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Strategic perspectives for Coimbatore water management and infrastructure

Report

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Project partners:

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[2] ISOE – Institut für sozial-ökologische Forschung
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Background

With 1.7 million inhabitants on an area of 257 square kilometres, Coimbatore city (Tamil Nadu) is one of the over 50 typical industrial cities with more than a million inhabitants in India. It is estimated that the population of the South Indian city will grow by another million people over the next 30 years. Securing the water supply and wastewater disposal is one of the most urgent problems: In many places, the supply of drinking water is limited to a few hours every 5 to 10 days. Similarly, many urban areas lack sewage systems and sewage treatment plants. As one of India's 100 Smart Cities, Coimbatore has the chance to realize exemplary solutions and set the course for a sustainable urban development.

In the context of the project Smart Water Future India (SWF India), funded by the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, Coimbatore's water sector has been analysed. The core of the new approach is to look at urban development challenges not only separately from traditional sectors. Instead, solutions for the water supply, energy supply and food safety have been developed across the board and intelligently networked in order to reduce competition for resources. At the same time, this project intended to provide information to German companies in the water sector about how to gain access to the huge Indian market for water and wastewater management. The methodology for the analysis of the urban dynamics and strategy development is based on the "City Lab" approach developed in the Fraunhofer research network Morgenstadt (Cities of the Future).

1. Introduction

This report is based on the analysis described in the report "Integrated analysis of water management and infrastructure in Coimbatore", as well as on a stakeholder workshop in Coimbatore, which took place in July 2018, many interviews and conversations in Coimbatore and Germany, and two workshops in April 2018 and February 2019 with German companies working in the water sector.

On the one hand, the report aims to address the decision makers in Coimbatore but also the Government of Tamil Nadu and German Ministries involved in the cooperation with India. In this regard, it summarizes the most important findings of the project *Smart Water Future India (SWF India)* and gives suggestions where to focus the further developments of the water infrastructure in Coimbatore. In addition, it stresses the potentials of Indo-German cooperation on the example of Coimbatore.

On the other hand, the report addresses companies from the water sector in Germany, which are doing business in India or are planning to do so. It aims to highlight the most urgent demands in the water sector of Coimbatore as an example of a medium sized Indian city. Thus, it could help to improve the cooperation with India by better understanding the situation on the ground.

First, important strategic action fields, which determine the development of the water sector in Coimbatore, as water supply, wastewater management, and master planning are characterized. A focus lies on the description of the approaches that have been developed to improve the Indo-German cooperation in the field of water management in Coimbatore. In the end, the main recommendations for the target audiences are given. The annex briefly explains the methodology of the analysis, based on the Morgenstadt City Lab method and presents the main impact factors, which influence the development of the water sector in Coimbatore.

2. Strategic action fields

2.1 Water supply

Although there are raw water resources in high quality available in the dams situated in the mountains, the citizens of Coimbatore only receive water every 5 to 10 days. Insufficient infrastructure for treatment and supply as well as high water losses due to leakages are the reasons for this. Due to the irregular flow regime in the pipelines and the storage time in domestic tanks, the water quality at the point of consumption is supposed to be much lower than at the water works. Mostly, water is not metered and users pay a very low flat rate. If the monsoon does not bring sufficient rain, the water supply for the city is endangered. Even with the Pilur-3 water supply scheme, the analysis of future water demand shows that without a reduction in water losses the demand is expected to exceed the supply capacity from 2025. All in all, there is much improvement potential in the area of water supply.

In 2018, Coimbatore City Municipal Corporation awarded a 26-year contract for the improvement of water distribution services to the company SUEZ. As the water professionals of SUEZ are currently developing solutions for Coimbatore, the project team SWF India as well as their counterparts in the administration of Coimbatore did not see much benefit in working on this in parallel, thus the water supply has not been in the focus of the project.

Most households in Coimbatore do not solely rely on the piped water supply, but use private wells and rainwater harvesting as alternative sources. In the context of SWF India, a Master Thesis has been conducted analysing the state of rainwater harvesting in Coimbatore. Rainwater harvesting is considered an important topic for Coimbatore, but the potential for Indo-German cooperation on this topic is considered as limited, as there are many local solutions available already.

2.2 Wastewater management

Coimbatore suffers from insufficient wastewater collection and treatment infrastructure for municipal sewage and industrial wastewater. This leads to pollution of water bodies (lakes, river Noyyal, and groundwater), health problems, odor emissions and ultimately to increased water scarcity through degradation of water sources.

Modern centralized systems for wastewater treatment are usually designed for >100,000 inhabitants to maximize efficiency and stability. This makes them complicated and inflexible to implement in rapidly growing cities, due to obstruction of streets during construction, coordination requirements and high initial investment. New facilities are currently under construction in Coimbatore, but still parts of the growing city are without wastewater collection and treatment and the new systems will not cover the entire existing city.

Industry is required to comply with “zero liquid discharge” legislation, meaning that companies must have wastewater treatment plants. Unfortunately, compliance is not systematically monitored or enforced, and there are no statistics on illicit industrial wastewater discharge. Due to the large number of small-scale industries, toxic wastewater is discharged into the sewer lines and mixes with household sewage, thus threatening the stability of biological sewage treatment plants.

Stakeholders in Coimbatore agreed that the collection and treatment of wastewater is one of the most urgent matters in city development, thus it has been a special focus for SWF India.

2.3 Monitoring

The integrated analysis of water management and water infrastructure in Coimbatore showed that firstly, the pollution of lakes, Noyyal River and groundwater is an urgent

problem and secondly, reliable environmental information is hardly available. In particular, for the qualities and quantities of water resources and flows in relation to their condition or changes thereto, no comprehensive and continuous spatial and temporal data are available.

Therefore, the stakeholders involved in the urban analysis process, together with the project staff, identified the need to promote the development of a smart monitoring and data management system as a central field of action. Data from a modern smart sensor and metering system should be combined with the analysis results of trustworthy laboratory services in one system. Such a system can fulfil different functions. For state and municipal authorities, the necessary information and data can be made available centrally for corresponding planning and decision-making processes. In addition, such a system can open up the possibility of better demonstrating the short to long-term effectiveness of measures in water management. Stakeholders also see the potential to support the identification of the causes of waterborne health problems or to anticipate and limit hotspots of health risks. Ultimately, better environmental information can serve as the basis for a fair and transparent tariff/cost system or for sanctions against polluters.

2.4 Capacities & Cooperation

Stakeholders in Coimbatore expressed a high demand for and interest in knowledge and technological exchange between India and Germany by strategic partnerships. SWF India takes this as a point of departure for Indo-German collaboration activities and smart, innovative approaches. A concept for strategic project ideas will foster long-term cooperation in the water sector that also includes the aim to increase the capacities of all actors involved.

2.5 Master Planning

The city analysis showed that the city and district of Coimbatore currently lack strategic master plans in regard to comprehensive (urban) development. Key infrastructures are improved in a piecemeal fashion. While this development approach can work for some systems, the water sector is special in that all its subsystems connect. Effects – whether depletion of water sources or pollution – are cumulative and travel downstream, affecting the entire river basin.

To create substantial and lasting improvements, a strategic and coordinated master plan should be drawn up, outlining strategies for all relevant actor groups: public actors, institutions, companies, and private citizens. Ideally, the master plan would address and include the entire Noyyal River Basin. The master plan should have a scope of at least 15 years and identify short-term actions. All individual actions, including the future initiatives proposed in this report, could increase their impact within the context of such a larger plan.

Strategies should include measures related to:

- rainwater management and flood prevention, groundwater management and protection, wastewater management, drinking water supply, green spaces,
- provision and maintenance of public infrastructures,
- education and communication campaigns,
- support for individual actions,
- monitoring and reporting,
- coordination of public agencies.

A master plan for the Noyyal River Basin would need collaboration and support of Coimbatore District, CCMC, TWAD Board and further agencies (see city analysis). Currently, these agencies lack funds, capacities and coordination to draw up such a comprehensive plan.

3. Approaches for future initiatives

3.1 Water Innovation Hub

Objective

Germany has decades of experiences in management and treatment of water and wastewater. Many German companies offer good solutions, and are exporting these solutions to other countries as well. India with its dynamic development has large demand in the water sector and is an interesting market for German companies. As most German companies are relatively small, they face difficulties on the Indian market, e.g. they do not have enough presence on site, are lacking relevant network partners, are not involved in planning water infrastructure, and might not always have solutions adapted to the Indian demand or the possibility to conceptualize and test prototypes. On the other side, Indian stakeholders are eager to exchange knowledge and technical solutions on the local water sector. Often the water situation on site is complicated and needs partners who are willing and have relevant resources to develop, test and adapt solutions. One of the results of SWF India is that there is a demand for a Water Innovation Hub acting as a platform in Indian cities in order to address the above-mentioned issues. A range of tasks for the Water Innovation Hub can be found in Figure 1.

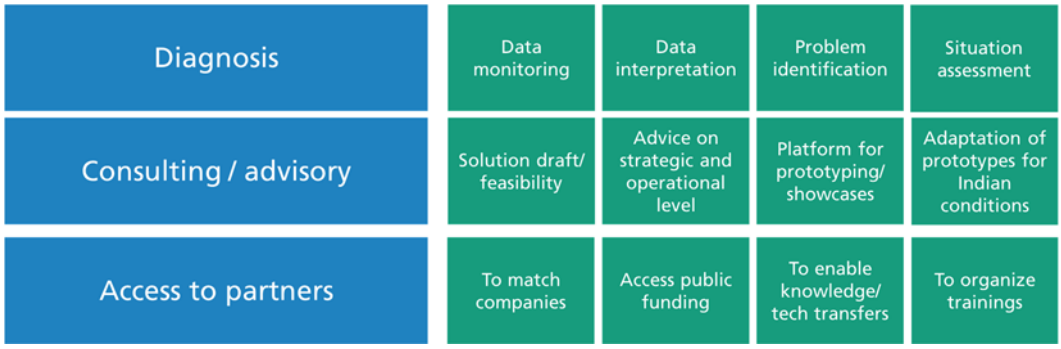


Figure 1: Tasks of the Water Innovation Hub

Approach

As the Water Innovation Hub should be addressing local issues, such a Hub will cover a city and its surroundings (e.g. in a radius of 50-100 km). As a minimum, two persons skilled in the local language will be in charge of the Hub:

- A coordinator, who is fluent in English, communicates over all usual means, is responsible for the communication and coordination with all partners.
- A senior advisor, who ideally has experience with the local administration, is responsible for the coordination with the different bodies of the local administration.

The staff of the Water Innovation Hub will be employed by an Indian organization, but independent from the local administration.

In the initial phase (2-3 years), the funding for these employees as well as for German institutions, organizing the set-up of the Water Innovation Hub could come from public German sources. In this phase, a number of selected German companies become start-up members of the Hub. After the initial phase, the member companies cover the costs for the Hub via a yearly fee. At the same time, the Hub is open for Indian companies as well, as long as they pay a membership fee. Local companies from the water sector will be addressed explicitly.

Implementation

First, the Water Innovation Hub serves as an office where information converges. A database on the water infrastructure in the city is created, which can be successively expanded. The exchange of students is organized. A homepage is set up, every two months a newsletter is published and sent to the members (content: current developments in the water sector of the city, new tenders etc.). At the same time, the Water Innovation Hub will be noticed (press reports etc.).

Future application and transfer potentials

Since the Water Innovation Hub focuses on solving local issues, but refers to similar circumstances in other Indian cities or even fast growing cities around the globe, the concept and its outcomes will be easy to multiply once tested.

3.2 Monitoring

Objective

This pilot project of the Water Innovation Hub aims at the implementation of a smart monitoring and data management system for water quality and quantity in Coimbatore. As a result of the SWF India project, the Indian stakeholders involved in Coimbatore highlighted the strong demand for a better assessment of the chemical, quantitative and ecological status of surface waters (especially lakes in urban areas) and their inflows. A temporally and spatially resolved monitoring of the situation would help to better assess

the pressures and the effectiveness of measures. The wish of the stakeholders was that sensor-based measurements and laboratory investigations should be combined in a data management system in order to make them flexibly available via different interfaces. Thus, the pilot project should build up such an initial system that integrates monitoring and data management at an exemplary site, addresses questions of long-term institutional ownership and develops a supportive academic and non-academic capacity development.

Approach

The smart monitoring and data management system will be implemented as a pilot project through the concept of a Water Data Management System (WDMS), which is a product of exchange and discussion with stakeholders in Coimbatore and German business representatives in SWF India. The WDMS is shown in Figure 2.

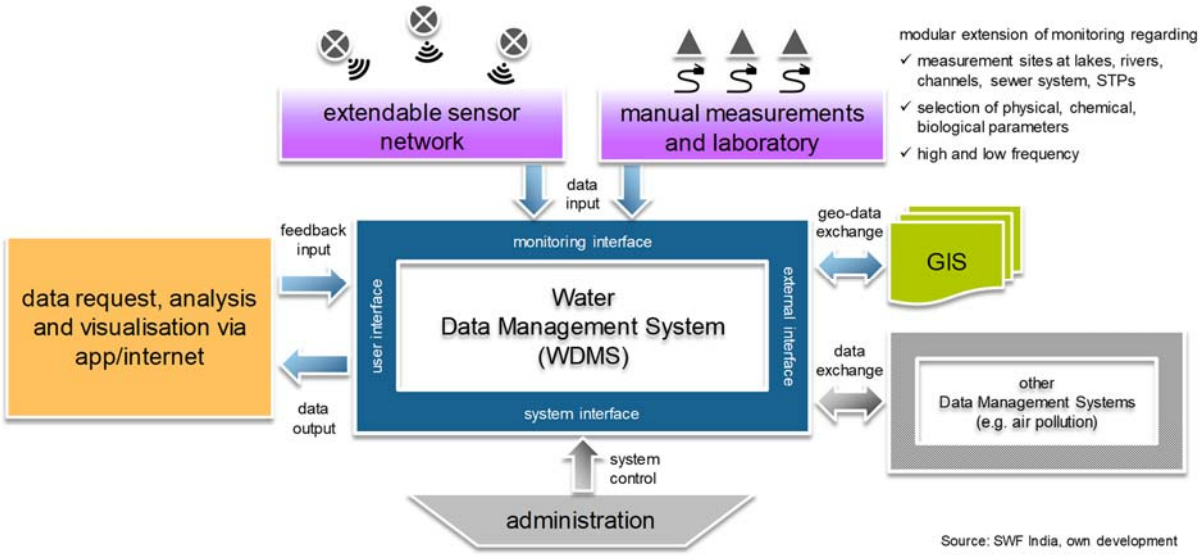


Figure 2: Structure and components of the Water Data Management System (WDMS)

The core is a database system to which four interfaces provide access to different functions. The monitoring interface allows the input and consolidation of data from a variety of different sources such as sensors, laboratory tests or observations. Via the user interface it is possible to access the information in the database, visualise and analyse it, but also to make further enquiries to the system or the administration. Via external interfaces, the information of the database can be linked with further spatial information or also with other (sectoral) databases. The database system and its interfaces are managed and controlled via the system interface to the administrator.

Modular extensions of the WDMS are intended in terms of measurement sites (spatial dimension), frequency of measurements (temporal dimension) and parameters of measurement (content dimension).

Implementation

As the first pilot implementation, a minimum configuration is proposed, in which the basic database structure is set up with simple initial versions of the four interfaces. As an

example, a spatially limited hotspot of the load at one of the lakes in connection with the Noyyal River and artificial feeder lines shall be chosen and equipped with high-frequency measuring sensors and seasonal laboratory measurements. A connection to GIS will be established and access via internet and apps will be integrated. Together with training materials, the pilot implementation will serve as a demonstration facility for future capacity development. Due to the available infrastructure, institutional and personnel capacities, Siruthuli offers a solution to the question of ownership.

Future extensions of the pilot implementation are offered in the following areas: (1) Expansion of the network of monitoring sites in terms of measurement density, measurement parameters, temporal frequency and spatial extension. Here, further hot spot sites in the urban area can be added. (2) A broader spectrum of sensors (remote, walk-by, drive-by, network technology) can be implemented and tested for their suitability. (3) A measurement network can be implemented up- and downstream in the environment of a Sewage Treatment Plant (STP). (4) The WDMS can be extended to leakage control in order to successively reduce water losses in the supply network.

Future application and transfer potentials

The pilot project contributes to the establishment of a Smart Water Data infrastructure in Coimbatore by bringing together, making available and analysing data on water quality and quantity from different sources. Thus, the system allows a significantly improved identification of hotspots of water body pollution and a faster adaptability of management measures. In perspective, the findings can be linked to the health sector in order to introduce precautionary measures at an early stage or to limit the causes of health problems. The Smart Data Monitoring and Management System can make an important contribution to the evaluation of the progress of Smart City development projects in Coimbatore in the field of water by providing a new opportunity to assess the effectiveness of measures.

Furthermore, it can be assumed that the system will provide innovative impulses for the engineering competence and IT industry in Coimbatore. The high mutual interest of Indian and German companies, authorities and civil society actors makes such a pilot project a promising field of Indo-German cooperation.

3.3 Semi-centralized wastewater management

Objective

Coimbatore currently has insufficient wastewater treatment capacity. It also has a growing need for sustainable waste management practice, renewable energy and clean water. A semi-centralized wastewater management plant can address these challenges on a ward level. A potential pilot project could implement one pilot plant with the following benefits and potentials:

- More flexible than conventional solutions
- Smaller service area: easier to get implementation approval

- Energy-efficient treatment of wastewater and organic waste
- Saleable by-products: fertilizer, service water, energy
- Service water use can reduce drinking water consumption by up to 40%
- Reduction of pollution and health risks
- Showcase solution can also be training and study site
- Large replication potential across the state and country

Approach

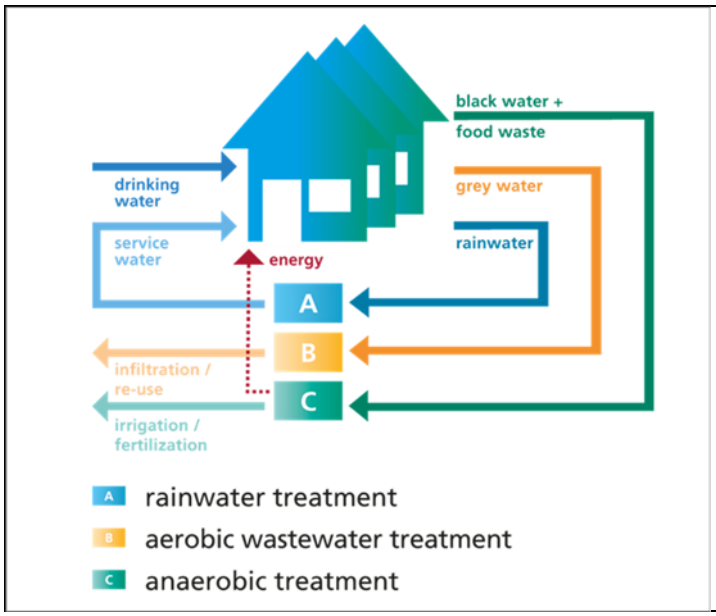
Semi-Centralized Wastewater Management integrates different technologies, combining benefits of large, centralized infrastructures and smaller systems.

The system treats wastewater and organic waste. At the same time, it produces treated water for non-drinking uses, as well as energy and fertilizer from organic waste and sludge. A semi-centralized wastewater management plant of ca. 1 ha area serves ca. 12,000 inhabitants (roughly one average urban ward of Coimbatore). A rough indication for the minimum number of inhabitants served by one plant would be ca. 3,000 (always dependent on numerous factors).

The “Semi-Centralized” approach allows for the upgrading of existing settlement and institutional structures with a lower coordination effort than large-scale centralized solutions. Many existing settlement areas have a separation of black water (discharged into septic tanks) and all other wastewater (discharged to sewer lines).

It can also be a solution for newly settled areas developing outside the areas scheduled for central wastewater connection. Besides this, municipal solid waste separation systems in Coimbatore are insufficient, leading to waste of organic resources that could be simultaneously addressed by this approach.

Reference project: A pilot project in a newly built mixed-use urban district in Qingdao, China was implemented in 2012 with support by Chinese and German government agencies (project SEMIZENTRAL, www.semizentral.de). Serving 12,000 people, the “Resource Recovery Center” has been successful and is still being monitored by a research team. The project is well-documented and could be adapted for local implementation.



Input:

- Domestic and commercial wastewater
- Rain water
- Food waste

Output:

- Service water for irrigation, washing and toilet flushing
- Specially treated water for industrial purposes
- Fertilizer
- Heat, biogas

Source: Fraunhofer IGB

Figure 3: Schematic of an exemplary semi-centralized wastewater management project

Figure 4: Project SEMIZENTRAL in Qingdao, China, © Simon Gehrmann, Susanna Neunast

Implementation

A minimum viable project may have the following specifications:

- Pilot area: suitable household area (~12,000 inhabitants, currently inadequate wastewater and waste infrastructure, sufficient space for plant installation) – ideally new built (easier), but possibly retrofit
- Base data for pilot area
- Technology consortium: Team of local and German technology manufacturers capable of equipping the plant; team for operations
- Linear infrastructures: Plant to households – for water, wastewater
- Collection system for organic waste
- Community and local political support

- Clear replication strategy for additional wards

Additional value can be delivered through the following solutions:

- Community outreach and public involvement
- Framework sales contract with service water consumers: non-potable, “fit for use”-treated water can be used commercially/industrially
- Monitoring: water use, waste generation, etc.
- Operations training programme
- Environmental economics cost-benefits analysis

Optional “add on” solutions:

- Linear infrastructure: plant to grid or battery – for excess electric energy from biogas
- Intelligent pricing scheme for water to incentivize sustainable behaviour
- State and GoI-level political support
- Tri-generation plant that produces electricity and cooling (depending on energy output)

A potential activity schedule for the implementation is proposed in Figure 5:

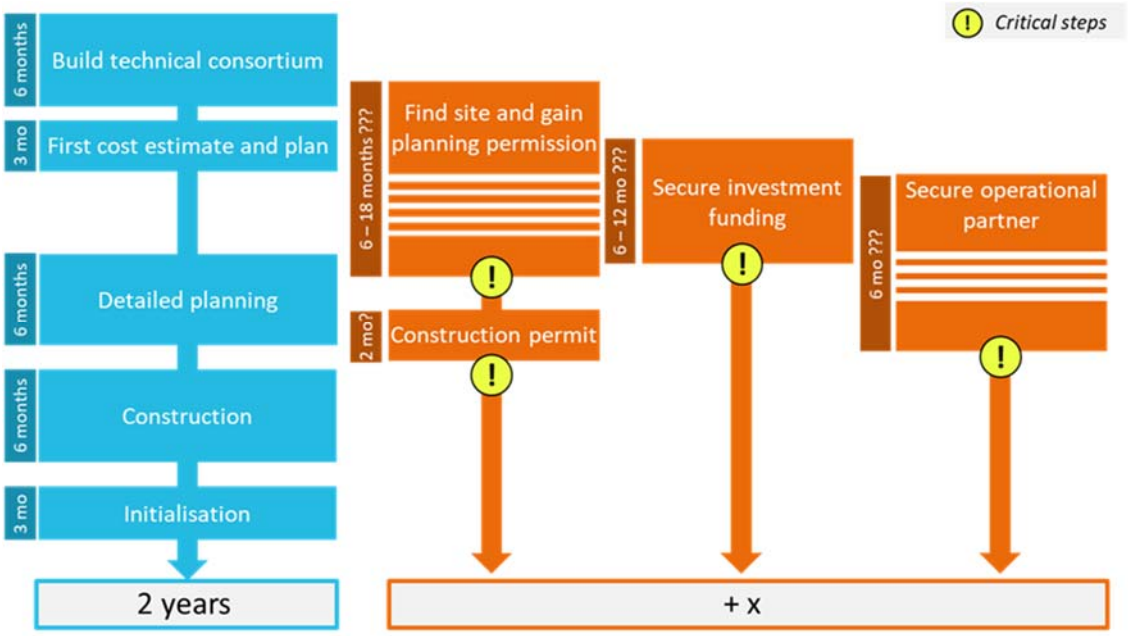


Figure 5: Potential implementation process of a semi-centralized wastewater management project

Future application and transfer potentials

In the stakeholder workshop (July 2018), this approach received a high level of interest from the stakeholders. This reflects the general need for solutions to the stated problems in India. Wherever it is implemented in India, a semi-centralized wastewater management plant could be a reference project for thousands of comparable urban developments across the country. Cities across India struggle with the same challenges and find it difficult to implement centralized solutions. Especially in fast-growing urban agglomerations, this approach would allow localized solutions for multiple infrastructural matters at once.

3.4 Industrial wastewater treatment

Objective

Pollution of surface water bodies and groundwater in Coimbatore is partly due to effluents from industries. At the same time, these industries need a secure water supply for their production processes and are interested in a clean environment to improve the living quality in their city, as improved liveability draws skilled labour and investment. A pilot project is shaped that would reduce the contamination of water bodies by the effluents of industrial water users.

Approach

A first conceptualisation of a pilot project for industrial wastewater treatment identified the following measures that could improve the situation:

- Development of showcase solutions for different industries
- Wastewater treatment and reuse for reducing water consumption from other sources
- Mapping of Coimbatore with producing industries and their status regarding water supply and wastewater treatment
- Cooperation of solution providers from India and Germany to develop ideal solutions for different industries
- Outreach to other regions in India to multiply the experiences from Coimbatore
- Clusters of neighbouring companies realizing joint treatment plants
- Complete Zero Liquid Discharge – no dependence on outside water resources for company
- Showroom for potential treatment processes

These ideas are in line with the activities of GIZ to set up an environmental technology platform for industrial wastewater in India[1]. As a reference, the German-Vietnamese project AKIZ[2] could be used. Here, an integrated wastewater concept for industrial zones has been developed.

Future application and transfer potentials

These approaches have been discussed on the SWF India stakeholder workshop in Coimbatore in July 2018. The feedback of the participants was that there is sufficient technological knowledge available in the region, which can be seen on the example of joint effluent treatment plants for textile industries in Tirupur, where zero liquid discharge is practised. The reason why so few industrial wastewater treatment plants exist seems to be a lack of compliance to regulations, which is caused by lack of enforcement of these regulations. As the project team of SWF India did not see a chance to improve the enforcement of these regulations by Indo-German cooperation, this approach has not been pursued any more.

[1] https://www.giz.de/projektdaten/projects.action;jsessionid=5835148C04F241EC37E217C188305F77

[2] http://www.akiz.de/index.html

4. Final recommendations

The dynamic development of Coimbatore combined with the high population density and the insufficient infrastructure pose a great challenge to the future development of the city. As the capacities of the local administration are limited, it has been a reasonable decision to hand over the responsibility for a proper water supply system to a private company. Still, the pollution of the surface water resources as well as the groundwater through untreated sewage and industrial wastewater will have a negative impact on the development of the city, which will be increased by rising water consumption when the supply system is improved. As the city developed in a chaotic way, many small scale businesses are scattered over the city, many of them discharging toxic wastewater into the drainage systems. Thus, the wastewater at most parts of Coimbatore is a mixture of municipal sewage and industrial wastewater, which might be difficult to treat with conventional biological processes.

The main recommendations for the local government of Coimbatore are thus:

- Develop a better **data basis**: spatial information about potential sources of pollution should be combined with GIS-data of the existing infrastructure, and results from water quality monitoring should be added to this data pool. This data pool should be accessible to all staff of CCMC and the respective authorities involved in infrastructure development. Only with sufficient information about the current situation, strategic decisions where to take measures can be taken reasonably.
- Take a **strategic approach** to improve the situation: many measures are necessary to reduce the pollution of water bodies in Coimbatore. A strategic approach, backed by a (Waste)Water Master Plan, could help to take the right decisions. Wastewater should be treated as close as possible to its source, to prevent its seeping into the environment, but a totally decentralized approach is not efficient, as the operation of treatment plants should be carried out by professional staff. Further growth of the city should be taken into account when planning wastewater infrastructure.
- Invest in the **capacities of the local administration**: To be able to prepare and realize the necessary measures, highly qualified staff as well as adequate technical equipment is required. Only with attractive working conditions, sufficiently qualified staff can be recruited for the local administration.
- **Involve the citizens**: They profit from a cleaner environment, and they should be informed about measures and involved as far as possible. Spreading information about planned and implemented measures via newspapers and websites is a first step, organizing awareness raising campaigns regarding water conservation, substances not to be disposed of via the sewage, not littering the water bodies etc. should follow.
- Make use of **international cooperation opportunities**: Germany has chosen Coimbatore as one of the Smart Cities to support. Many initiatives are currently running, the GIZ as well as the project Smart & Wise are involved in the water sector of Coimbatore, the KfW is interested in funding measures. Esslingen as a partner city is also interested in a closer cooperation. These activities offer access to consulting and financial resources.

Acknowledgements

The authors thank the interviewees and participants of the project workshops for their valuable time and willingness to work together. In addition, we appreciate very much the very fruitful support and commitment of the Coimbatore City Municipal Corporation (CCMC).

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List of abreviations

AKIZ	Integrated Wastewater Concept for Industrial Zones (Integriertes Abwasserkonzept für Industriezonen); project title
BMU	German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety
CCMC	Coimbatore City Municipal Corporation
GIS	Geographic Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoI	Government of India
IGB	Fraunhofer Institute for Interfacial Engineering and Biotechnology (Fraunhofer-Institut für Grenzflächen- und Bioverfahrenstechnik)
ISOE	Institute for Social-Ecological Research (Institut für sozial-ökologische Forschung)
KfW	Kreditanstalt für Wiederaufbau
STP	Sewage Treatment Plant
SWF India	Smart Water Future India; project title
TWAD	Tamil Nadu Water Supply And Drainage Board
WDMS	Water Data Management System

Annex: Methodology of the situation analysis

Morgenstadt City Lab

The method of analysis is based on the Morgenstadt assessment framework for sustainable urban development (City Lab method). This framework is structured in three levels of analysis – indicators, action fields and impact factors –, which in sum are designed to understand the current sustainability performance of cities and come to coherent strategies and an integrated roadmap for development:

- **Indicators**: current state of the city compared to peer cities
- **Action Fields**: assessed degree of intervention already made in identified key areas (current status)
- **Impact Factors**: restrictive and supportive drivers and pressures for the current state of the city

A mixture of quantitative benchmarks and qualitative data analyses makes sure that an objective performance profile of cities can be generated by at the same time respecting the individual factors of the city that make a direct comparison with other cities difficult and point towards an individual strategy for the city. The analysis of the data follows the larger fields of urban development and helps identify strengths and weaknesses within the city.

The Morgenstadt assessment framework was developed for the task of a very broad and thorough city analysis not focused particularly on any one sector. The task in SWF India differed in that the project focuses on the water sector and does not require a comparative benchmarking. Therefore, the methodology was adapted to reflect the needs of the project. Indicators were assessed informatively, but not benchmarked. Morgenstadt action fields served as a guide for integrated analysis of the status quo. They were supplemented by more in-depth research questions related to the water infrastructure.

Table 1: Topics of the analysis of Coimbatore

Focus topics	Additional topics for integrated analysis (based on Morgenstadt Action Fields)
■ Water supply ■ Collection and treatment of municipal wastewater ■ Industrial water supply and wastewater disposal ■ Stormwater drainage and utilization ■ Open water bodies ■ Waste management	■ Town planning ■ Energy supply ■ Agriculture ■ Climate change – impacts and adaptation measures ■ Governance structure of city administration ■ Qualification of human resources ■ Innovation and private sector integration

The analysis was carried out through a combination of desktop review, site visits and interviews with local stakeholders from the municipality and administration, private sector, research and consultancy, civil society including non-governmental organisations (NGO), see Table 2. These interviews focused on identifying the status of the water sector in

Coimbatore, including strengths, challenges and development opportunities stemming from within and without the sector.

The findings of the desktop research, interviews and site visits have been set out in the city analysis report[3]. The city is struggling with insufficient wastewater infrastructure, groundwater depletion, drinking water scarcity, polluted water bodies, derelict drains and monsoon flooding. While actions are being taken in most of these fields by public and private actors, the pressures are worsening due to climate change, population growth and growing water consumption, thus additional action is needed.

Table 2: Interviewed organizations and visited sites during the analysis of Coimbatore

Interviews	Site visits
Municipality and administration ■ Coimbatore City Municipal Corporation ■ Coimbatore Smart City Ltd. **Private sector** ■ Adithya Aqua Tech Solutions ■ Urban reflection studio ■ Indian Chamber of Commerce and Industry ■ GeeDee Weiler **Research and consultancy** ■ PSG College of Technology ■ Tamil Nadu Institute of Urban Studies ■ CDD **Civil society including NGOs** ■ Siruthuli ■ IC Centre for Governance ■ Residents Awareness Association of Coimbatore ■ Confederation of Real Estate Developers' Association of India	■ Ukkadam STP ■ PSG campus infrastructure ■ Rainwater harvesting Siruthuli ■ Reforestation Anna University ■ Industrial wastewater treatment GeeDee Weiler ■ Experience Center for Water & Energy Adithya Aqua Tech Solutions ■ Noyyal River ■ Siruvani water treatment plant ■ Composting plant and landfill

Impact factors of the water sector in Coimbatore

The city analysis revealed 35 factors that exert substantial influence upon the water sector in Coimbatore or substantial affectedness by the water sector, see Table 3. These systemic impact factors aid in understanding external pressures, underlying forces, dynamics, socio-cultural and historic implications that are present within a city and their impact (often unnoticed) on decisions, structures, strategies and measures taken on the city level and on the project level.

For stakeholders striving to act at any point within Coimbatore's water sector, awareness of these impact factors can help to make decisions.

[3] Smart Water Future India, Integrated analysis of water management and infrastructure in Coimbatore – Report, December 2018

Table 3: Impact factors identified in Coimbatore, clustered in groups

Economy/Finance	**Strong economy (industrial, IT, health)**
	Good availability of national and international funds
	Established PPP mechanisms
	Strong institutional international connections
	Lack of fair pricing for water
	Low willingness to pay (middle/upper classes, industry)
	Low ability to pay (lower classes, small industry)
General	Climate change
	Population growth
	Monsoon climate
Politics/Governance	Centralization of key tasks (groundwater, planning)
	Political uncertainty on many levels
	Municipality has low level of planning control
	Low level of regulatory oversight
	Low level of local of planning participation
Infrastructure	Strengthening of local rainwater harvesting method
	Depletion of groundwater through private wells
	Insufficient waste management
	Insufficient and insecure water supply
	Disrepair of rainwater drains
	Lack of sewage collection and treatment
	Pollution of water bodies
	Lack of recreational space
	Lack of publicly owned land for infrastructure
	Deteriorating air quality
	Increasing traffic congestion
	Competition for water resources with other cities
	Lack of data availability
Society	High entrepreneurship
	High education level
	Active, well-known NGOs
	Increasing health- and eco-consciousness
	Positive image of the city
	Strong private international connections
	High level of attention given to water subjects

The model for sensitivity analysis as laid out by Frederic Vester was taken as a reference to analyse the significance and interrelations between the factors at work in Coimbatore.

The cross-impact analysis of factors, see Figure 6, allows distinguishing between four different categories of factors:

- **Drivers** (top left): these factors have high impact on and receive little influence from other factors. They have the potential to drive change and to stay stable over a long time. Often they are difficult to change.
- **Levers** (top right): These factors have a high impact on and are also influenced by many other factors. These are the crucial factors that one needs to address in order to transform the system in the desired direction. Levers need to be designed carefully, because consequences in the system from changing them may be difficult to oversee.
- **Indicators** (bottom right): These are variables that have little influence over other factors, but are strongly influenced by others. They serve to show the change in the system. Therefore they can be used as indicators of a system's transition.
- **Buffers** (bottom left): These are factors that are rather inactive in any direction. They do not influence many other factors and they are not influenced by many other factors. One should not try to change the system by working with buffers.

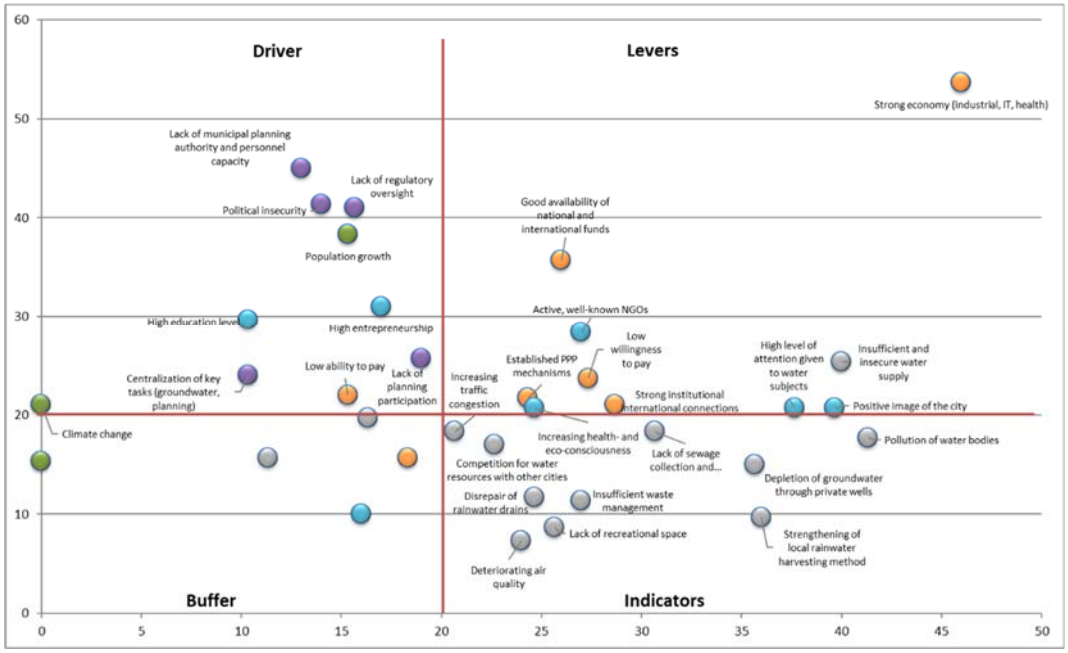

Figure 6: Cross-impact analysis of impact factors in Coimbatore (horizontal axis: affectedness by water sector; vertical axis: influence upon water sector; higher numbers indicate higher impact)

For Coimbatore, there is a set of factors that show disproportionate influence upon the development of the city's water sector. These **levers** should be addressed considerably in the development of successful projects and strategies. Aspects such as city image, local actors and local consciousness and funding mechanisms can strongly influence a positive development process and will provide stability for a long-term development, keeping the process on track:

- Strong economy
- Good availability of national and international funds

- Active and well-known local NGOs
- Established PPP mechanisms
- High level of attention given to water subjects
- Positive image of the city
- Increasing health and eco-consciousness
- Insufficient water supply
- Limited willingness to pay for sustainable improvements (middle/upper income households, industry)[4]

The strongest **drivers** for (or against) the sustainable development of Coimbatore's water sector are mainly governance and society-related. It is more difficult to influence these impact factors, but they have a strong impact on the development of Coimbatore and must therefore be considered.

- Population growth
- Climate change
- High entrepreneurship (resulting in commercial and industrial activity)
- Low ability to pay (in lower income households and small industry)
- Strong centralization of key tasks, resulting in lack of municipal control over planning and lack of participatory planning
- Lack of regulatory oversight (e.g. enforcement of ZLD rules)
- Political uncertainty (including state level; makes it difficult to implement projects)

The following factors can be used as **indicators** for the development, as they are quite sensitive. Projects that are successful in the water sector will have a measurable positive impact on at least one of these indicators. These indicators should therefore be monitored to be able to assess and communicate progress.

- Competition for water resources with other cities
- Coverage of intact rainwater drains
- Coverage of local rainwater harvesting
- Coverage of sewage collection and treatment
- Coverage of waste management
- Coverage of recreational space
- Air quality
- Groundwater level
- Pollution of water bodies

[4] *This seems counter-intuitively assessed as a Lever. However, it is assessed as a factor that can be strongly affected by increased awareness raising and/or the (worsening) quality of water bodies and infrastructures. Further investigation of this topic is outside the scope of this project.*