the action plan.

The projects as defined in this action plan have assumed that widespread action across the city would be needed to support transformational change and the costs identified have allowed for this.

It should be re-emphasised that the costs provide a preliminary estimate of the costs of each project recognising that the implementation of projects will span the period from 2014 - 2031.

In particular there are very broad ranges for the infrastructure capital programmes included within the plan. This is because further technical feasibility and concept design work is required to develop appropriate solutions and to identify the cost of these.

The project components relating to pre-feasibility and social capital building and community initiatives have a narrower range of costs.

Detailed specification and project design would be the next stage to establish a budget cost.

A targeting strategy for the proposals to confirm which parts of the city should be informed by pre-feasibility work and engagement between the City Partnership Group.

Table 4.2 - Summary of initial estimated project costs

Project	Part	Description	Cost range
1 Sewer system rehabilitation	A	Mapping of sewer system	up to US $1million
	B	Completion of the sewerage infrastructure	US $100 million
	C	Community up to $1m	
2 Sanitation community capacity building	A	Community capacity building	up to US $1million
3C Improved solid waste infrastructure	A	Introduce PPP approach for both primary and secondary waste collection	Up to US $500k
	B	Development of Anaerobic Digestion facility for managing organic waste	US $5-10m
	C	Developing basic recycling infrastructure	Up to US $1m
4 Improved solid waste management	A	Waste data collection	up to US $250,000
	B	Community awareness and education	up to US $100,000 (annually)
	C	Formalising the informal	up to US $100,000 (annually)
	D	Integrated waste management plan	up to US $500,000 initial set up and development; ongoing internal annual costs
5 Channel and tank restoration	A	Further mapping of channel and tank system, and improved understanding of interactions and operations	US $5 million
	B	Restoration of channels and tanks, especially south of the River Vaigai. To address potential climate impacts	US $10-$100 million

Project	Part	Description	Cost range
6 Channel and tank protection	A	Establishment or refinement of operational rules	$1-$10 million
	B	Abstraction management	$1-$10 million
	C	Discharge regulation and management, to prevent discharge of sewerage and industrial effluent into channels and tanks	$1-$10 million
	D	Encroachment management	$1-$10 million
7 Channel and tank community involvement	A	Channel and tank community involvement	up to $250,000
8 Flood and surface water infras improvements	A	Separation of sewers and storm drains	$1-$10 million
	B	Construction of adequate surface drainage	$10-$50 million
	C	Flood storage	$10-$50 million
	D	Flood defences	$10-$50 million
	E	Green infrastructure improvements: areas	$10-$50 million
9 Flood and surface water capacity building	A	Rural soil erosion management	up to $1million
	B	Flood risk awareness	up to $500,000
10 Water resources infra improvements	A	Study to examine the feasibility of reusing waste water	up to $1million
	B	Provision of local water treatment facilities	$10-$100 million
	C	Mains replacement	$10-$100 million and over
	D	Pressure management	$1-$10 million
	E	Metering	$10-$100 million and over
11 Water resources capacity building	A	Water Safety Plan	$1-$15 million
	B	Rain water harvesting. This is mandatory	up to $10 million
	C	Education on water sources and hygiene (linked with sanitation training)	up to $250,000

Project	Part	Description	Cost range
12 Blue-green Infrastructure coordination	A+B	Establishment and enablement of agreed City Partnership coordination structures	$250,000-$500,000 (excluding staff resourcing costs)
	C	Infrastructure standards and co-ordination procedures to enable effective infrastructure delivery	$250,000-$500,000
13 Green City Plan Linking to the City Development Plan and Masterplan	A	Policies on channel and tank protection	$250,000 - $500,000
	B	Identification of zoned areas/overlays for flood protection areas and supporting policies	$500,000- $1,000,000
	C	Identification and zoning of natural habitat areas and establishment of management norms	$250,000 - $500,000
	D	City greenspace plan with design and management standards	$250,000 - $500,000
14 Platform for community participation to develop and deliver city plans	A	Establishment and enablement of agreed community participation platform	$100,000

Preliminary Combined Cost Estimate is between US$195.8m to US$764.1m+
(dependent on cost of infrastructure delivery)

Some of the resources to implement proposals has been earmarked within existing budgets and it will be necessary to related planned expenditure and projects to the action plan proposals which take a long term perspective.

In parallel to the action plan process Madurai Corporation has developed Detailed Project Report budgeting estimates for series of projects within the Corporation area highlighted in Table 4.3 which equate to around US$900m.

These estimates are not directly comparable to the estimates in the plan as the scope and extent of projects is narrower.

However, budgets have been identified which include a significant range of the proposals included within projects 4, 5, and 10. In addition budget estimates have been provided for bringing a full range of infrastructure to the Wards newly added to Madurai Corporation where there is very limited infrastructure at present.

There are also proposals for Bus Rapid Transit and Road Over-bridge improvements which are not related to the focus of this action plan on blue-green infrastructure.

Table 4.3 Provisional Detailed Project Report Estimates

Name of the work	Preliminary cost estimate USD $	Action plan project the DPR is linked to
Solid waste management - Disposal of MSW through pyrolysis or methanisation	$ 24.8m	Project 4
Water bodies improvement project	$25m	Project 5
Revamping the existing water supply distribution system for old city area.	$63.8 m	Project 10
Source augmentation to water supply for the old city area	$94.3 m	Project 10
Storm water drain for the newly added area	$174m	Multiple projects
Water Supply Distribution System for the newly Added Area	$72.2m	Multiple projects
Source augmentation to water supply for the newly added area	$126.8m	Multiple projects
Under ground sewerage scheme for the newly added area	$100.3m	Multiple projects
River over bridge at Kuruvikaran Salai and Obulapadithurai, Anna nagar, KK nagar	$14.6m	Not related to the action plan
Bus Rapid Transit System (BRTS)	$203.2m	Not related to the action plan
Total	$899.1m	

Source: Madurai Municipal Corporation

Next steps

This plan will be shared and used to engage with potential project funders to explore how individual projects could be further developed and supported.

A more detailed phasing and budgeting plan can then be developed for the short term actions within the plan for the first five to six years.

This should link with the planning and budgeting process of Madurai Corporation and other State Level bodies whose support would be required to develop and approve individual projects.

End note

A further final report which provides a comparison of the future proofing action Plan process in Madurai and Bangalore has been produced. This provides lessons learned from applying the approach and key issues which are relevant to cities who may also wish to explore applying a similar approach in their city.

05

APPENDICES

Appendix A: Case studies Applying the approach at a neighbourhood level

This chapter considers how the city level approach to blue-green infrastructure specified in the action plan could be applied at the neighbourhood level. A case study area of the Thideer Nagar slum, on the banks of the Kiruthumal river has been used to demonstrate how the strategy can result in locally specific actions that can be taken forward by the city.

The value in applying a locally-focused approach

A key outcome from the consultation with various stakeholders was the need for an area focused strategy to test pilot initiatives and the ability of these to address the immediate needs of local people. A locally focused strategy should act as a vehicle to disseminate the principles of the city level strategy set out in previous sections of this document.

How the Thideer Nagar case study area was chosen

Detailed research was undertaken to understand the range of blue-green infrastructure issues along the Kiruthumal river corridor. Detailed documentation consisted of mapping, photo and video of about 15km of the corridor, from its origins at the outskirts of the city to the more urban sections, interviews with a wide range of people who lives alongside the river, and three focus group meetings (two meetings with communities living along its edges and one with experts, government officials and major land owners).

This primary fieldwork and action research lasted for four weeks in November 2013. The way the river corridor transforms from its natural spring origins to various locations across the city was documented in detail to understand the socio-spatial-ecological interactions and governance issues. This process revealed the complex risks and vulnerabilities that many people in Madurai are exposed to as a result of the state of blue-green infrastructure, as well as the challenges that lie ahead for Madurai's sustainable growth.

This research revealed that, although most areas have a set of complex interrelated blue-green infrastructure challenges, in some areas the issues are more urgent than others. In the Thideer Nagar slum there is a diverse mix of issues ranging from solid waste dumping and sanitation issues to lack of sufficient infrastructure (including storm water drains and drinking water connections). The magnitude of interconnected issues in the Thideer Nagar slum is significant and impacts on the quality of life and vulnerability of local residents.

Following consultation with the Madurai Municipal Corporation, it was decided that Thideer Nagar should form the first focus for the application of the city level strategy to improve blue-green infrastructure. Thideer Nagar is a small slum community abutting the Periyar bus stand, at the heart of the city. The community has a population of 5,750 people, with around 1,500 households. The definition of the Thideer Nagar area is shown in Figure A1.

These key issues have been explored in order to demonstrate the approach at neighbourhood level:

- sanitation
- flooding
- solid waste
- water supply.

Figure A1 - Definition of Thideer Nagar area

Sanitation

Figure A2 - Key sanitation issues in Thideer Nagar

LOCATIONS	ISSUES	POTENTIAL SOLUTIONS
S1	Newly constructed houses have open septic tanks, discharge sewage and waste into the channel. Community toilets are located within the slum, that have been recently renovated with Community participation, however there is shortage of such community toilet units. Out of a population of 5000 people, only 400 people are using the toilets, and several units are underutilized. Some Municipatility toilets are not under use as they need to be retrofitted and renovated to avoid leakage	Community toilets already built to be retrofitted with the help of Corporation and community participation. Additional toilets to be built based on shortage
S2	Individual toilet facilities along the railway line directly discharge excreta into the Kiruthumal channel	Community sensitisation and awareness programmes on Health, Safety and Hygiene. Open defecation to be stopped with immediate effect
S3	Cow-shed along the channel adds to the pollution levels and the animal waste is also dumped into the Kiruthumal channel	Measures to collect and discard Livestock waste and excreta and prevent dumping into Kiruthumal
S4	The newly constructed sewage pipeline discharges directly into the Kiruthumal channel, every street has manholes that are connected to the central sewage outlet, however it is not pumped to Avaniyapuram treatment facility which is utilized only 10%	Septic tanks and underground drainage facilities in the newly constructed BSUP houses need to be fixed
S5	The corporation drinking water supply line runs along Kiruthumal that's leads to mixing of sewage with drinking water	Installation of separate drinking water pipelines to prevent mixing with the sewage

Table A1. Key sanitation issues and solutions in Thideer Nagar

Flooding

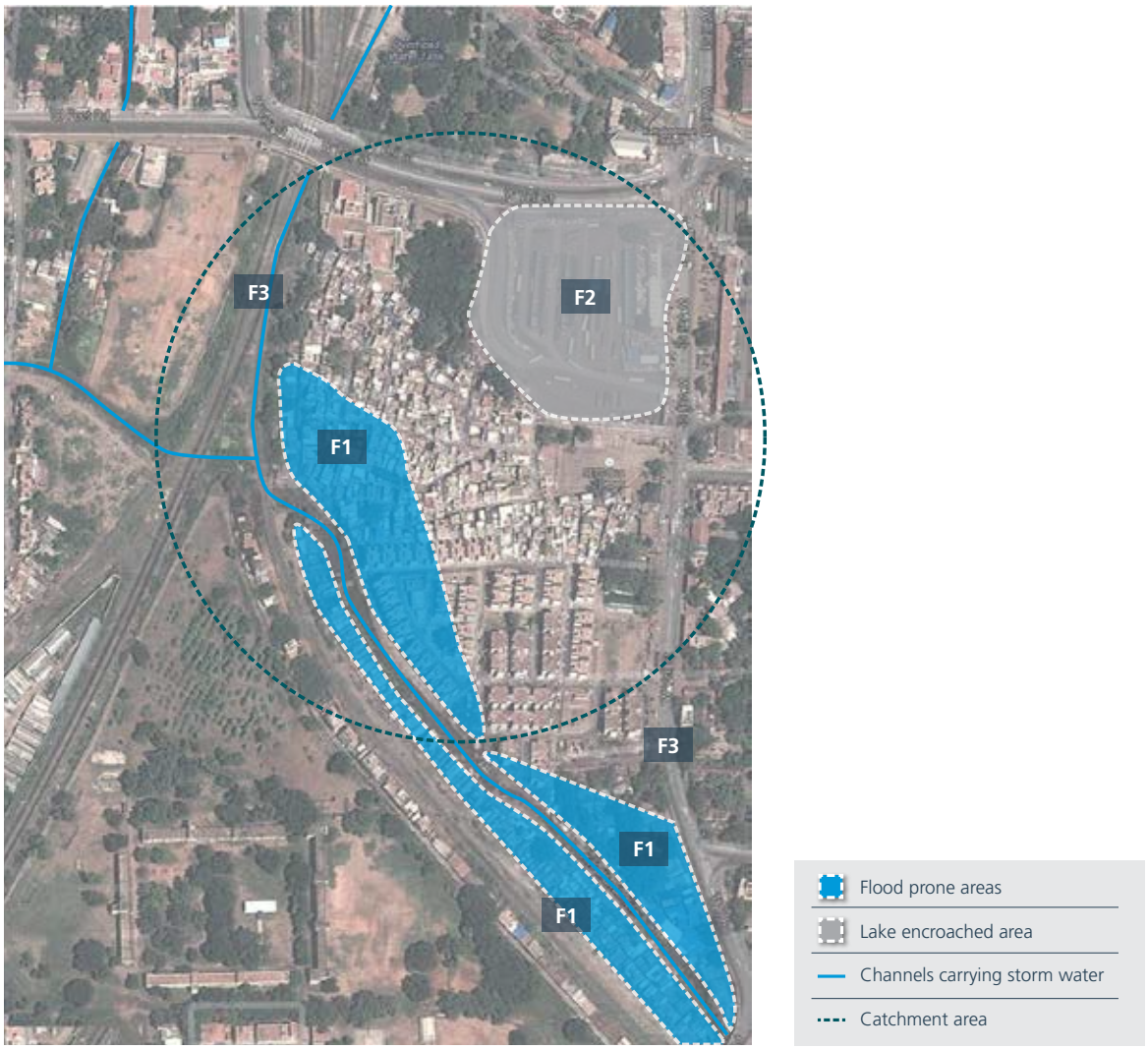

Figure A3 - Key flooding issues in Thideer Nagar

LOCATIONS	ISSUES	POTENTIAL SOLUTIONS
F1	Most of the Thideer Nagar slum, which is along the Kiruthumal channel and the entire Heera Nagar slum which falls under Railways objectionable slum are flood prone and area submerged up to 3 feet in water during heavy downpour. Flooding can be traced up to the 2nd block of the slum locality	Concretiasation of Kiruthumal channel is essential to prevent water logging of all the slums along the channel, and the channel needs to be deepened to carry surplus water during heavy rains.
F2	Periyar bus stand has been built on a dried up lake command area and hence the natural gradient makes the entire Thideer nagar -Heera nagar area as low lying and prone to flooding. The Kiruthumal channel overflows during heavy rains, clogged drains and sewer are overflowing, owing to pressure from rain water in the Kiruthumal channel	Raising the level of the foundation to avoid these low lying areas from getting submerged during heavy rainfall
F3	The storm water drains along the Kiruthumal channel are narrow and insufficient to carry surplus rain water and the excess water overflows to the slum residences and the narrow lanes of Thideer Nagar slum gets water logged. Water displacement is a major issue in the low lying settlements	Reinforcing infrastructure - Storm water drainage within the slum need to be improved and well connected to avoid leakage.

Table A2. Key flooding issues and solutions in Thideer Nagar

Solid waste

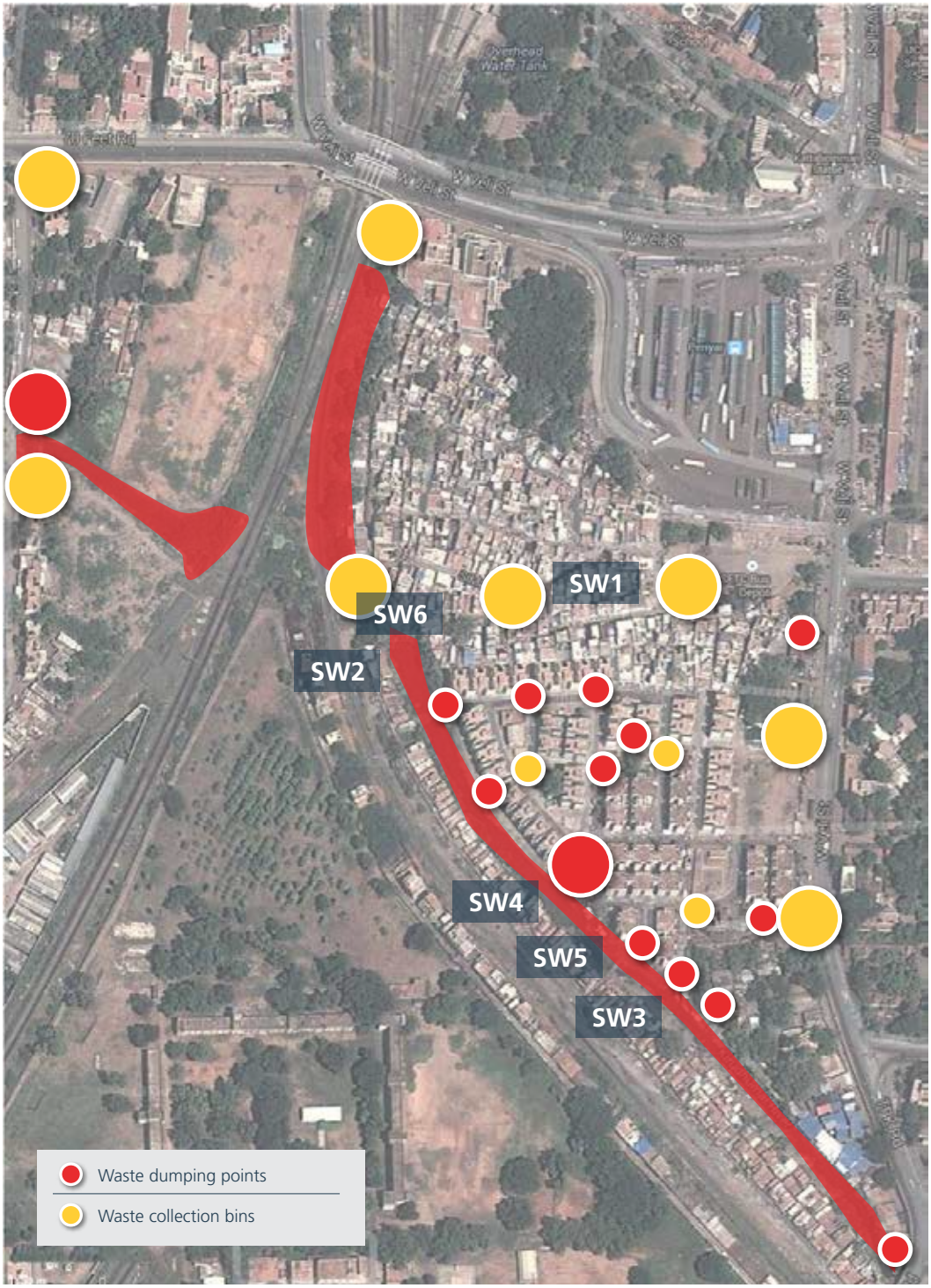

Figure A3 - Key solid waste issues in Thideer Nagar

LOCATIONS	ISSUES	POTENTIAL SOLUTIONS
SW1	Inadequate waste collection points within the streets, the frequency of waste collection is once every two days. Door to door waste collection is absent, leading to unhygienic waste dumping practices, into the Kiruthumal channel.	Awareness building and community sensitisation Installing more waste collection bins at regular intervals Dry and wet waste separation at source
SW2	Thideer Nagar has a total of 1500 HH, with a population of 5,423 people. Solid waste generated is approximately 0.6 tonnes/day. (63,000 tonnes of SW/year generated in Thideer Nagar). It comprises of 100% untreated and unsegregated biodegradable and non biodegradable waste that are dumped into the streets, pathways and into the Kiruthumal channel along the railway line.	Compost making was once initiated in the slum however the practice has been discontinued due to lack of community participation. This should be started again with Corporation & community accountability.
SW3	Majority of the waste collected from within Thideer Nagar and Heera Nagar are dumped along the Kiruthumal Channel abutting the railway line, clogging the channel further.	Cleaning of Kiruthumal channel with Community participation and Corporation engagement
SW4	The slums and squatter settlements along the channel which do not have private toilets and underground drainage system, directly discard the waste into the Kiruthumal channel and opt for open defecation. Discharge of human and animal excreta directly into the channel is common.	Awareness building and community sensitization to prevent open defecation and adopt hygienic practices. Community accountability to be strengthened and watch dog to prevent such practices.
SW5	Livestock waste and feed account for a major portion of the waste and the stagnant garbage attracts mosquitoes on a regular basis.	Separation of animal and human waste to be done. The segregated waste need to be disposed off at proper points to prevent waste dumping in Kiruthumal
SW6	Anaerobic degradation of waste can be observed on the waste dump sites along the entire Kiruthumal channel.	This should be cleaned with community action and waste stagnation and dumping in this area must be stopped.

Table A3 - Key solid waste issues and solutions in Thideer Nagar

Water

Figure A4 - Key water supply issues in Thideer Nagar

LOCATIONS	ISSUES	POTENTIAL SOLUTIONS
W1	The Chinthamani channel mixes with the Kiruthumal channel and enters as one channel carrying solid, liquid, sludge, sewage, drainage and storm water discharge	The untreated sludge mixing with sewage and entering the Kiruthumal channel to be stopped with immediate effect and to be redirected to a temporary treatment unit to prevent further pollution of the channel
W2	The water supply line is running through the Kiruthumal channel and is mixing with sewer, making the water unpotable	The drinking water line must be reinforced with immediate effect to prevent any leakage and mixing with sewage to improve the drinking water quality in the slum
W3	There are roof water harvesting facilities which are incompletely constructed in the newly built Jnnurm houses along the channel	Strengthening of the roof water harvesting units can be undertaken to improve water conservation.
W4	Public taps and Hand pumps installed by the Corporation are the main source of drinking water in Thideer Nagar. Such water sources are located in each individual street and from February, due to the onset of Drought conditions, the slum will be receiving the water supply once in four days. Bore wells and sumps and located at periodic intervals but there in considerable water deficit due to prevailing water conditions	Infrastructure strengthening: Ensure continuous and potable water supply to the community through water tankers and installing adequate water storage units.
W5	Majority of the storm water drainage channel running along the Kiruthumal channel, ultimately drains into the channel which has turned into sewage water carrier. All storm water drainage channels are also presently being utilized as an alternative to the underground drainage system adding to the pollution	The Villapuram channel to be developed as flood recharge tank. The storm water drains running parallel to the Kiruthumal channel needs to be cleaned and should be connected well to the existing lines within the slum to ensure there is no overflow

Table A4 - Key water supply issues and solutions in Thideer Nagar

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