ATKINS

# FUTURE PROOFING INDIAN CITIES

## FINAL URBAN DIAGNOSTIC FOR MADURAI

**January 2014**

Atkins in partnership with

dpu Development Planning Unit

UCL

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INDIAN INSTITUTE FOR HUMAN SETTLEMENTS

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# Summary

*Madurai has significant potential to play a major role in the future development of Tamil Nadu. However, the city has a significant proportion of its population living in slum areas. The city is growing rapidly, creating challenges in ensuring the provision of adequate infrastructure, housing, and basic services to meet the growing demands of its residents.*

*At the same time, Madurai is facing a wide range of risks to its future growth and prosperity from issues such as water scarcity, climate change, damage to important natural habitats, and growing traffic congestion associated with private vehicle use. Unchecked, these issues could place a significant break on future economic growth and improvements on the quality of life of its residents. However, Madurai has an opportunity to address these issues as part of its growth aspirations by looking at actions it can take now to future proof its development.*

*Analysis and consultations with a wide range of state and city level stakeholders as part of this urban diagnostic summary has shown that gaps in Madurai's 'green-blue infrastructure' is perhaps the most pressing nexus of challenges the city needs to address to safeguard its long term future.*

*The range of issues of particular importance include increasing demand for water resources, poor water distribution infrastructure, and contamination of existing supplies when combined could constrain the capability of Madurai to grow and prosper in the future as the needs of the city and wider region grow.*

*The severe water stress Madurai and the wider Vaigai Basin are already experiencing and the interconnectedness of Madurai's 'blue –green infrastructure' mean that the city will be impacted by climate change. The direct impact of climate change on blue-green systems along with indirect impacts such as the spread of communicable diseases means that addressing this nexus of issues figures high in the list of priorities for city stakeholders.*

*Madurai now 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 embraces integrated water resources management with management of urban growth and covers 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 in the context of a changing climate. The next phase of this project will focus on working in partnership with stakeholders to develop a City Action Plan (CAP) which identifies and develops transformative solutions to future proof Madurai's 'green-blue infrastructure.'*

*This document has been prepared for an audience of government, private sector and civil society stakeholders. The process of the preparation of this document proved useful in provoking discussion and debate among the wide range of stakeholders and in helping to determine the priority areas for action around which City Action Plans (CAPs) can be developed in partnership with and driven forward by key stakeholders. This document provides a synthesis of the key issues and priorities which have emerged from this dialogue, as well as information and issues highlighted within plans and strategies which have been developed for the city.*

*The document is also helping Madurai to make its case externally. Summaries and presentations of the document have reached a broad audience in the city through channels including the Madurai Symposium, local media and online forums which have built momentum beyond activities originating from the project.*

# 1. Introduction

## 1.1. The Future Proofing Indian Cities project

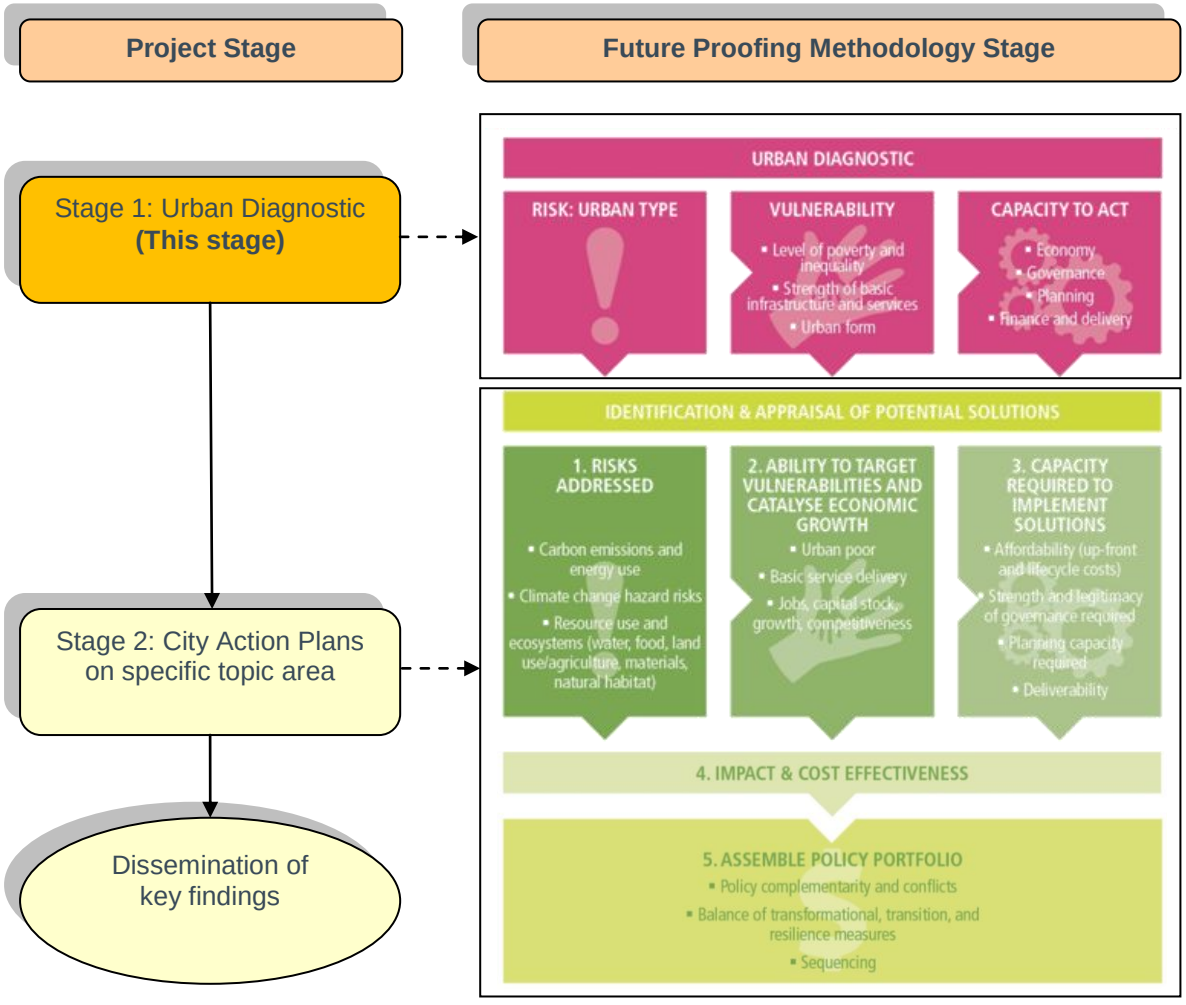
In March 2013, Atkins, supported by the Development Planning Unit of University College London and the Indian Institute of Human Settlements, were commissioned by the Climate Development Knowledge Network (CDKN) to undertake action planning with the city authorities of Bangalore and Madurai, focussed on developing future proofed urban strategies in the cities.

**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.

### 1.1.1. Overall approach to the project

The project is being 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). This report summarises the outcomes from the Urban Diagnostic stage, which identifies the key urban development challenges faced by the city and the capacity of the city's stakeholders to act to address these challenges. The outcomes of this stage form the evidence base to inform the production of an Action Plan for Madurai, which will be focused on a specific topic area. The identification of this topic area is also a key outcome of this stage of work.

**Figure 1. Overall approach to this project**



## 1.2. The choice about Madurai's future

**Madurai is an important city with significant potential to play a major role in the future development of Tamil Nadu.** Serving an extensive rural hinterland, Madurai is the most important trade and commerce centre in southern Tamil Nadu and has become the State's second largest city. The heritage assets which have made the city famous, and its role as a religious and pilgrimage centre and tourist gateway city to southern India, generate an estimated 210,000 visitors to the city every day.[1] Tamil Nadu State recognises the important role that Madurai could play in helping to realise the State's future growth potential and its objectives of boosting per capita income to US$10,000 per annum, enhancing levels of social development, and providing high quality infrastructure comparable with the best in the world.[2]

**Stakeholders in Madurai have made strong commitments to harnessing this potential to enhance the quality of life of its residents.** For example, the Madurai Corporation has committed to ensuring the city becomes slum free, provides universal water supply and underground sewerage system coverage, and improves the processing and management of waste.[3]

**However Madurai is growing extremely rapidly and this is creating significant challenges in ensuring the provision of adequate infrastructure, housing, and basic services to meet this growing demand.** The population of the city has grown by 23% in the past decade alone[4] and is expected to continue growing at a similar rate, rising to over 2 million people by 2031.[5] The economic base of the city, measured by GDP, could grow by over 200% between 2010 and 2025, increasing GDP per capita to almost three times that of 2010 levels.[6] The economic growth facilitated by the growth in tourism and the wider service sector has attracted significant number of migrants to the city from the rural hinterland.[7] This level of change has significant implications in terms of the infrastructure, housing, and local services required to support an expanded population.

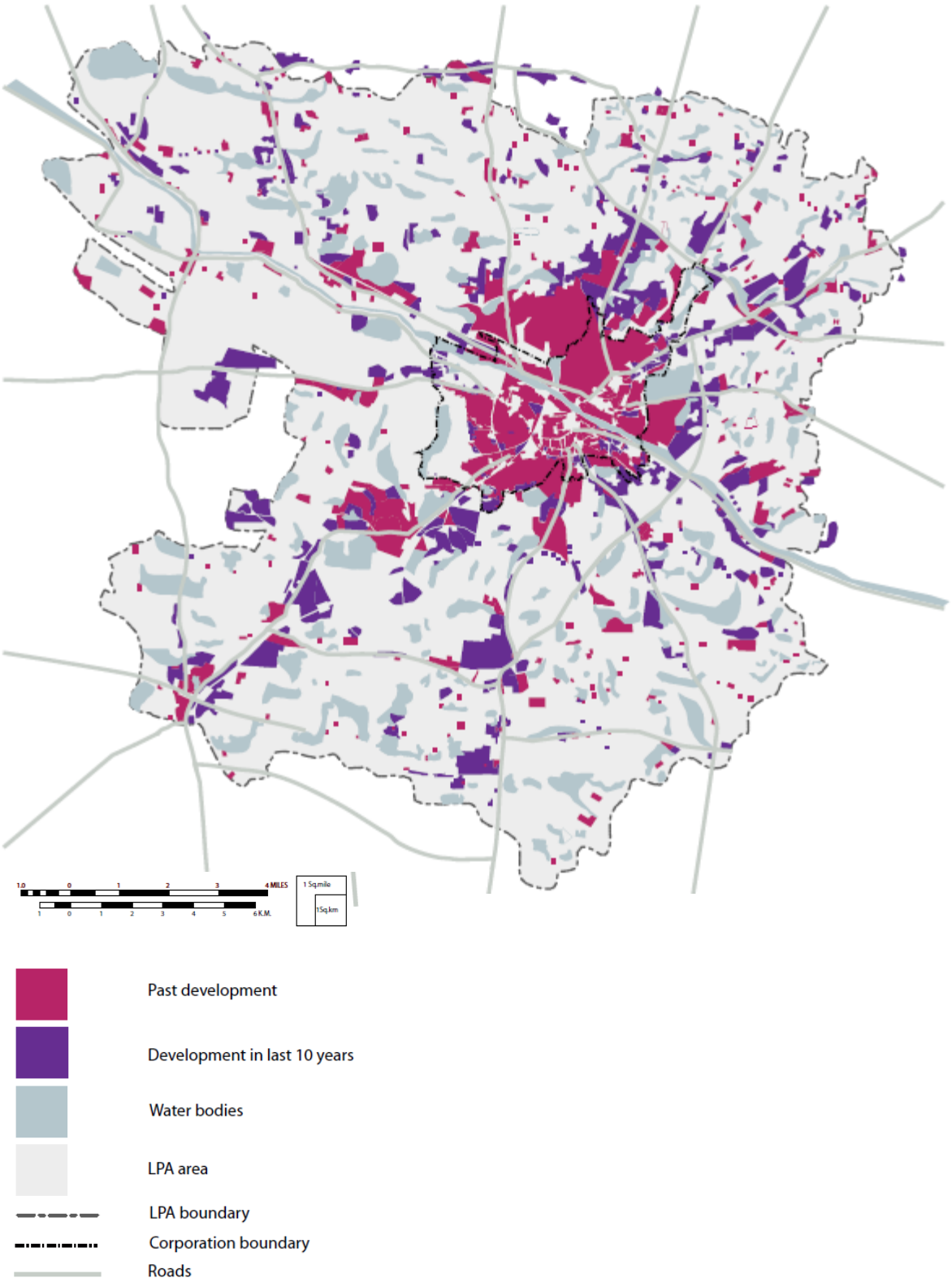
**Table 1. Population and economic growth dynamics for Madurai**

| Key indicator | Number |
|---|---|
| Population (2010) | 1,364,991 |
| Population (2015) | 1,508,782 |
| Population (2025) | 1,856,095 |
| Population (2031) | 2,100,000 |
| Growth % 2010-2031 | 54% |
| GDP per capita 2010 ($) | 5,899 |

Source: Atkins drawing on data from UN and C-GIDD

[1] Madurai Corporation Slum Upgrade Report
[2] Tamil Nadu Vision 2023
[3] Madurai City Communique 2
[4] Atkins analysis of 2011 and 2011 Census of India
[5] UN Population Projections
[6] C-GIDD Data
[7] Madurai City Development Plan

**Figure 2. Madurai is growing rapidly as a city. Over the last 10 years development the city core has grown outwards and pockets of dispersed development have taken place in many parts of the city. The areas selected were sometimes not planned in advance and some are lacking in key infrastructure**




Source: Atkins

**Madurai faces significant challenges to ensure that the proceeds of future growth can be distributed to address the high proportion of the city's residents who live in poverty.** Recent data suggests that around a quarter of households and some 278,100 people in the Madurai Corporation Area are living in slums. An even larger number could be considered to be living in Multi-Dimensional Poverty (MDP) with significant percentages of these people being deprived in electricity, water, and adequate sanitation. A significant proportion of households in Madurai are deprived in terms of access to adequate electricity and water supplies, with access to adequate sanitation being an issue of particular concern.

**Table 2. Selected urban poverty indicators for Madurai 2011**

| Key indicator | Number of Households (2011) | % of Total Households in Madurai (2011) |
|---|---|---|
| Urban Slum Population (2011) Madurai Corporation | 72,799 | 24.9% |
| Households without access to electricity Madurai Urban Area | 12,678 | 2.6% |
| Households who receive water from an untreated source Madurai Urban Area | 53,151 | 11.1% |
| Households without access to latrines. Madurai Urban Area | 75,580 | 15.8% |

Source: Statistical handbook of Madurai District 2011 – 2012, Madurai Corporation. Madurai Urban Area comprises of 478,813 Households of which an estimated 292,309 Households are located within the Madurai Corporation boundary. Note the average household size in Madurai District is 4.2 persons.

**At the same time, Madurai is facing a wide range of risks to its future growth and prosperity from issues such as climate change, water scarcity, damage to important natural habitats, and growing traffic congestion associated with private vehicle use.** If left unchecked, these issues could place a significant break on future economic growth and negatively impact the quality of life for its residents.

However, the good news is that **Madurai has an opportunity to address these issues as part of its growth aspirations by looking at actions it can take now to future proof its development**.

## 1.3. Purpose of this document

### 1.3.1. Rationale and purpose of the document

The purpose of this document has been to stimulate a discussion among local stakeholders concerning the future development issues facing Madurai and the role climate change could play in exacerbating existing risks and pressures.

Governmental Stakeholders are seeing the diagnostic as an advocacy document which can be used to engage with State and National governmental bodies and evidence the multiple intersecting issues facing the city. It is the first time such a document has been prepared in relation to Madurai with the issues synthesised in one place. The diagnostic has proved a catalyst and useful aid in drawing in other government bodies into the process of exploring future proofing opportunities for Madurai beyond direct Service Beneficiaries.

Following the issuing of the document many organisations and stakeholders have come forward with additional information and views regarding the risks and how they could potentially be tackled which has been fed in through the Madurai Symposium and Action Planning engagement activities to build upon the foundation provided by the diagnostic. Summary presentations of the document including some in Tamil have been shared with wider ranges of city stakeholders.

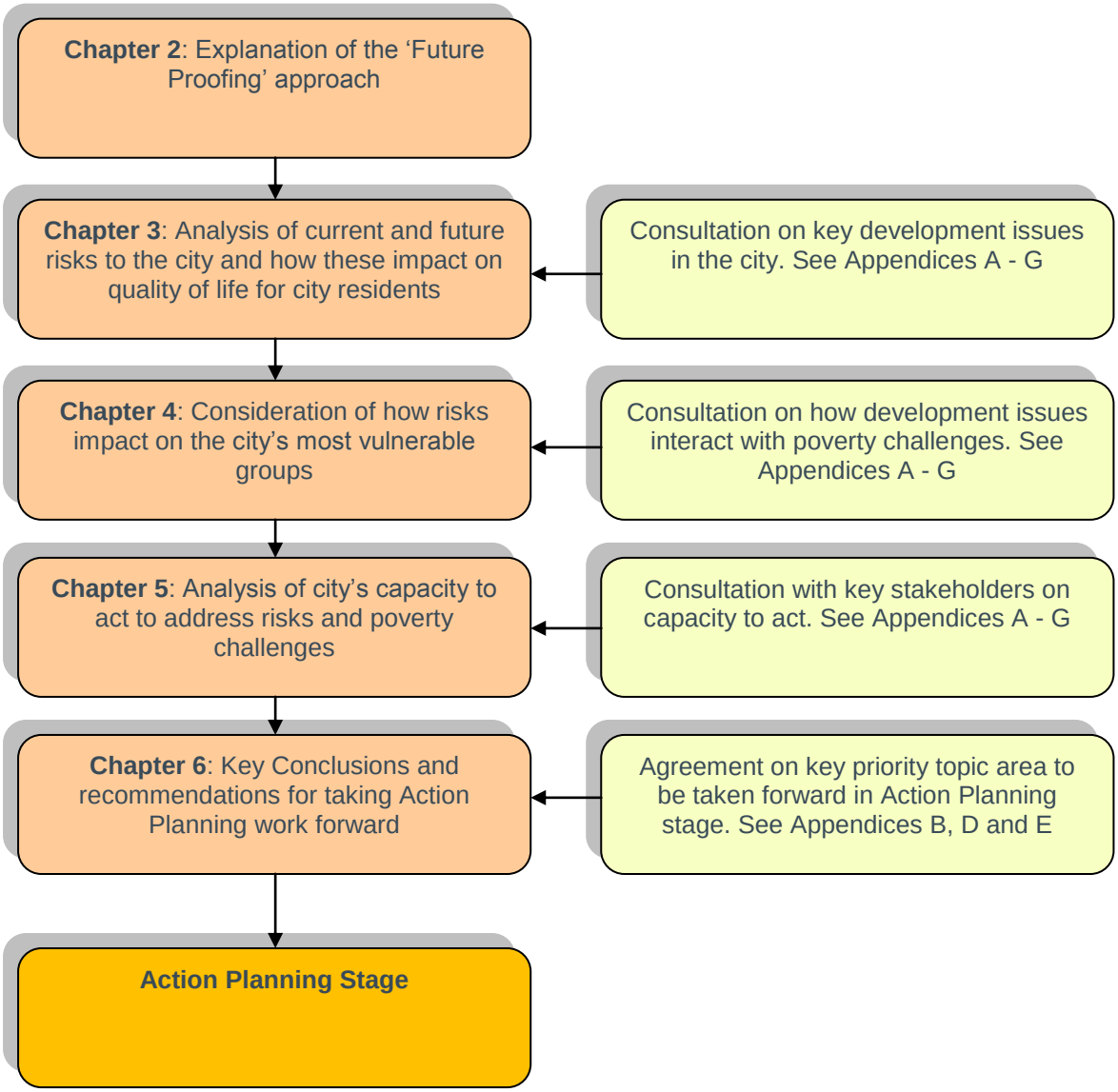
**Figure 3. More than 500 people attended the Madurai Symposium. As well as the plenary an exhibition took place to collate feedback from the community and a special session took place (pictured above) to discuss Madurai's Future.**


In turn civil society stakeholders have reported that the document will be useful as it provides documentation of the existing and potential issues and risks facing the city which can be shared more widely. Already the document has been helpful in sparking debate in the city through the media and in online forums in terms of prompting calls for action among city stakeholders and from governmental bodies. It was reported that while the scale and extent of Madurai's issues and are well known from lived experience at the individual issue and neighbourhood level these have not previously been summarised or related to one another in a single document. In addition the links made at city level as well as the links between the City Corporation and the wider Local Planning Area and beyond is also relatively new. Debate has become more active in the city with stakeholders discussing what needs to be done and eyeing some of the transformational opportunities which could assist the city in making a leap forward on multiple fronts.

## 1.4. Structure of this document

Figure 4 illustrates the approach adopted for this stage of work. It also demonstrates the interrelationship between consultation with stakeholders and the development of the diagnostic.

**Figure 4. Study Approach and Consultation**



# 2. The Future Proofing Approach

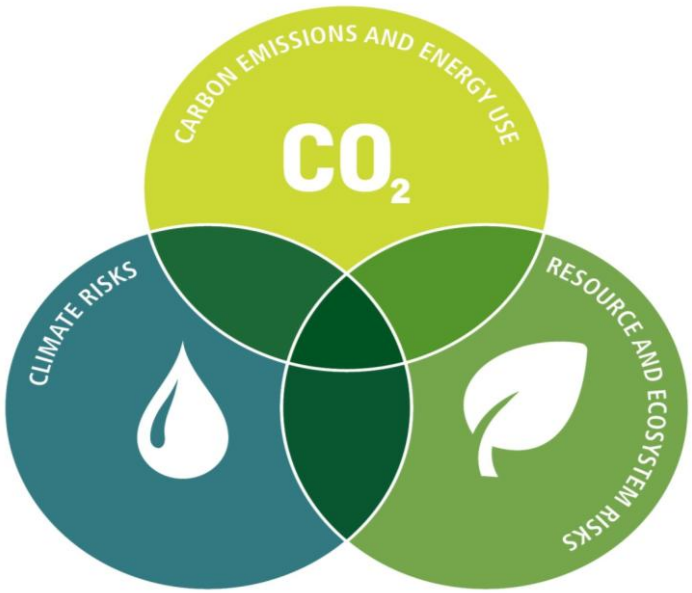
**In order to tackle the risks to its future growth as well as to meet the demand for adequate infrastructure and basic services, Madurai could benefit from a new approach to urban development: a 'future proofing' approach.**[8] Future proofing is about identifying and developing integrated solutions 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**. Madurai's current approach is often still too sectorally focused to be fully effective in dealing with the complex, interlinked issues facing the city. 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 5. Future Proofing Approach: Integrated Assessment Framework**




Source: Atkins

[8] Future Proofing Cities (2012), Atkins in partnership with DFID and UCL

**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.** The approach differs from most current approaches to urban development which tends 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; and
- The identification of measures which can be implemented and driven forward by stakeholders within the city given current capacities

# 3. Risks to Madurai's Future Growth and Prosperity

**Madurai faces significant risks[9] to its future growth and prosperity, including efforts to reduce urban poverty.** These risks include those from climate hazards such as flooding, risks related to critical natural resources such as water, and risks associated with rising carbon emissions and increasing energy intensity of development. These risks cannot be looked at in isolation - they are multiple, interlinked, and they are growing.

## 3.1. Climate hazards

### 3.1.1. Current risks

**Madurai faces a range of climate hazards – particularly flooding - which already impact 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 Madurai Coats on the northern bank of the Vaigai River. Other flood prone areas include Simakkalam, the area near to Amritham Theatre, the area near to Tallakulam Perumal Kovil temple, Narimedu - Kattabomman Nagar, and the Menakkshipuram – Bibikulam area.[10]

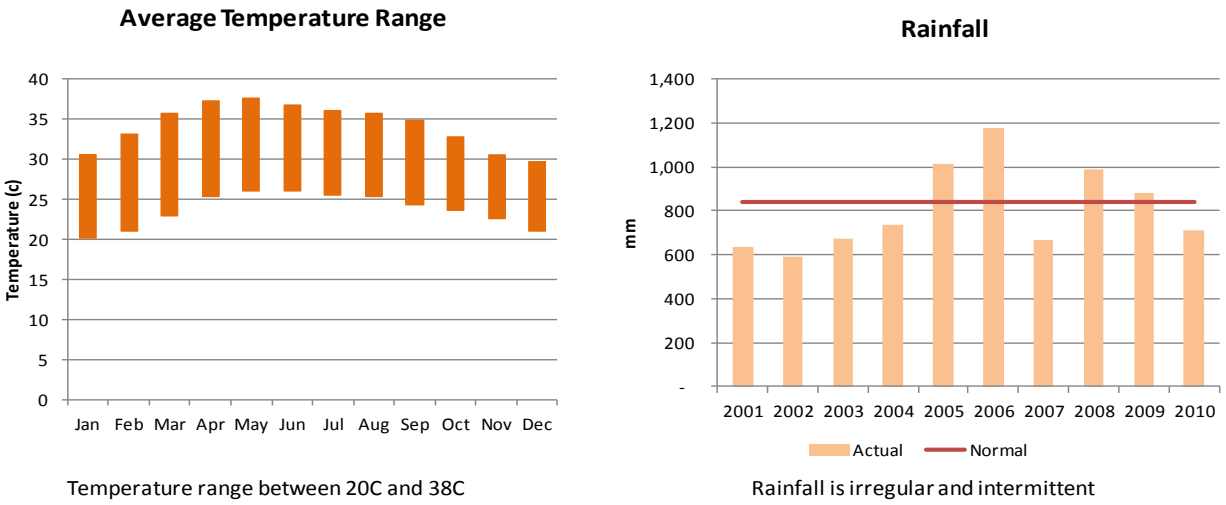
**Figure 6. Some slums are located directly in the Vaigai River channel. These dwellings are washed away every 3-4 years when the River floods requiring citizens to relocate and then rebuild their dwellings.**

[9] We define risk broadly as the potential that the 'activities' of cities which drive carbon emissions and pressure on critical natural resources and 'events' in the form of climate hazards and external pressures on resources used by cities will have an undesirable impact. Given that cities both contribute to and are impacted by environmental risks it is difficult to disentangle cause and effect. Hence, no attempt is made to delineate between stresses or risk drivers (e.g. carbon emissions) and shocks (e.g. rises in the price of energy, climate hazards).

[10] Madurai CDP

**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.

**Figure 7. Madurai's climate is generally hot and dry with irregular rainfall**




Source: Madurai Statistical Handbook

## 3.1.2. Future risks

**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.** For example, the results of the assessment of climate change out to 2030 published by Ministry of Environment and Forests are summarised in Table 3 [11]. This assessment is based upon global and regional climate models informing national and regional scale assessments and provides a useful indication of how Madurai might be impacted by climate change moving forward, as well as identifying issues which require further analysis. However, the results of these assessments generally have a spatial resolution of 250-300 sq.km and are not able to capture the climate at smaller scales which may be influenced by topography and land use patterns.

**Table 3. Potential implications of climate change for Madurai out to 2030[12]**

| Climate risk | Implications for Madurai and Catchment |
|---|---|
| Temperature trends | Projected increase in annual mean surface temperature of 1.7-2 degrees centigrade by 2030<br>Accelerated warming particularly during the winter and post monsoon seasons.<br>Monsoon and pre monsoon seasons experiencing warming but to a lesser extent.<br>Increasing frequency of hot days |

[11] The results for Madurai have been drawn from interpretation of the maps provided in the report. Reference should be made to the original sources for detailed modelling assumptions.
[12] Ministry of Environment & Forests (2010) Climate Change and India: A 4x4 assessment – A sectoral and regional analysis for 2030s.

| | |
|---|---|
| | Trend towards increased minimum temperatures and greater night time temperatures |
| Variability in monsoon rainfall | MoEFF Regional Climate Projections for 2030 show projected changes in the summer monsoon rain could be significant compared with 1970. There is a wide margin in the results of the different scenarios considered with adopted these range from -10 to 20%, -5%- +5% +10%-+20%. |
| Extreme precipitation events | Trend of increased frequency of rainy days within Vaigai basin catchment 1970-2010.<br>Regional Climate projections:<br>Comparing 2030 with 1970 it is projected that there will be a reduced frequency of rainy days of 0-5% but greater intensity of 0-2% within the majority of the Vaigai catchment.<br>For Madurai, projections for storm events for 2030 do not show a markedly different pattern compared with 1970. |

**These projected climate hazards are likely to have wide ranging impacts on a range of sectors in Madurai – including food and water systems, health, buildings, transport, and natural ecosystems and biodiversity.** Table 4 summarises the potential impacts indicated by a range of recent regional level studies out to 2030, including the study referenced above by the Ministry of Environment and Forests. These impacts could include significant declines in agricultural yields in Madurai's wider catchment (potentially impacting Madurai's food security and livelihoods for those working in agriculture), increased morbidity and mortality from flooding, an increase in water borne diseases and cholera, an increase in power demand in buildings, and damage to road infrastructure.

**Table 4. Summary of potential climate change impacts for Madurai out to 2030**

| Sector | Implications for Madurai |
|---|---|
| Agriculture[13] | No projections are currently available for the agricultural areas immediately surrounding Madurai but projections have been undertaken for Western Ghat and the Coastal regions for 2030. Changes within these regions could have implications for food prices and food security of Tamil Nadu as a whole.<br>**Western Ghats:**<br>Coconut yields are projected to increase by up to 30% by 2030.<br>Rice yields in rain fed areas are projected to decrease by 4% overall while irrigated areas may lose up to 10% of yield. This may be partly mitigated through deployment of crop management planting varieties tolerant to climate change.<br>Maize and sorghum yields are projected to fall by up to 50%.<br>**Coastal areas:**<br>Irrigated rice yields are projected to fall by up to 10%. Rainfed rice yields are projected to increase by up to 15%.<br>The impact of climate change factors on fisheries stocks is not easily discernible when considered with other factors.<br>Madurai is located within an area of the country which is projected by 2030 to experience 'severe stress' measured by the temperature and humidity index with a rating above 80. Livestock rearing may become a |

[13] Ministry of Environment & Forests (2010) Climate Change and India: A 4x4 assessment – A sectoral and regional analysis for 2030s.

| Sector | Implications for Madurai |
|---|---|
| | more cost intensive with livelihood implications for marginal farmers. |
| Natural ecosystems and biodiversity [14] | The ecosystem and natural capital of Madurai and coastal Tamil Nadu consists of a system of inland lakes and wetlands of a scale which is of national significance. The climate change impact on the functioning of these systems, flora and fauna is classified within the national assessment document[15] as moderately vulnerable based upon the percentage of areas identified as experiencing change.<br><br>However, the effect of climate change on aquatic systems is not considered. No assessment has been made on the cumulative impact of other climate change impacts could have on natural ecosystems and biodiversity. |
| Water resources | The hydrological scenarios and models used in national studies are of a scale which means that conclusions for Madurai cannot be drawn.<br><br>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 with water storage and replenishable groundwater resources within the city boundary. Further work is needed to understand the needs of the city and implications of climate change on water resources<br><br>An assessment of the water balance for river basins in Tamil Nadu was undertaken in 2011 which considered surface water (including existing dam and tank storage) and groundwater potential.[16] The findings suggest there was a water balance deficit of around -1,506.37 million cubic metres in 2004. This deficit was projected to increase to -1,576.59 by 2019 and -1,693.77 by 2044 excluding any consideration of climate change factors.<br><br>A number of the assumptions and findings in the report should be viewed cautiously. The projected population and urbanisation assumptions appear low and may underplay the extent of future deficits. The opportunities for future investment and deployment of water and irrigation technologies are not fully considered in this study. |
| Human health[17] | The following risks have been identified:<br><br>Increased morbidity and mortality from flooding.<br><br>Temperature increases lead to increased morbidity from water borne diseases and cholera.<br><br>Risk of increased malaria transmission.<br><br>Loss of livelihoods due to the effect on agriculture, tourism impacting health and life expectancy. |
| Buildings | Increased temperatures lead to increased usage of air conditioning. Increase power demand.<br><br>Forced migration and loss of housing in coastal Tamil Nadu following |

[14] Ibid.
[15] Ibid

[16] Centre for Agricultural and Rural Development Studies Tamil Nadu University (2011) Performance of Agriculture in River Basins of Tamil Nadu in the last three decades – A Total Factor Productivity Approach (Final Report).
[17] Ministry of Environment & Forests (2010) Climate Change and India: A 4x4 assessment – A sectoral and regional analysis for 2030s.

| Sector | Implications for Madurai |
|---|---|
| | storm events may lead to increased pressure on inland cities such as Madurai.<br>Decline in urban environment would put the historic assets at risk - which in turn would affect livelihoods dependent upon tourism, as well as liveability and the cities international profile and reputation. |
| Roads | Increased temperatures and intensity of rainfall events have implications for road maintenance and repair. |
| Flooding | Potential increased risk of fluvial flooding and storm water run-off during the monsoon and precipitation events. |

**The latest longer time horizon central estimates compiled by the World Bank using downscaled GCM projections[18] provide more recent projections over a longer timescale but at a broader geographic scale**. The World Bank study - looking out to 2080 - suggests the following climate change impacts could occur in Madurai and its hinterland:

- An increase in average temperatures of around two degrees by 2080. Other scenarios anticipate an increase in temperatures of up to four degrees. This will be associated with an increase in the frequency of unusual and unprecedented spells of extreme hot weather events and drought conditions, potentially impacting agriculture in the wider catchment, access to water, and risk of mortality.

- An increase in the unpredictability of the summer monsoon, reducing rainfall during the wettest months by 2080. This could have a significant impact on agriculture, as well as creating additional stress on water systems.

- An increase in the frequency of heavy rainfall events, with increased risk of flooding, particularly in areas close to the river basin.

**Whilst national and regional studies provide a good guide to the potential impacts of climate change, further analysis is required to better model the magnitude and spatial variation of projected impacts for Madurai and its wider catchment to provide a more robust basis for decision-making.** Progress is being made in this regard. For example, the State Action Plan on Climate Change for Tamil Nadu which we understand will be released in October/November 2013 has been informed by further climate change modelling and consideration of more fine grain sector-wide impacts in Tamil Nadu. The Department of Environment attended the State level workshop in August 2013 and pledged support for the project and sharing of information held at the SAPCC knowledge Management Centre based at Anna University. This information should be available to be used in conjunction with the Stage 3 Action Planning. In addition, further modelling of climate impacts for Madurai is being prepared by ICLEI as part of the Asian Cities Adapt programme supported by IIT Delhi and the Potsdam Institute. This study is due to be released later in 2013. Opportunities to sharing findings as part of stakeholder engagement for this project are being explored.

## 3.2. Resource use and security

Issues related to water and food supply will impact the future growth and prosperity of Madurai, and particularly its ability to reduce urban poverty given the dependency of the vulnerable on access to clean water and robust food systems.

### 3.2.1. Water security

**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.**

[18] World Bank Climate Portal and Turn Down the Heat, World Bank

### 3.2.1.1. Current risks – water availability

**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 that variability could increase.[19] 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. 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.

**Figure 8. Polluted water contaminated with untreated sewage is pumped from the Gridthumal River to irrigate agricultural plots in the city leading to health issues.**

**Given that ground water levels are falling quickly, carbon emissions related to water extraction are also growing**. Acute water shortages arise across parts of the city when groundwater levels become so low that water can no longer be extracted. The extraction of groundwater is also energy intensive, which is expensive and generates additional carbon emissions.

[19] World Bank Climate Change Portal

**Figure 9. Madurai is the largest urban area within the Vaigai River Catchment. The catchment already faces a water balance deficit. Shortfalls in meeting water needs will increase without action to address the issue.**


### 3.2.1.2. Current risks - water distribution

**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.[20] The frequency of supply is also poor and averages once in every two days outside of the summer season.[21]** 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.[22]

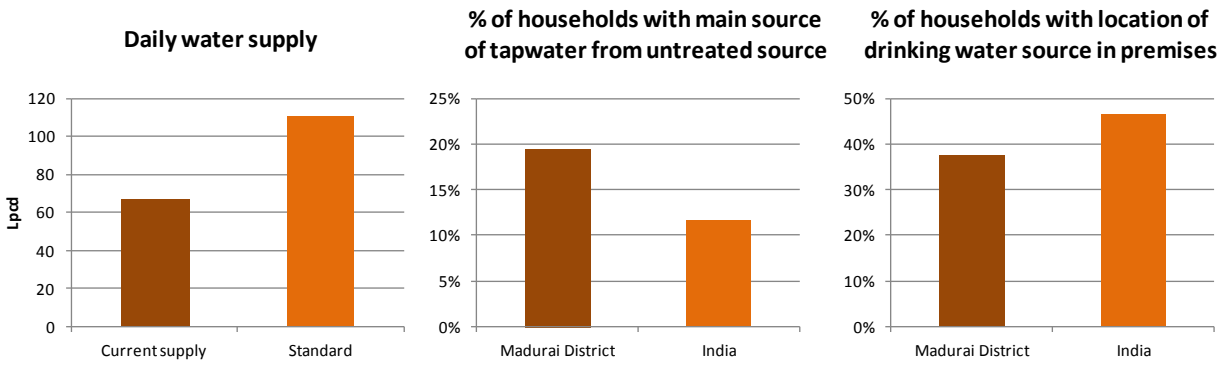
[20] Madurai CDP
[21] ibid
[22] Water Poverty in Urban India: A Study of Major Cities.

**Estimates of leakage also suggest high losses in the transmission and distribution of water, although reliable recent estimates are challenging to find**.[23] 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 issued 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.[24]

**Figure 10. A citizen highlights the issue that the piped water supply to some parts of the city is sometimes intermittent and not of a high quality**

[23] 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.
[24] DHAN City Communique

## Figure 11. Water supply indicators fare poorly with national benchmarks



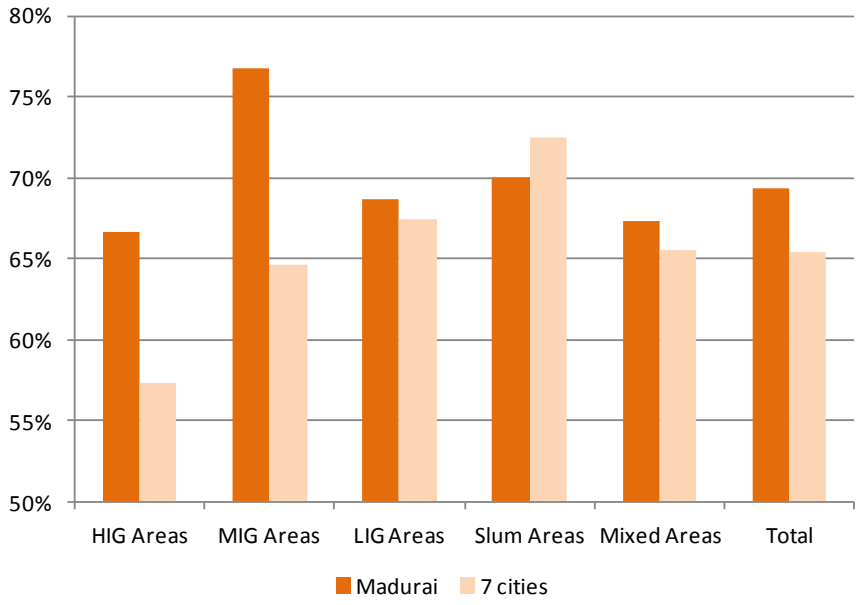

Frequency of supply is once every two days

Higher proportion of households using tapwater from an untreated source than national average

Lower proportion of households with drinking water source within the house than national average

Source: Madurai CDP, 2011 Census

## Figure 12. Proportion of water deficit households in Madurai by income type




Source: Water poverty in urban India: A Study of Major Cities

### 3.2.1.3. Current risks - surface water management

**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.

**Figure 13. 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.**

**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, Tiruparankundram, and Thirunagar,[25] 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;

[25] http://timesofindia.indiatimes.com/city/madurai/Vaigai-water-reaches-Madurai-outskirts/articleshow/21321680.cms

- 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[26].

**Figure 14. 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.

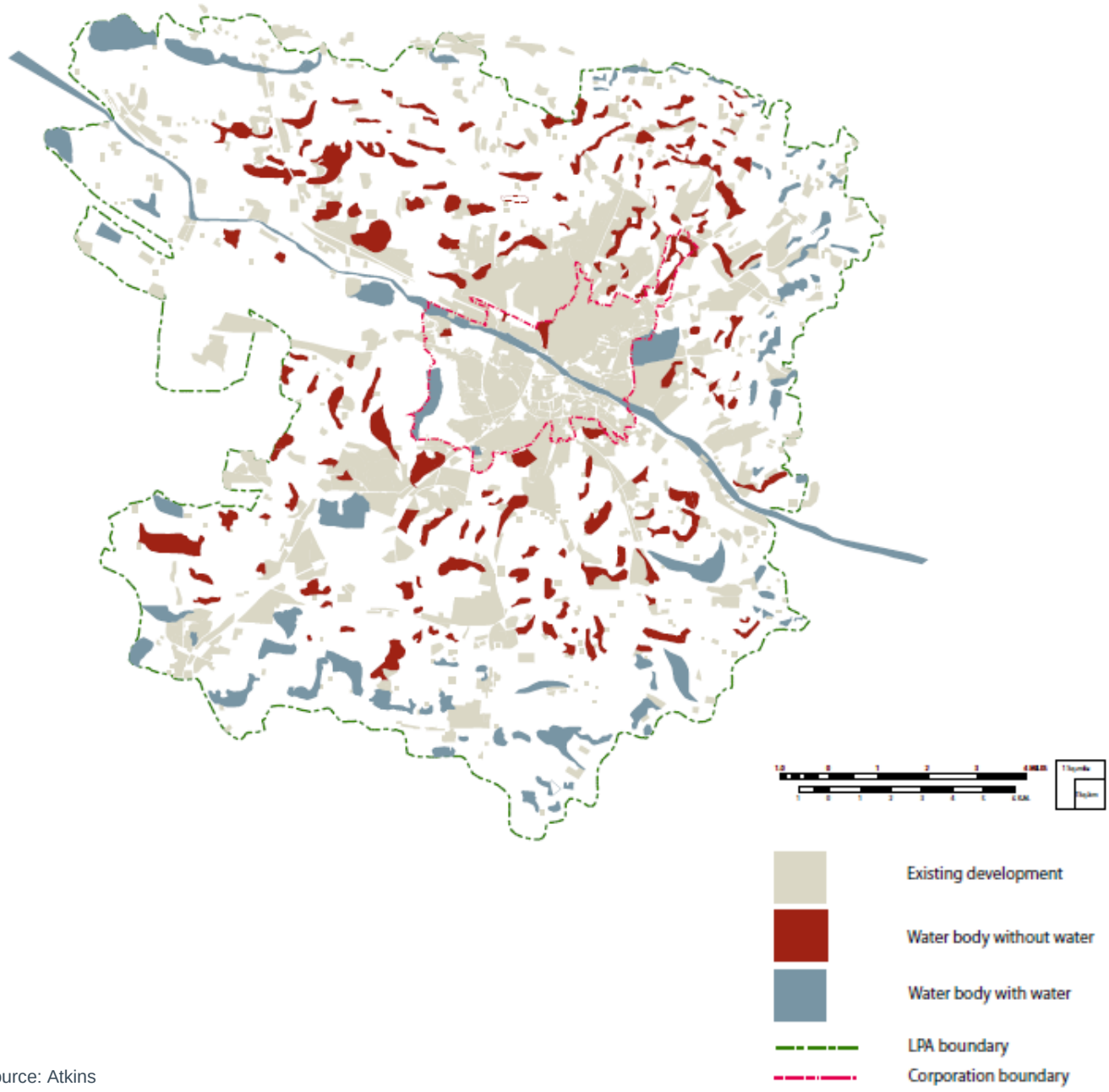
**This issue is compounded by deficiencies in existing wastewater treatment facilities and sanitation infrastructure.** Madurai has challenges in terms of its wastewater disposal infrastructure with a significant quantity of sewage flowing through open channels and rainwater drains into the Vaigai River 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

[26] Madurai CDP

Madurai Corporation limits.[27] 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.[28]

**Figure 15. Distribution of water bodies in Madurai including those with and without water.**




Source: Atkins

[27] City Communiqué
[28] Institute of Water Management

**Figure 16. Recent expansion and future growth of the city has expanded in and around water bodies in the city. In the absence of appropriate management, further erosion and degradation of this resource will continue.**


Source: Atkins

### 3.2.2. Future risks

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 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 per cent 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.**

**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.[29] 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.[30]

## 3.3. Agriculture and food security

### 3.3.1. Future risks

**Madurai is facing similar challenges in relation to safeguarding its food security as India is facing as a whole: in particular, rising demand, seasonal water variability, and rising temperatures due to climate change could have an impact on its food security due to falling yields and rising prices.** For example, whilst no projections are available analysing the implications of climate change for the agricultural areas immediately surrounding city, projections for Western Ghat and Coastal regions of the State out to 2030 suggest maize and sorghum yields are likely to be negatively impacted by 2030, and increases in temperature and humidity may lead to livestock rearing becoming a more cost intensive with livelihood implications for more marginal farmers.

**However, the assessment identifies that further analysis will be needed in the future to better understand Madurai's food system to inform decision making.** This should include analysis of the city's reliance on and ability to draw on food sources within and outside its immediate catchment, the strength of regional food distribution and logistics systems, and further analysis of the interface between food systems and Madurai's blue infrastructure, as well further analysis of the potential impacts of climate change (and its link to livelihoods) within Madurai's catchment. The State Climate Change Action Plan will include a sector implementation plan for agriculture to address this.

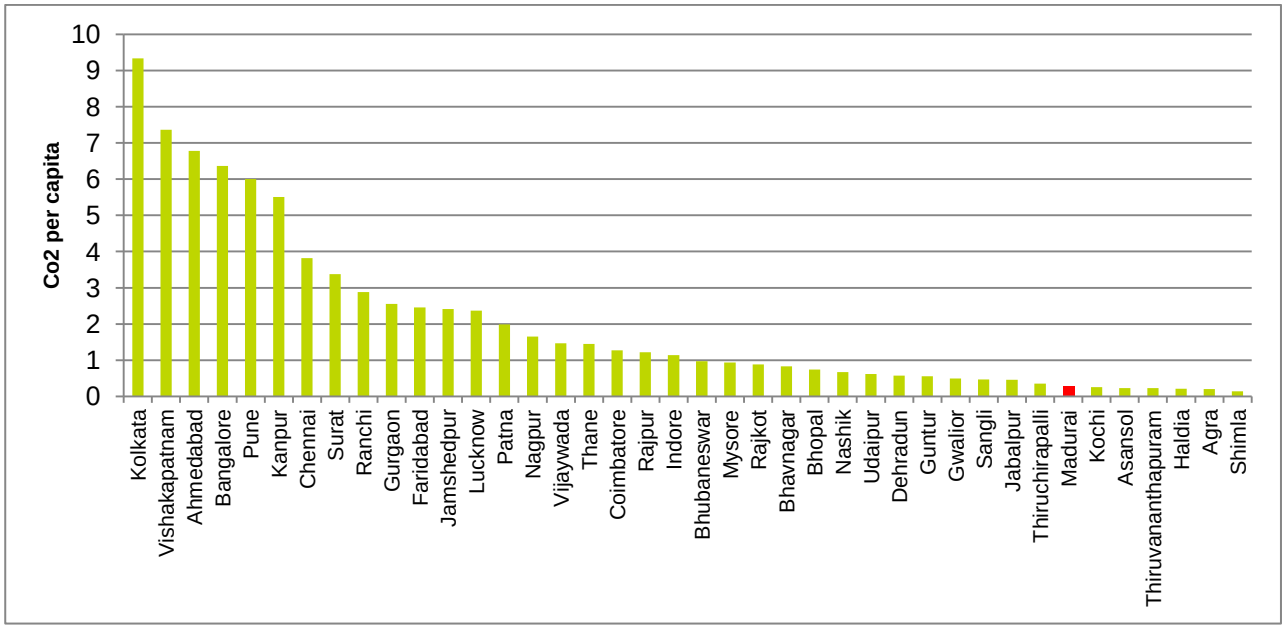
[29] Tamil Nadu Environment Report
[30] Integrated Urban Water Management Report

## 3.4. Energy use and carbon emissions

### 3.4.1. Current risks

**Madurai's estimated current carbon emissions are low when benchmarked against a range of other Indian cities and is primarily driven by emissions in the transport sector.**[31] Figure 17 indicates Madurai's carbon emissions per capita vis-a-vis the average of 40 other Indian cities. At 0.28 tonnes of CO2 per capita this is currently low by global and national standards. Transport – specifically road transport - is currently the biggest generator of carbon emissions in Madurai, contributing 53% of estimated total emissions.[32] Emissions from residential property represent over a third of total emissions, with emissions from transport and residential property accounting for around 90% of all carbon emissions. This is a much larger proportion than the Indian city average which includes a significant number of cities with more developed industrial and commercial sectors.[33]

**Figure 17. Benchmarking Madurai's CO2 Emissions with other Indian cities**




Source: Energy and Carbon Emission Profile of 45 South Asian Cities, ICLEI

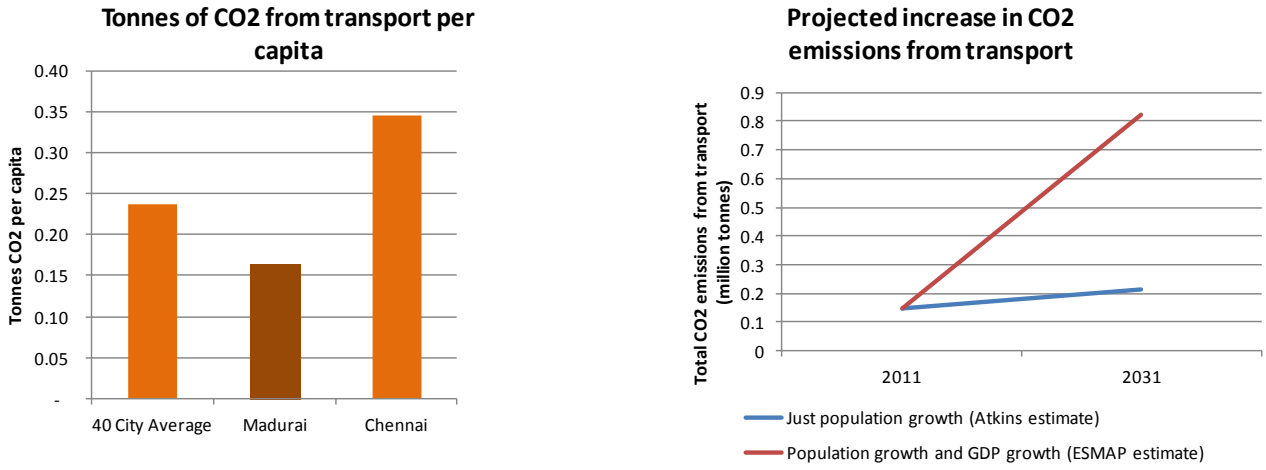
### 3.4.2. Future risks – emissions from transport

**Although in absolute terms emissions from transport are still relatively low when compared to other Indian cities, evidence suggests transport related emissions are growing fast driven by population dynamics and a growing middle class.** For example, the number of registered motor vehicles per capita increased by 10% between 2010 and 2011 alone, whilst the city recorded the fourth largest level of motor growth between 2002 and 2009 in India, largely driven by a sustained increase in incomes in this period.[34]

**Emissions from transport are expected to continue to escalate.** Work by Atkins estimates that population growth alone could drive up carbon emissions by 45% by 2031.[35] When combined with the projected shift in modes from walking and cycling to two wheelers, and from two wheelers to cars, emissions from road transport could increase by over 450% by 2031, largely due to the projected growth in incomes. This would result in over 800,000 tonnes of CO2 generated from road transport by 2031 in the city (see Figure 18).

[31] Carbon emissions are also low vis-a-vis the 1.5 tonnes of CO2 per capita emissions allowance estimated to be needed to keep global temperatures below two degrees warming.
[32] Energy and Carbon Emission Profiles of 54 South Asian Cities: ICLEI
[33] Atkins analysis of data produced by ICLEI
[34] Road Transport Year Book 2011. Transport Research Wing, Ministry of Road Transport & Highways
[35] Low Carbon Cities Handbook. Atkins

**Figure 18. Energy use and carbon emissions relating to the transport sector are projected to increase along with the number of vehicles per capita**




Source: ICLEI: Energy and Carbon Emissions Profiles of 54 South Asia Cities, Atkins, ESMAP: Energy Intensive Sectors of the Indian Economy

**The way that Madurai is expanding spatially and a lack of integration between land use and transport policy presents challenges for introducing public transit options which could temper emissions growth from private vehicle use**.[36] The recent pattern of dispersed low density development which has been planned without integration of public transport means that it is difficult to reach a critical mass of population necessary to support a viable high frequency public transport network. Although Madurai has a relatively high density core (one central ward has a density exceeding 1,000 persons per hectare[37]) - this has led to a rise in traffic congestion and high real estate prices. As a result, plans have sought to 'decongest' the city through extending infrastructure services and encouraging ribbon development along radial roads leading to the centre beyond the Corporation boundary into the wider Local Planning Area (LPA). However the scale, mix of uses and the design and layout of proposals has not been planned in a way which reduces the need to travel to the centre or other neighbourhoods to access employment or local services.

**Outside the City Corporation boundary development has started to sprawl, providing fewer opportunities for introducing mass transit options.** Outside the City Corporation area the pattern of development is largely market driven with development clustering around villages and areas with access to ground water. This has resulted in a land use pattern where employment and services are located some distance from residential areas, resulting in an increased propensity to use motorised modes and providing fewer opportunities for efficient provision of mass transit options which could provide opportunities for reducing congestion, carbon emissions, and fossil fuel based energy use vis-a-vis business as usual.

[36] Urban form has a significant impact on carbon emissions. Compact cities with mixed land-use and higher population density can provide more energy efficient mass transit infrastructure, reducing carbon and energy costs. For example, many newer U.S. cities are defined by the Interstate Highway system and their reliance on the automobile for most public travel whereas European cities tend to be more compact, with a greater reliance on public transportation with this variation in density and design being a major reason for the striking differences in per capita greenhouse gas emissions between newer cities in the United States and older cities in Europe.
[37] Madurai City Development Plan

**Figure 19. Urban development is taking place in peri urban areas on an unplanned basis and without provision of infrastructure or utilities.**

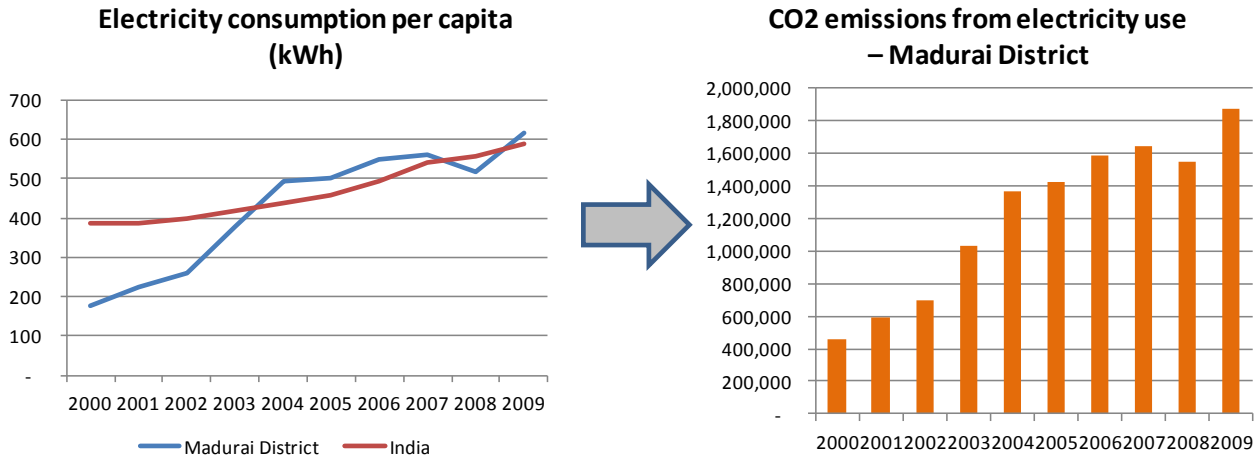
**Figure 20. New road building and construction is taking place in the city but does not generally follow sustainable design principles or approaches.**

### 3.4.2.1. Future risks – emissions from energy use

**Energy use in Madurai – particularly in the residential property sector - is growing quickly driven by demand for cooling and lighting and greater use of appliances.** Electricity consumption (kWh per capita) tripled between 2000 and 2009 and is now in line with the Indian average (see Figure 21). Projections estimate that residential energy consumption could increase by 400% to 2031 (Figure 22), largely as a result of increased demand for cooling. Demand for cooling is also likely to be compounded over time due to climate change.

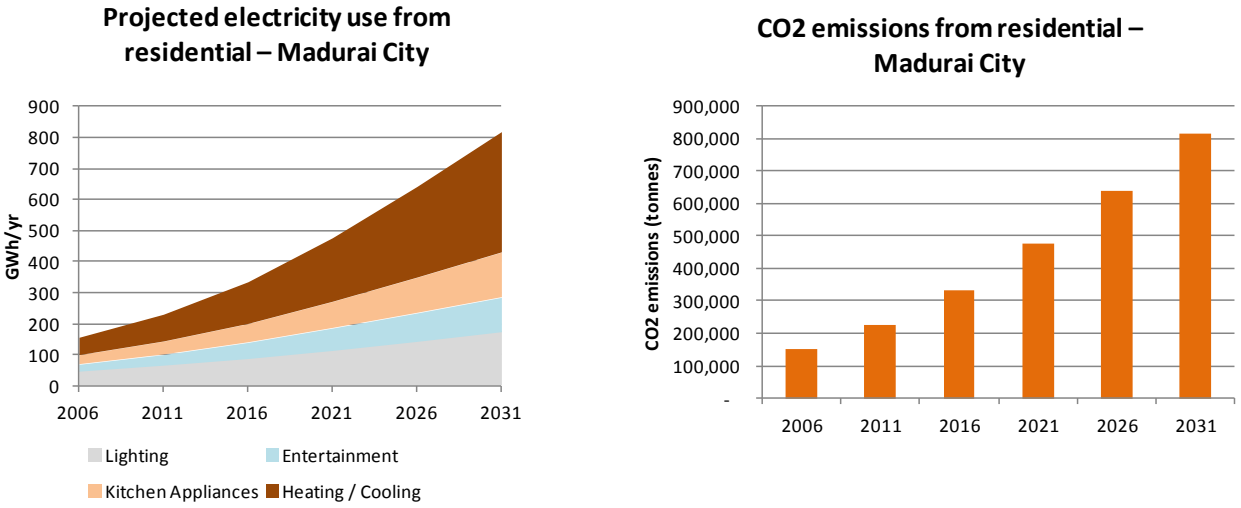
**The combination of the rapid increase in emissions from the transport sector and the rapid increase in emissions from domestic cooling means the city is on track to increase its carbon emissions per capita significantly. Madurai needs to act now to ensure it does not become 'locked in' to a high carbon development pathway that will be difficult to reverse.**

**Figure 21. In line with Tamil Nadu as a whole, energy consumption is increasing in Madurai**




Source: Madurai Statistical Handbook, Atkins analysis

**Figure 22. Energy use linked to residential and commercial development is projected to rise as the city grows. However, there is an opportunity for new development to be built to enhanced standards to reduce its energy intensity**




Source: Atkins analysis

**The scale of future development in Madurai offers an important opportunity to embark upon new build programmes that integrate energy efficiency goals.** With a projected increase in population of 1 million people by 2031 over 200,000 residential units are likely to be needed, as well as many thousands of

commercial and community buildings. Implementation of the Energy Conservation Building Code and opportunities for renewable development including Solar Hot Water and Solar Photovoltaic are key opportunities which can be delivered in conjunction with new development.

**Given the scale of growth projected for Madurai, there an important is a window of opportunity to make choices today on city planning, transport options, building and neighbourhood design, and energy mix at the city level which could have a significant impact in helping Madurai avoid locking itself into a high carbon, high energy pathway.** This could have significant benefits in terms of:

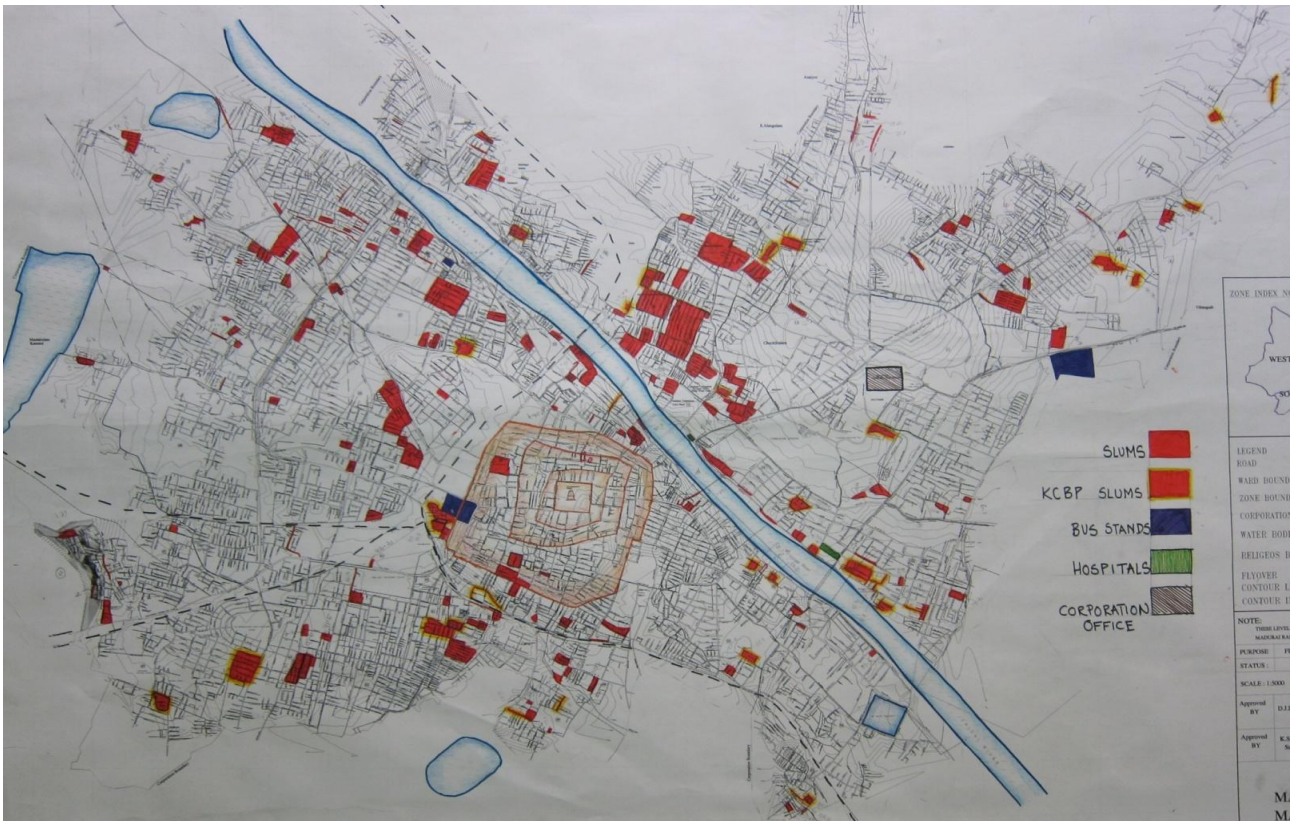
- Enhancing the competitiveness of the city as a place for doing business by (i) providing resilience against rising prices and/or limited availability of traditional fossil fuel based energy sources; (ii) reducing the impacts of air pollution and congestion; and (iii) providing resilience against the impacts of long term carbon price legislation or market mechanisms for pricing carbon
- Safeguarding the livelihoods of the urban poor by boosting resilience to disruptions in the supply of and/or rises in the prices of fossil fuel based energy sources
- Providing opportunities to access climate finance via urban CDM or dedicated urban funds supported by external funding agencies

# 4. Vulnerability to Risks

**Not only does Madurai face a wide range of environmental risks, but segments of Madurai's population - especially the urban poor - are particularly vulnerable[38] 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.

**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[39].** 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. 85% of the slums in the city are on Government land and 9.2% are on Corporation land.[40]

**Figure 23. Location of Slum areas inside Madurai Corporation Area**




Source: DHAN Foundation

[38] 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.

[39] Including 208 within the former Madurai Corporation area

[40] Slum upgrade report

**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 Ramavarman 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 high 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.[41] 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%).

**Figure 24. Many slum areas are built on land along rail and rover corridors and experience multiple vulnerabilities. Water is drawn from channels which are polluted by raw sewage.**

**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. Thoseresidents in slums without public toilers 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.[42] There are no designation Solid Waste Collection Points or Waste Bins provided in slums. As

[41] Slum upgrade report
[42] Slum Upgrade Report

a result, in most of the slums, the waste is disposed in nearby vacant areas with significant public health risks.[43]

**Figure 25. 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**

Source: Project team visits

**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.[44] Areas which have been 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.

**Figure 26. Many of Madurai's slums are located near to river banks vulnerable to flooding**

[43] Ibid
[44] ibid

**Table 5. Risks Facing Selected Slum Areas in Madurai**

| Slum Area | Core characteristics | Key Environmental Risks/Hazards | Risk mitigation measures |
|---|---|---|---|
| SMP COLONY (Ward 33) | Located along the river Vaigai and within the flood plains<br>Primarily housing construction workers | Repeated floods every 3-4 years. Last major flood 2003-04.<br>Unsafe drinking water<br>Open drains and sewers<br>Solid waste dumping<br>Health and sanitation issues: water borne diseases, jaundice typhoid and dengue | Artificial bund (about 3-4m high) provides some barrier to prevent flooding.<br>Houses have been allocated for slum relocation under JNNURM: families are unwilling to relocate due to increased travel distance for employment. |
| Vandiyur Devar Nagar (Ward 32) | Located along the river Vaigai and within the flood plains<br>Primarily housing skilled labourers – masons, carpeters, hotel workers | Repeated floods every 3-4 years. Last major flood 2003-04.<br>Poor quality of drinking water<br>Poor sanitation<br>Poor waste management | Some construction of houses on raised platforms allowing water to penetrate ground floor areas. |
| Nethaji Nagar (Ward 32) | Located along the river Vaigai and within the flood plains<br>Primarily housing skilled and semi-skilled labourers in construction sites | Subject to frequent flooding during rains.<br>Contaminated drinking water<br>Absence of land tenure<br>Improper sewerage & drainage systems leading to health issues | No flood barriers<br>Residents have constructed stone houses over the time to protect them from floods<br>Unanimous consent for relocation is lacking. |
| Nagamal Madam, Therkuvaasal (Ward 62) | Located along the Kridhumal river channel<br>Primarily housing marginal workers - waste picking, old newspaper collection | High flood risk<br>Water contamination<br>Land contamination<br>Air pollution | No flood barriers<br>Families are unwilling to relocate due to increased travel distance for employment. |
| Avaniapuram – emerging growth area on edge of city | Low lying area on urban fringe with close proximity to water tanks | Water contamination due to encroachment and sewage dumping in tanks - high levels of BOD, COD and NOx content<br>Lack of integration of storm water drainage plans and sewage network plans<br>Dengue and malaria | None |

Source: Project team consultations and field visits

**A range of efforts have been taken to improve the living conditions and reduce the vulnerability of Madurai's slums including via relocation away from areas at risk of flooding, most recently through the RAY slum upgrading programme.** Box 1 provides a summary of the programme which is being implemented through the Tamil Nadu Slum Clearance Board (TNSCB) and includes measures to relocate slum areas away from land vulnerable to climate hazards such as flooding with the help of state and central government.

**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 1800 units that have already been constructed at Rajakaur - about 10 kilometres from the city centre – less than 10% of slum dwellers have taken possession after a year. Even plans to run special bus routes between Rajakaur 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 judgment prevented tenure regularisation on objectionable lands, the requirement to resettle vulnerable communities in slum areas has slowed down the whole RAY programme implementation.

**Figure 27. New housing developed for relocated slum dwellers on outskirts of city**

Source: Project team visits

**Box 1: Madurai's Slum Upgrade Programme and vulnerability of Madurai's slums**

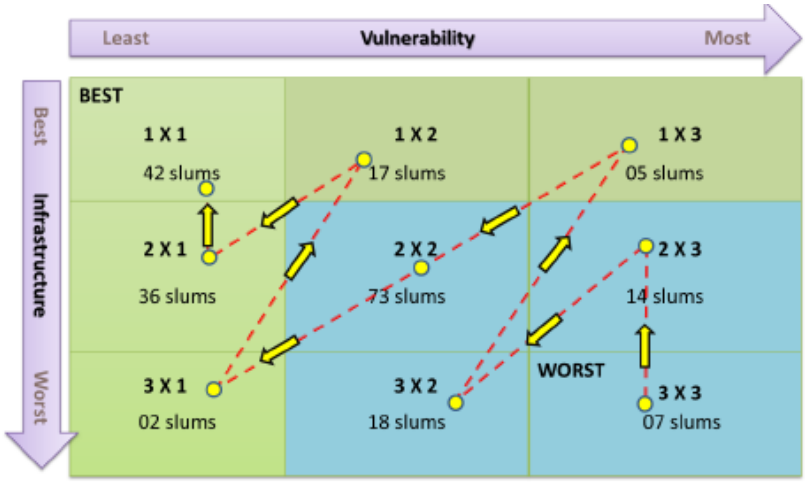
Rajiv Awas Yojana (RAY), a path breaking scheme announced by Government of India for the slum dwellers and urban poor, envisages a 'Slum-free India' through encouraging States to tackle the problem of slums in a holistic manner. The Government of Tamil Nadu has adopted the scheme for implementation with the Tamil Nadu Slum Clearance Board acting as the State Level Nodal Agency for RAY.

Under RAY a new slum free city plan of Madurai has been prepared and is under review. Out of the 331 slums in Madurai, 135 slums have been identified and are under development. The RAY program aims to build a 25 sq m house for beneficiaries living in informal settlements. This is done either by upgrading existing settlements or by building new homes to resettle the residents away from vulnerable land parcels. Further to upgrading or building new homes, the program also upgrades the public infrastructure in the settlement. The scheme is funded 50% from central government, 40% from State government, and 10% from beneficiary contributions. The RAY programme is an example of government authorities coming together to commit to and devise a city-wide solution.

A new report is currently under preparation capturing for the first time a full survey of informal settlements in Madurai assessing their vulnerability and infrastructure availability as the basis for prioritising those slums most in need of upgrade/relocation. This information is summarised in the deficiency matrix below.

The RAY programme in Madurai is not seen as an adequate solution by all slum dwellers as the land selected for relocation is located beyond the city boundaries and away from employment and livelihoods which are centred around the city. Although there is a bus service planned this has not convinced all residents that a move out of the city is desirable. There are also concerns regarding the separation and break up of existing communities and the support networks they offer as well as the nature of the accommodation provided (flats rather than smaller scale dwellings which cannot be adapted by resident's over time). This highlights the need to avoid underestimating the wide inter-connectivity of issues that need to be addressed to solve the slum issue.

Without adequate land management and planning enforcement the relocation of existing slum dwellers provides an opportunity for new migrants to the city to move in. i.e. creating another slum community in place of those who have relocated.




Source: Project team interviews with Tamil Nadu Slum Clearance Board

**More generally, parts of Madurai's critical infrastructure are vulnerable to a range of hazards.** For example, certain parts of the city are particularly vulnerable to flooding and heavy rainfall events primarily due to:

- A lack of drainage: drains cover only 28% of highways in the city and are easily damaged by traffic, further limiting their effectiveness;[45]

[45] Madurai CDP

- Silting and uncontrolled solid waste dumping which causes blockages, stagnates water channels, and causes wastewater runoff; and

- Depletion of the city's system of linked reservoirs and canals which previously mitigated against flooding; as above, many of these water systems have been encroached upon by development.

**There is also emerging evidence to suggest that certain socio-economic groups – such as women - are likely to be more vulnerable to the shocks and stresses related to environmental risks.** For example, women in Madurai still fall behind compared to men in terms of education; while for every 1000 men in Madurai 775 are literate, only 625 women are literate.[46] A lack of empowerment of women can also been seen from the fact that more that 85 percent of the women living in urban areas in Madurai district are classified as non-workers by the Annual Statistical Abstract of Tamil Nadu (2003-2004), while this is around 45 percent for men.[47]

[46] ibid
[47] ibid

# 5. Capacity to Respond to Risks

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. This section provides a short overview of the main challenges shaping the capacity of the city to respond to the identified risks. Targeted work is needed to unpack how these issues are likely to impact the ability of the city to respond to priority issues. This will be taken forward in the next phase of the project.

## 5.1. Governance

Figure 28 provides an overview of the government organisations and their functions in Madurai, including the jurisdictional areas over which they are responsible.

**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 co-ordination 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 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.

**Different geographic areas and responsibilities for the co-ordination of planning, land development and infrastructure provision at city and sub-regional levels influences the co-ordination of development.** The Madurai Local Planning Authority is the statutory body at the city level responsible for implementation of the Development Plans, enforcement of the Development Control regulations and to ensure that no unauthorised developments take place within the physical boundaries of the planning authority boundary. The LPA is also the agency which is responsible for coordinating plan approval, masterplan implementation and financial assistance through central and state sponsored schemes between the Madurai Municipal Corporation and the DTCP at the state level.

Once approved the land use allocation and plot demarcations are done by the LPA. The LPA is tasked with implementing the Masterplan prepared by the DTCP. Once the location of basic infrastructure like roads and land classification is in place, it then becomes the corporation's responsibility to provide infrastructure amenities as Sewerage, Drainage, Street Lighting etc for the areas that are then included within the corporation's boundary.

**Figure 28. Responsibilities of Selected State and Government Organisations and Functions with relevance to Future Proofing**

| Government Organization | Jurisdiction Area | Tax, Revenues & Finances | Land Use & Transport Plans | Development Control Regulations | Water Supply, Sewage & Drainage Infrastructure | Slum Clearance & Rehabilitation Schemes | Water & Air Pollution | Urban Financing | Housing Schemes-, Rental Housing- LIG, MIG, HIG, EWS | Road Infrastructure | Transport- Road | Transport-Rail | Electricity | Law & Order |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Madurai Corporation | Municipal Boundary-72 Wards 54 Sq. Km | | | | | | | | | | | | | |
| Madurai Local Planning Authority | Madurai Urban & Rural, 100 Wards & 170 Villages 720 Sq. Km | | | | | | | | | | | | | |
| Madurai Public Works Department, Water Resource Organization | Periyar Vaigai Basin Division | | | | | | | | | | | | | |
| Support for National Policies on Urban Poverty Reduction (SNPUPR) | Madurai | | | | | | | | | | | | | |
| Directorate of Town & Country Planning (DTCP), Tamil Nadu | Entire State | | | | | | | | | | | | | |
| The Tamil Nadu Water Supply and Drainage Board (TWAD) | Entire State | | | | | | | | | | | | | |
| The Tamil Nadu Slum Clearance Board (TNSCB) | Entire State | | | | | | | | | | | | | |
| The Tamil Nadu Pollution Control Board (TNPCB) | Entire State | | | | | | | | | | | | | |

| Government Organization | Jurisdiction Area | Tax, Revenues & Finances | Land Use & Transport Plans | Development Control Regulations | Water Supply, Sewage & Drainage Infrastructure | Slum Clearance & Rehabilitation Schemes | Water & Air Pollution | Urban Financing | Housing Schemes-, Rental Housing- LIG, MIG, HIG, EWS | Road Infrastructure | Transport- Road | Transport-Rail | Electricity | Law & Order |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Municipal Administration & Water Supply Department (M.A & W.S) | Entire State | | | | | | | | | | | | | |
| Commissionerate of Municipal Administration (CMA) | Entire State | | | | | | | | | | | | | |
| Tamil Nadu Housing Board (TNHB) | Entire State | | | | | | | | | | | | | |
| Tamil Nadu Public Works Department (P.W.D) | Entire State | | | | | | | | | | | | | |
| Tamil Nadu State Transport Authority | Entire State | | | | | | | | | | | | | |
| Regional Transport Office | Madurai | | | | | | | | | | | | | |
| Southern Railways | Entire State | | | | | | | | | | | | | |
| Tamil Nadu Electricity Board (T.N.E.B) | Entire State | | | | | | | | | | | | | |

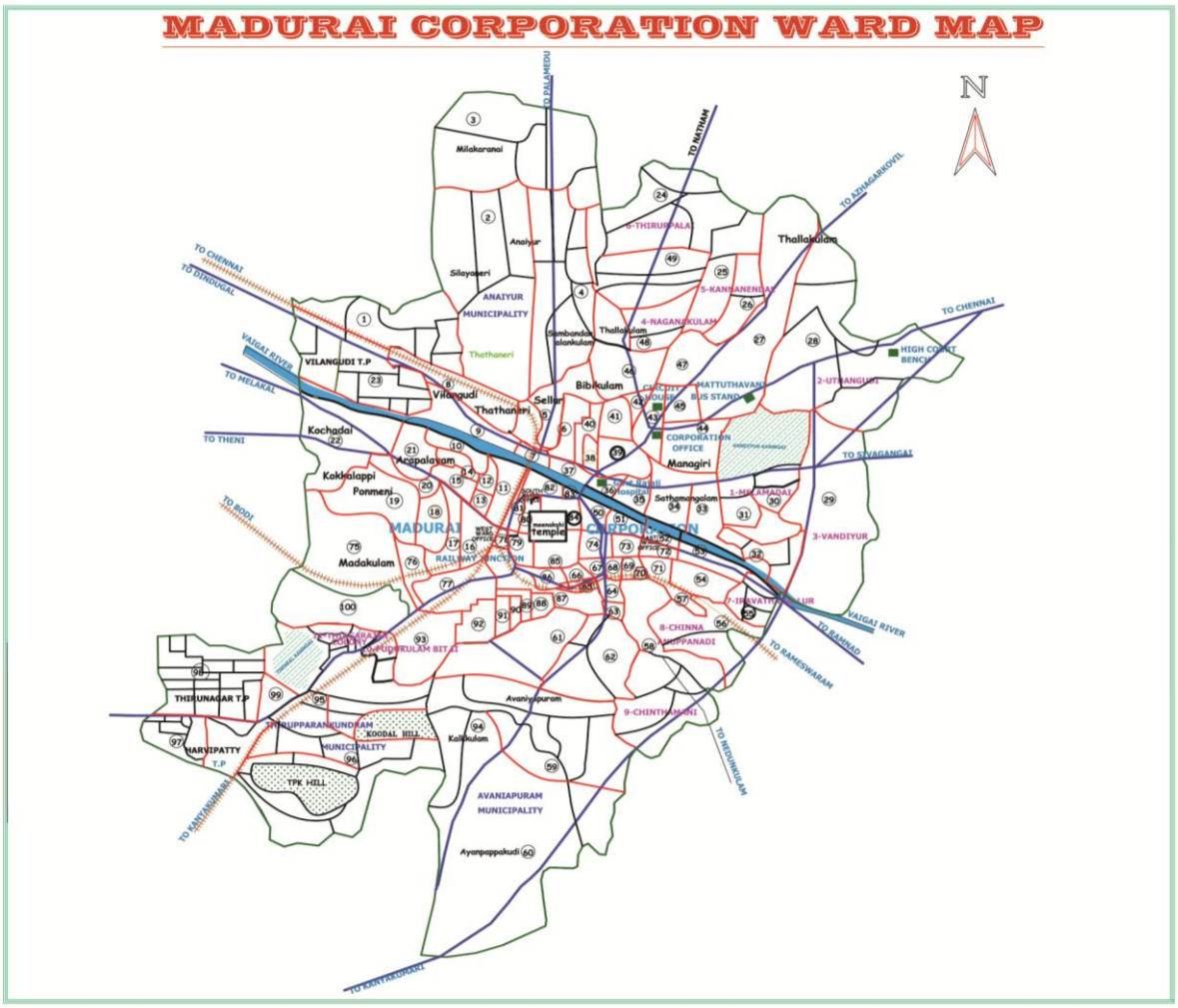
**Original Function**

**Overlapping Function**

**Coordinating Function**

Source: Atkins analysis

**Figure 29. Local administrative boundaries: Corporation boundary recently extended. Note does not show wider LPA area used for planning purposes.**




**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 such Board (TWAD) is responsible for creation of water and sewerage infrastructure in the state and the Municipal Administration and Water Supply Department (M.A. & W.S.) 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 co-ordination 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 City Development Plan a living document to guide programme implementation.

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 sensitizing the different stakeholders of the rights, roles and responsibilities and be the watchdogs of the development process. CVTC facilitates the exchange of information and 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 co-ordination, 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.

## 5.2. Finance

**The Corporation has historically been dependent on external resources for implementation of its capital programmes.** Rates of collection for local taxes and levies are low and no revenues are forthcoming from areas of informal or unauthorised development to support infrastructure enhancement. The city does not measure favourably against national benchmarks and some infrastructure improvements remain partially implemented as insufficient match funding has been mobilised.

It is reported that while some water supply and sewerage schemes have been partly funded by national level JNNURM and State level programmes the local co-funding component has proved difficult. Reforms such as charging schemes are difficult to justify politically if households are not receiving a good service.

Most Indian cities have a significant proportion of residents living and working in the non-formal sector and many cities have a poor fiscal base. Madurai is no exception. The management of resources at a city level therefore needs to embrace a variety of levels and diverse practices, ranging from the formal private and state sectors to community-managed local systems.

**There is a need to find new solutions to mobilise funding to address the challenges facing the city.** There is a growing realisation among urban managers on the need to innovate, especially in the context of declining state and central government's financial support to ULBs, to sustain investments and to carry on their functions. Madurai has the opportunity to enhance its resource base through a series of reforms at local levels and by making the case for funding from a range of other sources including international agencies and the private sector.

There may be potential for funds in the form of direct borrowing from capital markets (through municipal bonds), or through appropriate financial intermediaries or institutions and various other arrangements for attracting direct private investment (indirect access). Tamil Nadu Urban Development Finance has played a role in other cities in holding loans and funds from international and private sector funding bodies and working close with State level and Urban Local bodies to deliver capital projects.

In order to access such funds or supplement resources by way of external borrowing, the city will need to strengthen its finance and budgeting capabilities and to make progress in revenue collection and local contributions towards service provision and enabling public-private partnerships.[48]

## 5.3. Planning

**The co-ordination between the formulation of plans to support urban development and sector plans for infrastructure is weak leading to gaps.** Whilst there are formal mechanisms in place to develop land use strategies for the long term growth of the city, the plans focus on identifying future opportunities for land development and the zoning of land and are not formulated to fully respond to the full range of development needs of the city in terms of socio-economic development, infrastructure needs, environmental protection and safeguards. For example, there are no policies in place to safeguard areas at risk from flooding or water bodies from development. Guidelines and mechanisms to promote sustainable models of city development were has been identified by stakeholders in the city as a gap.

[48] A Case of Urban Local Bodies in Tamil Nadu

Changes to urban governance and regulatory reform at the city level, requires changes to state regulation and potentially national legislation. The opportunity for local byelaws within the framework was highlighted as a starting point. Some cities have sought to enhance their capacity by focussing on devolution of power, authority and resources from the central and sub-national to the municipal level, requiring a holistic amalgamation of functions and functionalities.

**The speed of growth and lack of staff to enforce planning regulations often means that the independent decisions of landowners drive city development rather than the long term interests of the city and its citizens.** Major decisions with respect to the approval of masterplans and city development plans rest with the state level nodal agencies. The number of qualified staff which the Corporation has is relatively small compared with other cities of its size. The resources the city has to follow up on development opportunities are limited and the penalties for non compliance are an insufficient deterrent.

**The lack of an effective mechanism to acquire, assemble land, and provide infrastructure and distribute serviced land to citizens and the development industry impacts on the effectiveness of the city in meeting its development needs and represents an impediment to growth.** Development authorities in other cities play a role in this process and have had some success in addressing this issue. However, there is a need for the needs of those sections of the population who do not own land or property to be addressed.

Weaknesses and gaps in planning effectively leads to a situation where the urban poor are generally deprived of access to basic urban services, largely due to their inability to pay for them. In such cases, even where these services are provided by the urban local bodies, the real beneficiaries are generally everyone else other than the urban poor.

Since the Madurai Corporation is not responsible for provision of services outside the Corporation limits, the area falling outside the Corporation limits and within the LPA boundary often lack basic services and amenities. The planning that LPA does can only be termed as land use planning. This does not necessarily take into consideration the ecological and socio-economic impacts of urban growth and transformation.

# 6. Conclusion: Priority Areas for Future Proofing

The development of this urban diagnostic involved a wide range of meetings and three major workshops were held with key state and city level stakeholders to better understand the most important environmental risks to growth and prosperity impacting Madurai's development. This dialogue was used to review the relevant issues facing the city and validate and agree with relevant stakeholders the key priority areas which will form the basis for the development of a City Action Plan (CAP).

The specific climate and development risks the city stakeholders see as urgent areas for action were confirmed.

**There was a convergence of opinion of developing a CAP focusing on future proofing Madurai's 'green-blue infrastructure', including building its resilience to climate change.** This is essentially about demonstrating how to manage the interconnected set of challenges related 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 consultation process resulted in the identification of 5 spatially defined areas within the city which the stakeholder engagement process as a whole converged on as being potential areas for action. The sharing of data will help to finalise the boundaries of the area of focus and to enable identification of critical hotspot areas (it is possible that the location of interventions may be located some distance from where resultant problems are visible on the ground).

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 masterplan49. 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 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 green-blue infrastructure system will be more able to lever in finance and provide a longer term solutions 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.

Madurai Corporation felt that the action plan should focus on two scales:

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

- A programme of opportunities for future proofing blue-green infrastructure at the city-wide scale to mobilise widespread support and commitment for change. It was felt that identifying these opportunities which would provide an agenda which technical teams within the Corporation engaging with other stakeholders could address and gain broader commitment for as part of the review of the City Development Plan.

- The action plan should also select one part of the city to act as an exemplar and demonstrator of embedding a future proofing approach to tackling green-blue infrastructure needs in more detail which is characteristic of other situations within the city. It was felt that the process would help to develop capabilities within the city for scaling the approach and gain commitment for applying solutions more broadly by showing the difference the approach can make in practice. A key issue for stakeholders is to be able to see evidence for the additional benefits which future proofing process and a more integrated approach to development needs could deliver vs. BAU so that this could be communicated to decision makers and funders.

For the process for action planning to work effectively for the service beneficiary, the process will need to involve trusted partners and intermediaries who have been supporting Madurai Corporation to make best use of information data and past experiences of implementing solutions in the city (including a number of local universities and advisors). The support and involvement of civil society and community sector was also felt to be an important to the success of the action plan. Local politics would need to be carefully handled. It is important that proposals are communicated to decision makers by the Corporation in order that these gain support for implementation. Handling of engagement with elected representatives and in particular needs to be managed by the Corporation as timing and messaging will be a highly sensitive issue.

A number of other issues and priorities emerging from the process were also felt to be important for the future development of the city specifically around urban transport and congestion issues as well as solid waste management.

It was felt that transport issues would be best addressed in conjunction with the Madurai Comprehensive Development Plan review and that available data and mapping required to make a future proofing process effective for transport related solutions at city scale would not be available during the timelines for this particular project. The solid waste management issue of insufficient collection and waste management capacity in the city can more easily be addressed with targeted action around this particular sector. However, aspects of the issue would be addressed as part of the blue-green infrastructure – for example unauthorised dumping of waste.

# 7. References


Vulnerability of the urban poor, Liselore Havermans, DHAN Foundation 2008

Housing Products for the poor, Madhan Kumar Alamanda, Dhan Foundation

Climate Change Risk: An Adaptation and Mitigation Agenda for Indian Cities

City Development Plan, Madurai Corporation (2006)

Detailed Project Report for Basic Services to Urban Poor Under JNNURM, Madurai Corporation

Deterioration of the Informal Tank Institution in Tamil Nadu: Caste-based Rural Society and Rapid Economic Development in India, Jegadeesan and Koichi

Development Indicators at District Level in Tamil Nadu. Population Research Centre

Dynamics of Urban Mobility: A Comparative analysis of megacities of India. B.Sudhakara Reddy & P.Balachandra (2010)

Energy and Carbon Emissions Profiles of 54 South Asian Cities. ICLEI (2009)

Energy Intensive Sectors of the Indian Economy. Path to Low Carbon Development. Energy Sector Management Assistance Programme

Wastewater Pollution in Urban Rainwater Catchment Tanks: J Goetzenberger & R.Devika (in Development Matters August 2008 – DHAN Foundation).

A Case of Urban Local Bodies in Tamil Nadu . National Institute of Urban Affairs

Impact of Population on Environment in Madurai District. T.Maheswari (2012)

Innovative Approaches to Municipal Infrastructure Financing: A case study on Tamil Nadu, India. Venkatachalam (2005).

Integrated Urban Water Management. Global Water Partnership Technical Committee (2012)

JNNURM Newsletter: Building Cities for Generations – City Communique 1

JNNURM Newsletter: Building Cities for Generations – City Communique 2

Low Carbon Source Book. Atkins (2013)

Madurai District Ground Water Brochure: Government of India Ministry of Water Resources (2007)

Ministry of Environment & Forests (2010) Climate Change and India: A 4x4 assessment – A sectoral and regional analysis for 2030s.Foundation Programme for Anchor NGOs to build City Volunteer Technical Corps and City Technical Advisory Group. JNNURM

Road Transport Year Book (2007-2009). Transport Research Wing, Ministry of Road Transport & Highways, Government of India

Study on Traffic and Transportation Policies and Strategies in Urban Areas in India. Ministry of Urban Development (2008)

Tamil Nadu State of the Environment Report, Department of Environment, Tamil Nadu Government

Tamil Nadu Economy and Vision 2023. Presentation by R.Raghuttama, IMaCS

Tamil Nadu Annual Plan 2012. State Planning Commission

Vision Tamil Nadu 2023. Strategic Plan for Infrastructure Development in Tamil Nadu. Government of Tamil Nadu

Urban Issues, Reforms and Way Forward in India. Department of Economic Affairs, Ministry of Finance, Government of India (2009)

Urban Sprawl and its Transformation Over Land Use: A Case Study on Madurai Fringe Area. P.Saravanan, S.Padmasri and K.Lakshmi (2012)

Urban Renewal Programme Madurai. Directorate of Town & Country Planning, Government of Tamil Nadu (1999)

Water Consumption Patterns in Domestic Households in Major Cities. Abdul Shaban & R N Sharma

Water Poverty in Urban India: A Study of Major Cities. Abul Shaban

Water Sector Approaches to Combat Climate Change: DHAN Foundation