University of Stuttgart
Institute of Human Factors and
Technology Management IAT

Fraunhofer

EXECUTIVE SUMMARY 2020

CITY LAB KOCHI, INDIA

Photo: Alain Dubois

mgi MORGENSTADT GLOBAL SMART CITIES INITIATIVE
GLOBAL APPROACH – LOCAL SOLUTIONS

MorgenStadt City of the Future

Supported by:

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CONTENTS

1. INTRODUCTION

ABOUT MORGENSTADT GLOBAL SMART CITIES INITIATIVE

The Morgenstadt Global Smart Cities Initiative (MGI) is funded by the German Environmental Ministry through the International Climate Initiative (IKI). The MGI project aims at a transformational change of urban systems through the analysis, identification, and development of sustainable cross-sectoral solutions to optimize urban infrastructure, processes or services in Kochi (India), Piura (Peru), and Saltillo (Mexico).

The MGI intends to help the cities to increase their resilience to climate change impacts, as well as to support their GHG emission reduction efforts. Climate change represents a global challenge that can only be overcome through international cooperation. As part of the IKI network, the MGI's primary objective is to mitigate the consequences of climate change in the pilot cities, to increase their resilience to climate impacts and risks, and to preserve their natural resources better.

The selection of the three City Labs of Kochi (India), Piura (Peru), and Saltillo (Mexico) was based on the challenges they face in terms of climate change and urban development. All of them present a high degree of urbanization or urban growth. They have identified urbanization as a source of and a solution to many sustainability challenges in regional development strategies. However, none of the cities appear to have a coherent approach that underpins urban climate resilience and sustainable urban development with innovative policies and efforts to develop cross-sectoral interventions and infrastructure.

ABOUT THE CITY LABS

At the heart of the MGI project is the Fraunhofer Morgenstadt Initiative which has been instrumental in establishing the network of experts leading the City Labs for three selected cities. The Fraunhofer Morgenstadt Initiative is a network consisting of Fraunhofer Institutes, municipalities and companies that was launched in 2011 by the Fraunhofer Institute for Industrial Engineering (IAO) to conceptualize, develop and test innovations for the city of tomorrow.

The Morgenstadt City Lab consists of an in-depth analysis of a given city based on performance indicators for assessing the quantifiable sustainability performance; key action fields essential for sustainable development and the unique impact factors affecting each city. The results of each City Lab include an individual sustainability profile, a detailed analysis of specific urban sectors, an action-oriented roadmap as well as the development of innovative measures and projects. Figure 1 illustrates the comprehensive framework deployed in all three City Labs.

MORGENSTADT FRAMEWORK FOR MGI (FIG.1)

Examine city governance structure, climate risks, urban planning, economy and business, environmental management

1. INITIAL URBAN SYSTEM SCREENING

- **MCI Index**
- **Local stakeholder consultation**

2. IN-DEPTH URBAN SYSTEM ASSESSMENT

- **Sectorial analysis**
  - Sector specific Afs & indicators
  - Onsite data collection
- **Urban system assessment**
  - Overarching indicators and action fields
  - Onsite data collection
- **Climate risk & resilience assessemnt** to analyze climate risk and to track adaption measures

Identifying current strenghts, challenges and development opportunities of the city

3. IDENTIFICATION & ASSESSMENT OF MEASURES

- **City sustainability profile & prioritization of strategic measures** trough influence matrix
- **Clustering of measures** according to their expected impact and interrelation
- **Impact factor analysis**
- **Local stakeholder consultation**

Enhanced local capacity and expertise

4. FORMULATION OF THE ROADMAPS

Roadmap of project ideas
Including key building blocks, preliminary Cost benefit analysis, GHG mitigation potential estimates and risk assessment

ABOUT KOCHI

Photo: Ernesta Maciulyte

Kochi city is home to approximately 600,000 inhabitants, whereas the urban agglomeration accommodated 2.1 million inhabitants. It is the economic, touristic and commercial center of the state of Kerala, which is located in the south-west region of India on the Malabar Coast. Second to Mumbai, Kochi is the most important port city on the western coast of India. However, the city has become increasingly exposed to the risks and concerns associated with climate change. Kochi lies barely 5 meters above sea level on average and has a coastline of 48 kilometers. The city is embedded into a complex network of rivers, tidal creeks and backwaters, due to which Kochi has been regularly subjected to natural disasters like floods, cyclones, droughts and landslides. Over the past decade, sea level rises and increased frequency of extreme rainfall events have led to growing concern. Rising temperatures exacerbate the heat island effect in Kochi too.

It is therefore crucial for the urban development of Kochi to have a climate change and policy landscape that provides the framework for a sustainable transition. To tackle the effects of climate change and to

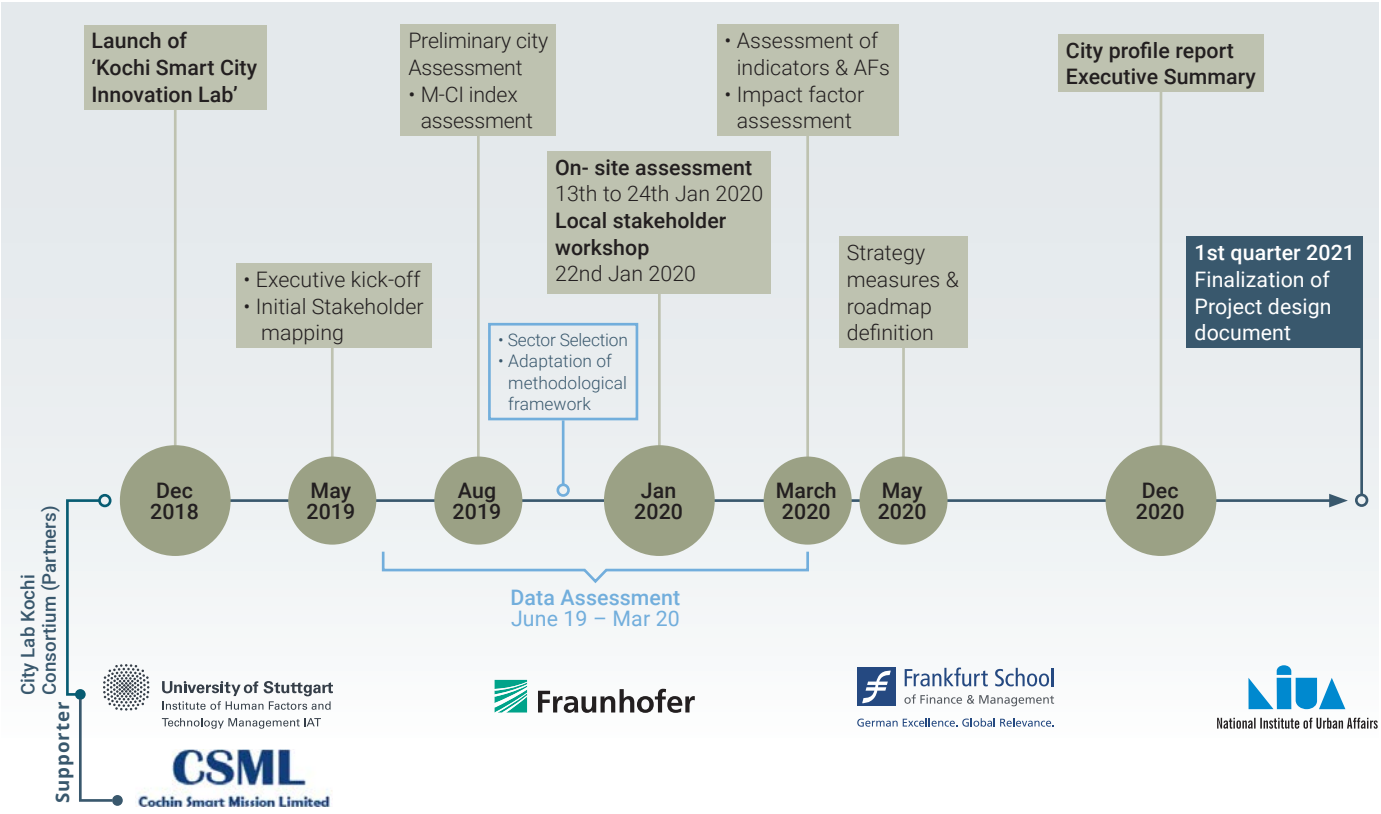
realize both economic and environmental objectives, India launched the National Action Plan on Climate Change (NAPCC) in 2008. At the sub-national level, SAPCC (State Action Plan on Climate Change) was developed to align the national framework with the regional development goals and to manage local climate risks effectively. Furthermore, following the ratification of the Paris Agreement in 2015, national schemes such as NDC (Nationally Determined Contribution) attempting to promote clean and renewable energy and development of less carbon-intensive and more resilient urban centers and National Adaptation Fund for Climate Change (NAFCC) supporting adaptation and mitigation efforts to combat climate change were developed by the Government of India. On the city level the Kochi Municipal Corporation is responsible for town planning and health and engineering in the city. Apart from the municipal corporation, parastatal bodies[1] are responsible for governance on the local level. Nevertheless, in the absence of city level authority, the climate change issues and actions are handled at the state level by the Climate Change Cell located within the Directorate of Environment and Climate Change.

India's Smart Cities Mission aspires to promote urban infrastructure providing a decent quality of life along with a clean and sustainable environment with the application of Smart solutions. At the heart of this the City Lab investigated the key challenges and opportunities in Kochi following the Morgenstadt City Lab methodology process, which is described in the following chapter.

1 Kerala Water Authority (KWA), The Public Works Department (PWD), Greater Cochin Development Authority (GCDA), Cochin Port Trust (CPT), Goshree Islands Development Authority (GIDA), District Disaster Management Authority (DDMA)

2. CITY LAB KOCHI

CITY LAB KOCHI TIMELINE (FIG.2)



The City Lab Kochi builds on Kochi's Smart City Development priorities[2] and supports the city's efforts in achieving India's Smart Cities Mission[3] objectives. The goal of this City Lab is to help Kochi become a model for innovative, locally tailored, climate-smart solutions targeted at increasing its resilience to climate change impacts while preserving natural resources and stimulating the local economy.

The City Lab Kochi is focused on the three sectors "Housing and built environment", "Energy", and "Water and Sanitation". The sectors have been selected based on the critical sustainable urban development challenges as well as local stakeholder consultation by understanding the strategic priorities for Kochi. This City Lab explores the relationship and potential impacts of three identified sectors on climate change adaptation and mitigation. Between October 2019 – May 2020, the City Lab Kochi Team carried out the city assessment. The project followed the timeline shown in Figure 2.

As a result, measures were identified and assessed as a part of the City Lab process which can be seen in the following chapter.

2 https://smartnet.niua.org/sites/default/files/resources/Kochi_SCP.pdf
3 https://smartnet.niua.org/smart-cities-network

2.1 SUSTAINABILITY PROFILE

ACTION FIELD ANALYSIS OUTCOMES (FIG.3)

Energy
- Energy policies are governed by State of Kerala
- High potential for solar power
- No use of Smart grid technologies

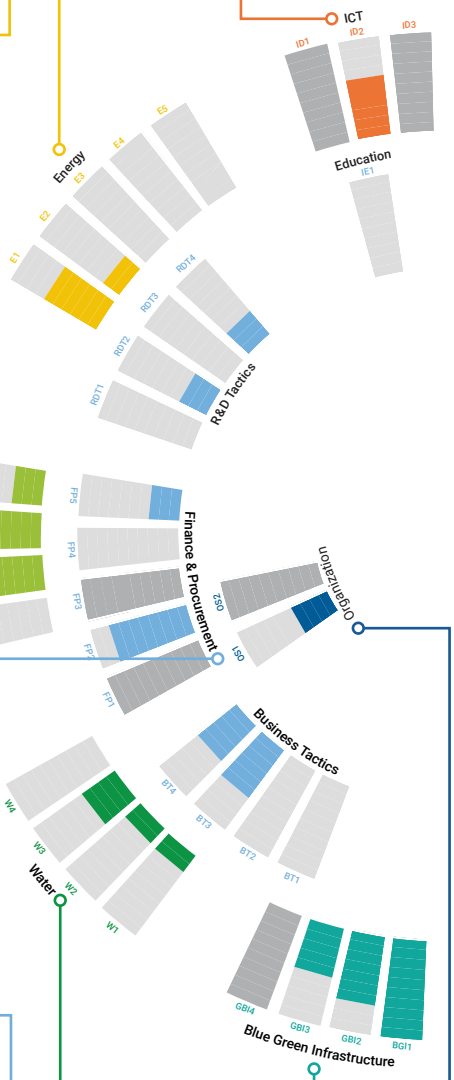
ICT
- Municipal departments and agencies practicing
- Effective data management

Mobility
- Require focus on Transport Oriented Development
- Kochi Metro is operating since 2017
- Water Metro system under development

Regulations & Incentives
Require reformation of regulations and development of Incentive schemes to encourage different sectors like water, energy, mobility and buildings to address sustainabiltychallenges

Solid Waste & Resources
- Missing updated waste management plan
- Waste separation at source
- City applies waste fees
- City is planning to generate energy from Waste

Strategy & Planning
- Lack of long term sustainability goals
- Missing City level Climate change action plan



Finance & Procurement
Active Public-private partnerships

Water
- Missing sewage collection system
- No trend towards reduction of water pollution levels
- Require management of Water- Energy –Food Nexus

Blue Green Infrastructure
- Active implementation of green infrastructure components
- Efforts by city towards pollution control and enhancement of urban air quality

Urban Planning & regeneration
- Active citizen engagement in district development
- Lack of Sustainability solutions in long term planning
- Identified socioeconomic development zones

Organization
Different governmental departments imply siloed governance structure

Buildings
- Building bye-laws are followed to meet the standards
- Active incentive schemes to motivate building users toward energy and resource saving behavior

Resilience
- Existing emergency plans for critical infrastructure
- Missing integrated risk management city plan for infrastructure

2.2. CLIMATE OBSERVATIONS AND IMPACTS OF CLIMATE CHANGE


Photo: Damian Wagner

As part of the City Lab Kochi, a risk and resilience assessment for climate change impacts was carried out, including an expert evaluation conducted by local and city lab experts. The following are the findings of the topics assessed:

Sea Level Rise & Coastal Erosion

Expected impacts include an increased risk of flooding and coastal erosion, which would predominantly affect areas of touristic interest and densely populated central areas. Increased saltwater intrusion in both surface and groundwater sources threatens the natural freshwater reservoirs. Named as especially vulnerable are the local marshlands, which will be impacted by an increase in salinity and flooded areas, and the population dynamics of aquatic life.

Heavy Rainfall and Stormwater

Future projections of Indian summer monsoon rainfall suggest a reduction in the frequency of light rainfall and an increase in high to extreme rainfall events. The change in precipitation patterns is perceived as a very relevant risk for Kochi. Across all risk and vulnerability factors, it was ranked the highest by experts. Waterlogging and flood events have been said to occur at times. Here, impermeable paving and the blocking of canals with solid waste have been identified as intensifying factors that obstruct stormwater flow and worsen flooding.

Water Scarcity

The annual rainfall volumes and natural water resources make water availability in Kochi less of an issue. However, a decrease in rainfall or shift in precipitation patterns is associated with a greater likelihood of shortages of drinking water, increased water pollution due to less dilution and flushing, and more extensive saltwater intrusion. Furthermore, high-quality drinking water is not accessible to all citizens – a situation that could become worse under the pressures of climate change.

Temperature Rise and Urban Heat Islands

In terms of temperature increase, Kochi has seen a rise in average temperature of around 1°Celcius over the last 50 years. A major contributor to the high temperatures in cities is the urban heat island effect (UHI) which is a predominant climate risk in urban areas resulting e.g., from lack of vegetation, surface moisture or extensive paved surfaces. Altogether, high and increased temperatures in cities may lead to climate-related health issues, especially among vulnerable groups with low adaptive capacity, as well as higher demand on water and electricity (e.g. for cooling and refrigeration devices). In general, the effects of rising temperatures and UHIs are perceived as important risks for Kochi, especially because the center is already quite densely built-up, blocking natural ventilation and cooling structures such as the lagoons and water bodies.

Change in Biological System

The combination of increased flooding, water stagnation, waste accumulation and warm temperatures in Kochi were found to provide excellent breeding grounds for disease organisms and vectors (mosquitoes, flies, and rodents) which can transmit diseases to humans. This situation already contributes to disease outbreaks, and such impacts might become more frequent and severe. Another main concern, which was raised by multiple experts, related to potential negative impacts on aquatic and marine life, especially fish and shellfish populations which are the primary source of income for the Kochi fishing industry.

Climate Change Adaptation Measures

In the face of the aforementioned risks, climate change adaptation needs to play a more important role in the future of urban planning and development. In terms of mainstreaming climate change, high-level strategies in general exist at national and state level (National Action Plan on Climate Change and Kerala State Action Plan on Climate Change)[4,5]. Due to weak enforcement and lack of priority, there have been no city-level plans or policies on climate change in Kochi itself. The need for structural and binding plans, especially in the areas of water drainage, stormwater management and urban heat islands, was perceived as crucial for the city's future. In terms of available financing and funding sources, it was mentioned that access to funds is very limited. Regarding the availability of climate information, existing data sources at state level were mentioned, whereas for the Panchayat (village) or the Municipal level, significant data gaps were noted. On an overarching level, planning is perceived as rather top-down where the city level itself does not have much power and the community level is not really considered in planning and implementation. General awareness among stakeholders on climate risks and impacts (especially on flooding and heat stress) is rather high. On the other hand, the knowledge on how to act and improve local resilience towards climate impacts within daily life was perceived as rather low.

The climate finance landscape in India

It is highly fragmented with no main coordinating entity and various roles for stakeholders at different levels of engagement. There is a broad range of stakeholders associated with climate finance in India which include nodal ministries, commercial banks, financial institutions and international agencies. Kochi has implemented a wide variety of climate change mitigation and adaptation projects. These projects mainly include energy efficiency, E-mobility, zero carbon buildings and city forestry. Most of these projects[6] are funded by consortia of multilateral finance and development agencies. Kochi has been progressive in implementing climate change projects and takes the lead in developing new initiatives in the area. However, it is highly desirable to promote exchange and cooperation among the different initiatives to achieve a more significant impact and avoid a doubling of efforts.

GHG Emission

With regards to climate change, Kochi is quite vulnerable to climate change impacts, yet its contribution to climate change in terms of GHG emissions per capita is rather low. The City Lab Kochi research sug-

4 Government of India: National Action Plan on Climate Change. Available online at http://moef.gov.in/division/environment-divisions/climate-changecc-2/national-action-plan-on-climate-change/, checked on 7/20/2020.

5 Government of Kerala (2014): Kerala State Action Plan on Climate Change.

6 List of climate change mitigation and adapation projects by Kochi is available in the "City Profile Kochi – Full Technical report of Comprehensive analysis and initial roadmap definition for the city of Kochi". The document would be available upon request.

gests that Kochi emits ~2.6t CO2eq/capita (Figure provided by C-HED as per Draft Climate Smart Cities report), placing it well below the "good performance" ESCI benchmark of 5t CO2eq/capita developed on behalf of IDB. While the GHG mitigation strategies should be continually supported to maintain good performance, climate change adaptation interventions might prove equally urgent and hence should be a crucial component of new and existing projects and initiatives in Kochi.

Overarching insights from climate risk and resilience assessment show a clear priority and need for improved water management and flood mitigation. Also, proper risk assessment and monitoring schemes are needed to build a basis for knowledge-based decision-making. In addition, high-level policy work is needed to create a legally binding planning document with clear regulations and instructions. In addition, Kochi should further extend the work on the community level, to leverage on community-based adaptation.

2.3. SECTORIAL ANALYSIS

The City Lab Kochi is focused on the three sectors of housing and built environment, energy, and water and sanitation. The sectors have been selected based on the critical sustainable urban development challenges as well as local stakeholder consultation. The main findings on the three focal sectors are discussed in the following sub-chapters.

2.3.1. Housing and built environment


Photo: Sabine Giglmeier

Adequate supply of affordable, low-carbon, climate-resilient housing is essential to ending poverty and supporting economic development in cities around the world. In India around 20% of GHG emissions are generated by the construction sector[7]. This sector, therefore, has a high potential to contribute to India's mitigation goals.

Typical single- and smaller multi-family houses in Kochi are made of brick with plaster inside and

7 Nagrath, Kriti (2013): OPINION: Policies for a green construction sector in India. Edited by Climate & Development Knowledge Network (CDKN). Climate & Development Knowledge Network (CDKN). Available online at https://cdkn.org/2013/12/opinion-policies-for-building-a-low-carbon-construction-sector-in-india/?loclang=en_gb.

outside, with a simple roof construction and rather simple windows. Usually, no insulation is used. The average living space per inhabitant is approximately 9.5m² [8]. According to the population census, around three out of four (77.10%) housing units are inhabited by their owners in Kerala[9]. Kochi is very densely built-up (over 66.61% of the total area is sealed) and due to the strong influx from the surrounding areas, there is a lack of housing units, especially for low-income groups. Kerala currently has a deficit of about half a million housing units. Efforts are being made by the local, state and central governments to provide affordable housing. The biggest challenges, however, are the limited availability of suitable building land and low-income groups hardly accepting the housing units provided. Housing programs aim to offer public housing to the urban poor. To this end, different offers are made available to low-income residents. However, the relocation plans often fail, and the occupancy rates in the mass housing sites are low because citizens in the target group are often reluctant to leave their livelihood. Due to high land prices, these mass housing units are often located on the outskirts of towns or in unattractive surroundings with poor infrastructure and limited job opportunities.

As most of the structures in the city are built in the low line area or close to the coast, the built infrastructure is expected to be extremely vulnerable to even minimal rises in sea levels. The infrastructure is already facing challenges and is in many cases not very resilient. In addition, new challenges with regards to soil integrity, bearing capacity, and the stability of buildings are expected to arise. As Kochi is densely built-up, there is little space for green areas. However, green areas are significant for the urban climate, and as the effects of the urban heat island increase noticeably, initial steps are being taken to make the city greener.

Currently, India's space cooling energy consumption per capita is one of the lowest in the world and only about a quarter of the world's average consumption[10]. However, mainly due to the growing Indian economy, the associated increase in prosperity, urbanization and climate change, the cooling energy demand will increase significantly in coming decades. Measures to reduce this rapidly growing cooling demand can have a huge impact in reducing greenhouse gases in coming decades. Green and blue areas in the city offer a high potential for climate change adaptation by creating a so-called sponge effect. The greener areas can absorb and store water, during heavy rainfall events for example, increasing the likelihood that flooding will be prevented or reduced. Green and water surfaces also result in evaporative cooling which helps reduce the effects of the urban heat island[11].

Activities in coastal areas in Kochi have been regulated in the CRZ (Coastal Regulation Zone) to prevent regular flooding of the affected areas and subsequent major damage. However, some of the regulations were not observed and high-rise buildings were built in prohibited areas of the CRZ. A large number of buildings in the CRZ are still inhabited and exposed to the risk of flooding. There are also many families who make their living from fishing in this area.

8 Thakur, Atul (2008): 33% of Indians live in less space than US prisoners. Edited by The Times of India. The Times of India. India. Available online at https://timesofindia.indiatimes.com/india/33-of-Indians-live-in-less-space-than-US-prisoners/articleshow/3753189.cms, checked on 3/23/2020.

9 Census (2011a): Kerala Population 2011-2020 Census. Edited by Census Population 2020 Data. Census 2011. Available online at https://www.census2011.co.in/census/state/kerala.html.

10 Birol, Fatih (2018): The Future of Cooling. Opportunities for energy-efficient air conditioning. Edited by IEA. IEA. Available online at https://www.iea.org/reports/the-future-of-cooling.

11 Oke, Timothy R.; Mills, Gerald; Christen, Andreas; Voogt, James A. (2017): Urban climates. Cambridge, New York, Melbourne, Daryaganj: Cambridge University Press. Available online at https://www.amazon.de/Urban-Climates-Dr-T-Oke/dp/1107429536.

Based on these reasons, the following actions are needed to enable sustainable development of the housing and built environment of Kochi. Firstly, experts should develop a holistic concept to bring the families out of the endangered areas, but still ensure that the effort for commuting remains manageable. Secondly, in order to counteract the growing heat island effects, green spaces should be created in the city on one hand, and on the other hand the supply of fresh air from the surrounding areas should be ensured, e.g. via water canals. This would require a rejuvenation of channels. Finally measures to reduce the rapidly growing cooling energy demand can have a huge impact in reducing greenhouse gases in coming decades. This can be achieved by improving the boundary conditions for the building stock, e.g. by optimizing current construction principles and methods and by taking steps to reduce the heat exposure of buildings and people in urban areas.

2.3.2. Energy

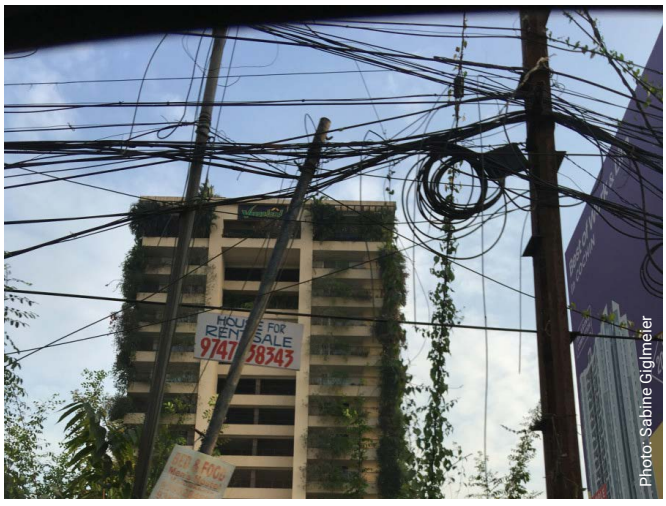


Photo: Sabine Giglmeier

The main sectors of energy demand in Kerala are electricity and fuel for mobility. The KSEBL (Kerala State Electricity Board Limited) takes care of electricity supply in the state. On the demand side the residential sector with 50% in 2019-20 and the industrial sector with 27% are the most relevant sectors. Based on the ~34.8 million inhabitants of Kerala, every citizen consumes 658 units of electricity (kWh) per year on average. Therefore, the average electricity consumption per inhabitant in Kerala is only 58% of the average in India, at 1144 units per inhabitant.

In Kerala, 74.5% of the gross electricity demand is imported and mainly generated by fossil fuels. Hydro power plants are the main source of electricity generation in the state. They are owned and operated by KSEBL and supply about 35% of peak demand and 25% of the electricity requirement of the state[12]. Kerala also shows a huge solar potential. Only 62.5 MW PV has been installed by December 1, 2019. The wind potential in Kerala is smaller than the solar potential; however, by December 1, 2019, 70.3 MW of wind capacity has been installed in Kerala[13]. The share of electricity demand produced by renewable energy sources currently adds up to 25.5% of the total electricity demand.

In India, the energy sector is governed at national and state level. Most of the energy policy related to Kochi is made by the Kerala state government. Under the Ministry for Electricity of Kerala, several departmental institutions and organizations implement the energy policy of the state. Though energy policy is mainly defined at state level, there are good reasons for Kochi to actively support the development of a sustainable and climate-friendly energy system. Increasing the energy efficiency and the local generation of

12 KSEBL (2020): Budget Estimates 2020 - 2021 and Supplementary Financial Statement For 2019-2020. Edited by Kerala State Electricity Board Limited (KSEBL). Thiruvananthapuram, Kerala. Available online at http://www.kseb.in, checked on 5/17/2020.

13 KSEBL (2019): Electricity generation capacity in Kerala. Installed Capacity in MW as on 01.12.2019. Edited by KSEBL. Available online at http://www.kseb.in/index.php?option=com_content&view=article&id=45&Itemid=553&lang=en, checked on 5/17/2020.

renewable energy within Kochi will not only reduce CO2 emissions but also increase energy supply security and reduce import dependencies and energy prices.

Based on these reasons, the following actions are needed to enable sustainable development of the energy system of Kochi. Firstly, a long-term energy plan must be developed for the City of Kochi together with recommendations for short-term measures to start the implementation of the plan. Secondly, intial steps should be taken to increase the efficiency of buildings. Thirdly, the implementation of local renewable energy sources, especially rooftop-photovoltaic systems, should be demonstrated and the replication supported to increase self-supply of energy. Finally, it is recommended to have the entire city in mind, but to work with the citizens, institutions and organizations in the wards to develop adapted and promising solutions and actions. The participation of the citizens is important, since the final goal of the energy transformation is to increase their quality of life.

2.3.3. Water and Sanitation

Photo: Marius Mohr

Several physical and geographical features challenge the local water and sanitation situation in Kochi. The high water table leads to the infiltration of groundwater into sewers. Narrow roads, predominantly sandy soil, heavy rainfall during the monsoon season and unfavourable terrain conditions further complicate the construction of new sewer lines and are major challenges for sanitation services.

The main source of water in Kochi is the Periyar River around 20 km northeast of the city. Around 170 MLD (Million Liters per Day) complying with national potable water standards are supplied via a centralized network from Aluva Water Treatment Plant, located next to Periyar River. According to SAAP 2016-17[14] provided by the State Government of Kerala, 85% of the population have access to piped drinking water. As the water is not supplied to all households regularly, they additionally depend on private water tankers or private bore-wells. Water losses due to old, leaky pipes are very high, estimated between 40% and 80%. Regarding sanitation, onsite sanitation facilities are the predominant form of containment, namely septic tanks which cover 71% of domestic households. However, in the SAAP 2015-16[15], the State Government of Kerala reveals that around 3% to 6% of households in Kochi are connected to a sewer system leading to the estimation that around 4% of Kochi's wastewater is actually treated at two relatively small sewage treatment plants currently in operation. Treatment facilities for faecal sludge are under construction, but not operating so far. Illegal dumping and the pollution of surface waters are the consequence. Infrastructure for stormwater drainage covers around 43% of the city. Further, water-related projects under the Smart City scheme include the implementation of household and street bins for solid waste collection and segregation.

14 Government of Kerala (2016): STATE ANNUAL ACTION PLAN (SAAP). (SAAP -2016-17). Source: ATAL MISSION FOR REJUVENATION AND URBAN TRANSFORMATION (AMRUT).

15 Government of Kerala (2015): STATE ANNUAL ACTION PLAN. (SAAP -2015-16). Source: ATAL MISSION FOR REJUVENATION AND URBAN TRANSFORMATION (AMRUT).

The NUSP (National Urban Sanitation Policy) was launched in 2008 by the Ministry of Urban Development. The extensive framework supports the cities' development towards generating public awareness about sanitation, achieving ODF (Open Defecation Free) status and an integrated, city-wide sanitation system. It grants financial support to the states and cities for the preparation of State Sanitation Strategies and City Sanitation Plans respectively, also including decentralized onsite sanitation solutions, to first look on faecal sludge management as of importance for public health.

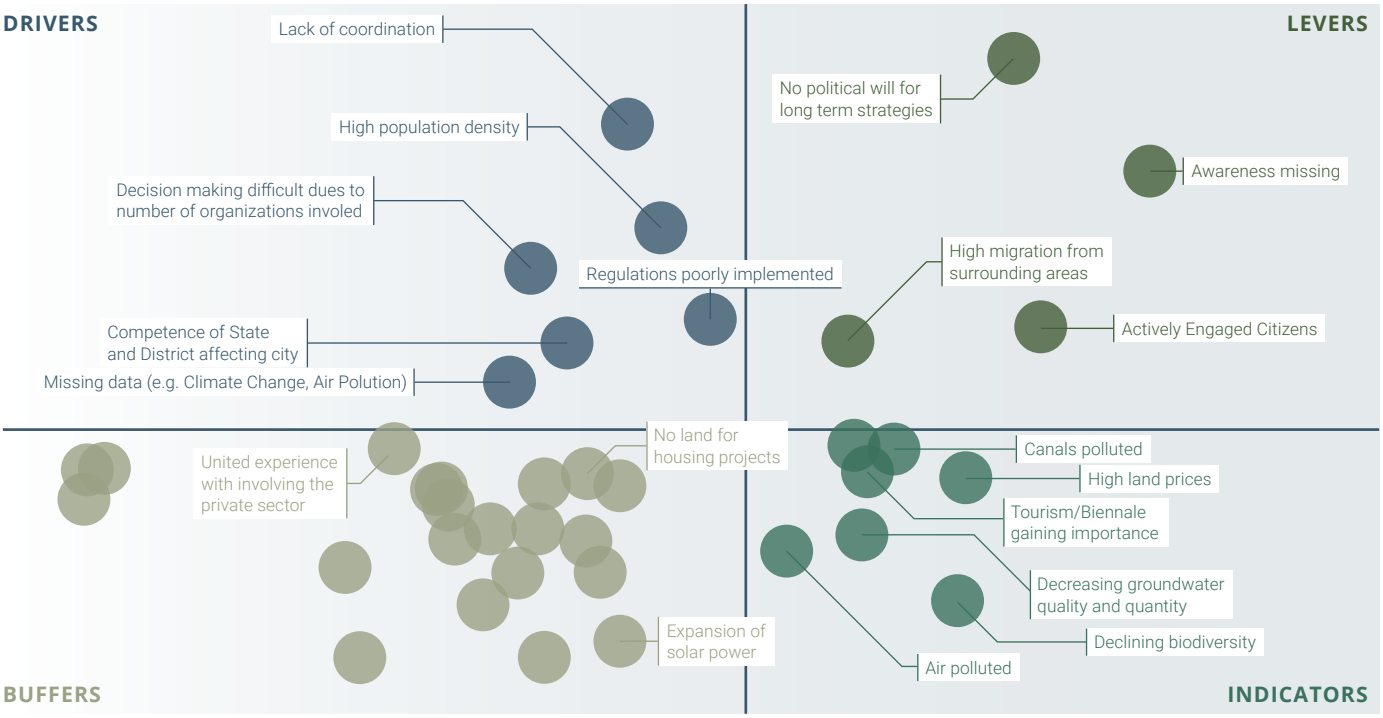
Both state-level and municipality-level agencies share responsibilities for the water and sanitation sector. The KMC (Kochi Municipal Corporation) is the local urban body and responsible for the planning of water related infrastructure in collaboration with KWA (Kerala Water Authority) and the KPCB (Kerala Pollution Control Board), with the latter two being Kerala state agencies with local offices. The responsibilities for water and sanitation aspects at state and city level are, however, diffuse and overlapping within Kochi Corporation and Metropolitan boundaries. This applies especially to the monitoring of onsite sanitation systems. Since the channels, rivers and canals already play an important role in the transportation sector in Kochi, KMRL (Kochi Metro Rail Limited) the transport management agency is also involved in urban water management.

These canals provide an alternate and cheaper mode of daily transport of people and goods, adding critical and sustainable connectivity within the city. To develop the waterways in a manner that increases attractiveness for transportation and other activities, rejuvenation and sustainable water management are required. Thus, extension of improved sanitation, sewer lines and sewage treatment capacity could indirectly mitigate the climate change-related emissions while creating an alternative and efficient mode of transportation. In addition, comprehensive solid waste collection and treatment schemes are required to avoid pollution of the canals and blockage of sewers and drainage lines.

Based on these reasons, the following actions are needed to enable sustainable development of the water and sanitation sector of Kochi. The implementation of city-wide rainwater harvesting at building level could contribute to climate sensitive water management. It will decrease the amount of water that has to be drained in a short time and also the harvested water can be used for domestic purposes such as toilet flushing and possibly even as potable water if the water quality allows. Simultaneous greening of roofs could complement sustainable rainwater harvesting. Another potential measure targets the high rates of non-revenue water. The water supply system requires urgent retrofitting to sustain water supply and reduce energy requirements.

3. SENSITIVITY ANALYSIS

IMPACT FACTOR ANALYSIS OUTCOMES (FIG.4)



Based on 34 interviews with local stakeholders, the on-site assessment of Kochi revealed a total amount of 39 Impact Factors that exert substantial influence upon the development of the city. Following the Sensitivity Model of Frederic Vester[16], a cross-impact analysis of these factors allows distinguishing between four different categories. Drivers have the potential to drive change and to stay stable over a long time, but often are difficult to change. Levers have a high impact on many other factors, and many other factors also influence them. These are the crucial factors that one needs to address in order to transform the system in the desired direction. Indicators have little influence on other factors but are strongly influenced by other factors. Buffers are rather inactive in any direction.

A comprehensive analysis of the prioritized Action Fields and the most crucial Impact Factors leads to the following fields of intervention for the city system of Kochi:

- Lack of coordination
- Lack of awareness
- Migration/population density
- Long-term strategies
- Implementation of regulations
- Engaged citizens
- Data availability
- Regulations and taxes, budgetary policy
- Water-Energy-Food nexus
- Public transport
- Waste management

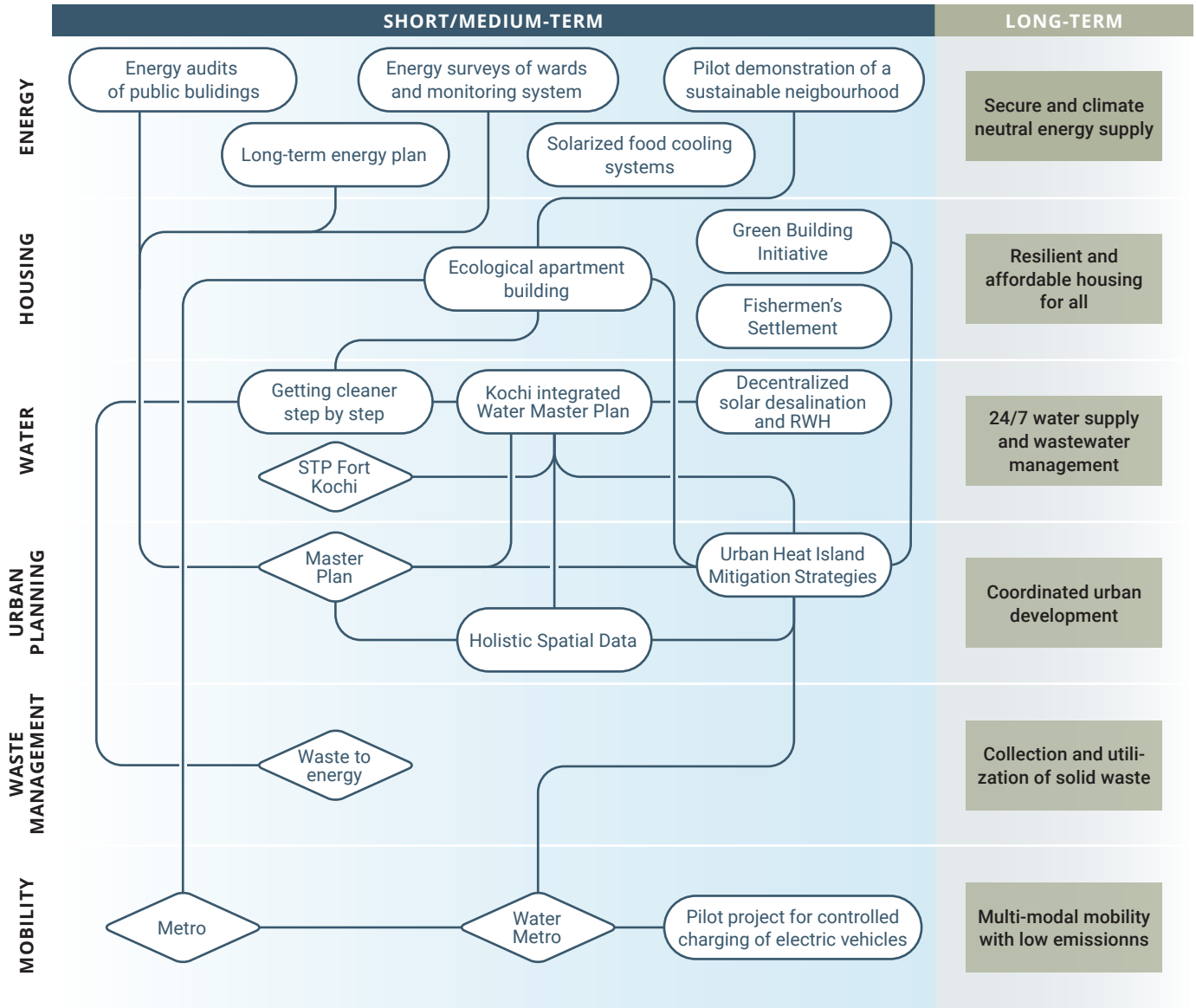
Hence, to have a lasting effect, the measures developed to improve the sustainability and resilience of Kochi against climate change should address one or more of these fields.

16 http://www.frederic-vester.de/eng/sensitivity-model/

4. ROADMAP: STRATEGY & MEASURES

4.1. STRATEGY ROADMAP FOR SUSTAINABLE DEVELOPMENT OF KOCHI

PROJECT IDEAS (FIG.5)



4.2. SUGGESTED MEASURES

1. Fishermen's Settlement

Related fields of Intervention:

MIGRATION

AWARENESS

This project aims to develop and implement a holistic concept for a settlement for the fishermen and their families. Many of the local fishermen in Kochi live in informal settlements in the CRZ. Each year, even without special events like the flooding in 2018, these settlements are flooded for around two months during the Monsoon (June – October), and the affected families have to move to shelters. There are different offers from the government to give housing to the people, but acceptance is poor because that would mean the beneficiaries leaving their livelihood and moving away from their workplace.

2. Green Building Initiative

Related fields of Intervention:

WATER-ENERGY-FOOD NEXUS

AWARENESS

This project aims to integrate more green spaces into the city to make it more resilient to massive weather events and to improve the urban climate. Parts of it will be used for urban farming. Here, the combination of urban greening and urban farming is intended to create a double added value, with food production as a perk to the sponge city effect. Current urban farming concepts have hardly been economically viable so far, and this project does not explicitly aim at this. Nevertheless, this project can pave the way to urban economic farming in the long term.

3. Integrating Climate Services into the Kochi GIS-Map

Related fields of Intervention:

DATA AVAILABILITY

This project aims to integrate information on future climate predictions with assessment and information tools into the Kochi GIS-map that is currently being developed by AMRUT. This map includes necessary geographic information like buildings, streets, water bodies, land use and utilities. Underground information is provided where possible. Furthermore, information services are to be added, for example, to provide necessary data for land or house-buying. A data standard was also developed for the current AMRUT project. However, the existing project focusses on mapping the current state of Kochi. To enable foresighted planning and adaption, future developments and drivers must be considered in such an informative tool. Therefore, the proposal is to add climate services into this new GIS-map for Kochi, for example, scenarios for sea-level rise.

4. Urban Heat Island Mitigation Strategies

Related fields of Intervention:

LONG-TERM STRATEGIES

COORDINATION

This project idea aims to implement a pilot that works as a proof of concept for strategies to mitigate climate change and Urban Heat Islands in Kochi. The pilot combines measures of increased ventilation and vegetation in a localized area: the rejuvenation of a canal, ideally close to the coastline, with accompanying vegetation on its banks and surrounding buildings. A central part of the project must be an information campaign to raise the awareness and sensitivity of Kochi's population to climate change. The citizens should be included in the planning and implementation process. The pilot can be carried out in coordination with ongoing parallel projects like canal rejuvenation or the water-metro to minimize costs and land use.

5. Kochi integrated Water Master Plan

Related fields of Intervention:

LONG-TERM STRATEGIES

COORDINATION

This project aims at the development of a comprehensive Water Master Plan to coordinate the various water-related activities in the Greater Kochi Area. It can allow a strategic development of water infrastructure, the protection of aquatic ecosystems and the improvement of livability in Kochi, where most inhabitants live close to a water body. As climate change, with increasing heat waves, periods of water scarcity and massive rain events, threatens the water sector particularly, coordinated planning is needed even more in the future. The integrated Water Master Plan covers the following areas: water supply (multiple sources), sewage collection and treatment, groundwater protection, protection of surface waters (canals, sea), and flooding through heavy rain. It should be developed based on the Kochi Master Plan (town planning) and involve citizens where appropriate. The Water Master Plan shall be published as a report and updated regularly, at least every 5 years.

6. Holistic Spatial Data

Related fields of Intervention:

DATA AVAILABILITY

The objective is to get a quick overview of available data concerning the state of the infrastructure in Kochi. A coordinated collection of spatial data (GIS) as a basis for planning and maintenance as well as for coordinated infrastructure development will be carried out. It includes data on water pipes, sewer lines, drains, canals, electric lines, etc. It should be integrated with the Command Control Centre; thus, data are available easily for all legitimate users.

7. Ecological apartment building

Related fields of Intervention:

AWARENESS

This project shall demonstrate a best-practice sustainable apartment building in Kochi. The development and implementation of this demonstration apartment building should cover the following aspects: it should address housing for lower and medium income groups in proximity to a metro station (densification, less individual traffic). Regarding water, rainwater harvesting, on-site sewage treatment plant and water-saving installations in households are included. A comfortable indoor climate, heat-resilient and durable construction with local materials and construction techniques, and an awareness campaign for residents are part of this project.

8. Decentralized solar desalination and rainwater harvesting

Related fields of Intervention:

WATER-ENERGY-FOOD NEXUS

The primary source for drinking water in Kochi is the Periyar River. Due to high water losses in the distribution network, residents far away from the water source do not have reliable water supply and need additional supply by water tankers. Seawater desalination is a proven technology, but the energy consumption is relatively high, and brine disposal is an unsolved issue at large-scale plants. As Kochi has an abundance of sun, it is proposed to combine a decentralized seawater desalination plant with PV electricity production. Due to limited space, the PV cells shall be floating on the water. Due to there being less sun during the monsoon, but sufficient rain, a rainwater harvesting facility shall be combined with the desalination plant. Depending on the weather, the two water sources can be combined flexibly, thus guaranteeing water supply for around 10,000 to 100,000 residents along the coastline. Modular units can be developed, thus reducing the transport requirements of the water (via pipeline).

9. Getting cleaner step by step

Related fields of Intervention:

WASTE MANAGEMENT

ENGAGED CITIZENS

AWARENESS

Sewage infrastructure is mostly lacking and urgently needed in Kochi. However, there are no areas available for centralized treatment solutions, and sewer systems are challenging to build and operate due to the high groundwater table and frequent waterlogging during the monsoon. This project intends to create a best-practice solution for decentralized sewage treatment, while simultaneously improving the state of the local environment by composting bio-waste and involving the local community in the collection of solid waste and maintaining the installations. For a community of 100-500 inhabitants, the sewage will be collected and treated in an anaerobic tank and a plant filter. The residents will be involved in the planning process to create ownership. A team of residents will be trained to operate and maintain the installations. Thus, with a limited budget, the cleanliness of the area will improve actively. A particular focus is on surface water bodies, like canals, which contribute actively to the quality of living if in good condition.

10. Long-term energy plan for Kochi

Related fields of Intervention:

LONG-TERM STRATEGIES

COORDINATION

The plan will be based on sound analysis of the existing energy system, the expected development of energy demand based on assumptions about the growth rates of population, industry, welfare, and energy efficiency, as well as the assessment of the local potential of renewable energy sources. On this basis, the design of an optimal and cost-effective, climate-neutral energy system will be calculated, which provides a secure energy supply in each hour of the year. Also, a set of short-term actions will be developed which serve as a good starting point of the long-term transition roadmap. The study will provide data on the optimal mix of renewable energy sources, the generation capacities needed, and the optimal combination of the electricity, cooling, heating and mobility sector. The long-term energy plan will help to increase awareness of the need for energy transformation within the City of Kochi and will provide a common goal for politicians, citizens, industry and other stakeholders in the city. As a result, Kochi would serve as a role model for other cities in Kerala and India on energy planning.

11. Energy surveys of wards & energy monitoring system

Related fields of Intervention:

DATA AVAILABILITY

To provide transparency on energy data to the citizens and politicians of the wards, energy surveys should be conducted in all wards to evaluate the energy demand and supply today, and the potential of using renewable energy in the ward. Additionally, proposals should be provided on how energy efficiency can be increased and renewable energy sources used, including costs and expected savings. Furthermore, data must be made easily accessible for the citizens via the internet, and services offered to support their decision making. The project should include the following steps on data collection: evaluation of existing data sources and the accessibility of these data on households, businesses and wards level, development of an energy system model for different wards including supply, distribution, transformation and demand of energy, development of a concept on data collection from households, businesses and institutions based on interviews and online-questionnaires, and development of an assessment method for unavailable data. On energy statistic development and provision of data, the following steps should be implemented: development of an Energy Data Platform of the City of Kochi and its Wards as part of the Kochi Smart City data platform.

12. Solarized food cooling systems to stimulate local commercial activities

Related fields of Intervention:

WATER-ENERGY-FOOD NEXUS

Agriculture is an essential economic sector in Kerala. Cooling of vegetables and other agricultural goods is essential for the farmers to be productive and buffer the mismatch of supply and demand for their goods. Using solar energy for cooling is very useful since cooling demand is high at the time of intense solar radiation. In addition, if solar electricity is generated at the place of cooling demand, costs for electricity distribution can be avoided, and the independence of the local energy system increases the resilience of the local economy. Therefore, it is proposed to build up a solarized cooled agricultural warehouse in Kochi.

13. Energy efficiency audits for public and commercial buildings

Related fields of Intervention:

DATA AVAILABILITY

This project aims to implement the Energy Efficiency Audit Initiative for all public buildings as public and commercial buildings are the largest energy consumers. It will be a joint project of the Kochi City Council and the Government of Kerala. Owners of commercial buildings should also be invited to join the efficiency initiative. To this end, grants could be awarded to motivate them to carry out audits. The Energy Management Centre Kerala (EMC) has extensive knowledge of energy efficiency and provides a list of registered energy audit firms. EMC could serve as co-organizer of such an initiative. Other energy institutions like Energy Efficiency Services Ltd and the Bureau of Energy Efficiency could be invited to join the initiative as well. With this approach, the Energy Efficiency Audit Initiative for public buildings in Kochi could become a role model for all public buildings in Kerala.

14. Pilot project for controlled charging of electric vehicles

Related fields of Intervention:

PUBLIC TRANSPORT

The government of Kerala has set ambitious targets for the market launch of EVs. However, providing the charging infrastructure for EVs could become a bottleneck for EV deployment. The EV charging infrastructure needs to be built in parallel with the market penetration of EVs and requires a concept for EV charging in public spaces, at work and at home. The project could be directly linked to the smart grid initiative in Kochi with the goal of developing a strategy for grid stabilizing electric vehicles (EV) charging. As part of the Kochi Smart City initiative, it is recommended to complement this initiative with a pilot project for the evaluation of controlled charging of EVs. Additionally, the project must be complementary with the KSEB initiative to build up an EV charging infrastructure and must, therefore, be implemented together with KSEB. For the investigations, a research institution with knowledge on controlled EV charging technologies and strategies must be involved.

15. Pilot demonstration of a sustainable neighborhood

Related fields of Intervention:

ENGAGED CITIZENS

AWARENESS

As a chance to make the Smart City Kochi visible in one place, a project is recommended which demonstrates a Sustainable Smart City Neighborhood in Fort Kochi, in which all buildings undergo energy-efficient renovations and historical restorations, receive a photovoltaic system and are served by sustainable water and sewage systems. The combination of historic refurbishment and future-oriented smart technologies would make this neighborhood an attraction for smart city experts as well as tourists and the flagship of the Smart City Kochi. Besides, it would stimulate the local economy. The experiences with the holistic approach of the Sustainable Smart City neighborhood should be scientifically evaluated in order to gain knowledge on how the inter-sectoral and integrated planning and implementation can be used for the roll-out of Smart Cities in future.

5. OUTLOOK

Based on the aforementioned analysis, Kochi is highly vulnerable to climate change impacts and thus, there seems to be a high demand for holistic and sustainable solutions. The three analysed sectors of "Housing and built environment", "Energy", and "Water and Sanitation" are at the heart of the contemporary urban development challenges the city is facing. Yet, these sectors hold great potential for enhancing the city's resilience to climate change, while preserving the natural resources as well as mitigating GHG emissions.

A vision to be taken over by Kochi could be to develop this city into a best-practice example for sustainable development for a medium-sized city in an emerging nation. On the one hand, economic development and increase of liveability should not lead to rising greenhouse gas emissions. On the other hand, the impacts of climate change should be absorbed by forward-looking risk assessment and incorporation into planning. Financial resources made available on a global scale to fight climate change shall be directed towards Kochi and used in an efficient way. Experiences shall be made available for other cities under similar conditions, an intense exchange of experiences shall be initiated.

This report has analysed and presented the status quo and has introduced a list of potential project ideas that could be taken up by the city of Kochi or other interested stakeholders. These projects have been developed based on the holistic Morgenstadt City Lab methodology.

However, MGI project activities do not conclude with the development of the Roadmap presented in this report. As a next step, one prioritized project idea will be elaborated in terms of its technical and financial components and feasibility, as well as the corresponding, quantified GHG emission savings and their potential regarding climate change adaptation. Further local stakeholder consultation will be carried out to ensure the feasibility of the project and to obtain local project ownership.

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