WATER-ENERGY NEXUS

# Bhubaneswar

Development Alternatives

HEINRICH BÖLL STIFTUNG
INDIA

The **Water Energy Nexus in Bhubaneswar** Report jointly published by the Heinrich Böll Stiftung Germany and Development Alternatives New Delhi, December 2020

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"Water Energy Nexus in Bhubaneswar"

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# ACKNOWLEDGEMENTS


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**Our special thanks go to the many experts from academia, government, non-profits, and research organisations who provided invaluable perspectives and expertise throughout the project.**

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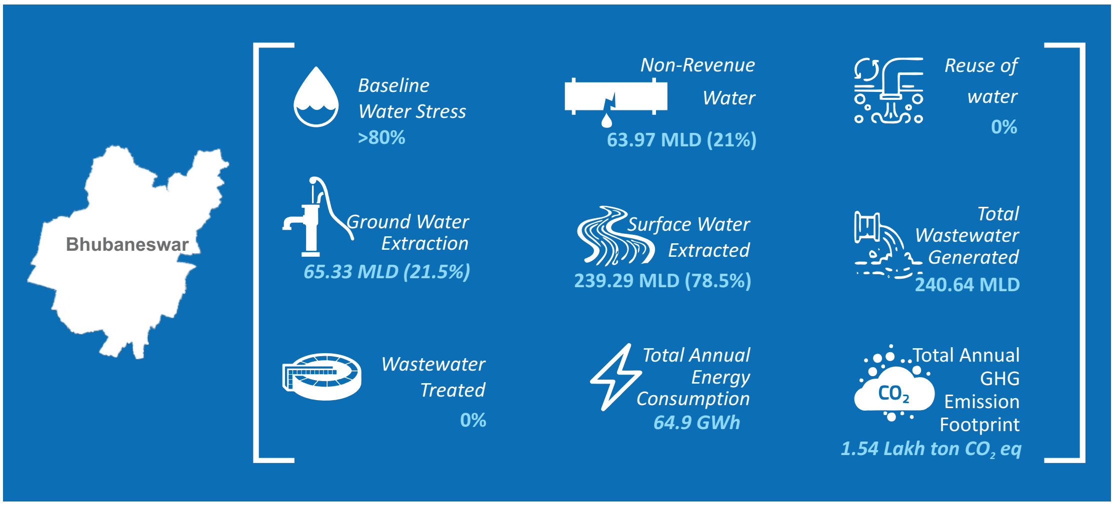
# EXECUTIVE SUMMARY

Water is a necessary element for maintenance of life on earth and is indispensable for the economy. The rivers, lakes and groundwater are the main source of freshwater for purpose of irrigation in agriculture and drinking and sanitation in the cities. Water sector is one of the most energy-intensive sectors. The water system efficiencies can be understood from the energy use in water systems in conjunction with the management of extraction, treatment, storage and consumption across the flows of the resource. This problem calls for an integrated approach such as study of water-energy nexus to provide effective strategies to address the gaps in the urban water systems. Water-energy nexus approach highlights the interdependencies between water resource and energy security for economic development and well-being of humans simultaneously ensuring sustainability of global natural resources without harming the natural ecosystem.

This study focuses on finding the energy consumption and associated environmental footprint of the urban water system of city of Bhubaneswar. Mapping the flow of water, calculation of power consumption across each stage of the urban water system starting from water extraction to final disposal and calculation of carbon emission at each stage is the approach adopted in this study. The study conducted in 2019 finds that the city of Bhubaneswar extracted approximately 78.5% of its total supplied water from surface water and 21.5% is extracted from ground water and this amounts to a total of 305 MLD. The total consumption of water by the city was 240.64 MLD out of total water extracted as 21% were physical losses. Currently, wastewater is not being treated and is disposed untreated in the nearby drains. The total annual energy consumption of the total water supply system based on data collected in 2019 accounting for water extraction, conveyance, treatment and distribution is 64.9 GWh. The total GHG emission of total water supply system is 1.54 lakh tonne $CO_2$ eq which is 18.0 x 10-4 kg $CO_2$-eq per litre of water. It is found that city needs to increase energy efficiency by revamping the infrastructure of the urban water system which will reduce total energy consumption and in turn will reduce emission footprint. Further, reduction in non-revenue water is required which can be done by mending leakages in the system, arresting unauthorized connections and smart metering of water connections. Wide spread of sewerage network along with functional STPs for increasing the treatment of wastewater will ensure tapping huge potential for reuse of treated wastewater. This will also reduce load on drains and the emissions released by untreated water. Diversifying to other water sources and building a resilient system will be a long term solution. Such comprehensive analysis of the system provides scientific basis to city managers in making balanced decisions.



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| | |
|---|---|
| AMRUT | Atal Mission for Rejuvenation and Urban Transformation |
| BPL | Below Poverty Line |
| BWS | Baseline Water Stress |
| DoDW | Department of Drinking Water |
| GHG | Green House Gases |
| GWh | Giga Watt per hour |
| HH | Household |
| HP | Horsepower |
| JICA | Japan International Cooperation Agency |
| kWh | Kilo Watt per hour |
| LPCD | Litres per Capita Day |
| LPM | Litres per minute |
| MLD | Million litres per Day |
| NRW | Non-Revenue Water |
| OWSSB | Orissa Water Supply and Sewerage Board |
| PHEO | Public Health & Engineering Organization |
| PMU | Project Management Unit |
| STP | Sewerage Treatment Plant |
| WTP | Water Treatment Plant |
| WWTP | Wastewater Treatment Plant |
| WATCO | Water Corporation of Odisha |

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# INTRODUCTION AND BACKGROUND

Water and energy in the urban environments are managed in isolation and in India the respective ministries work in silos. This creates hindrance for effective management of the urban water systems and such problems call for an integrated system. Hence, there is a need to analyze the urban water-energy nexus and provide effective strategies to address the gaps in the systems. Water-energy nexus is typically characterized in resource use efficiency terms such as energy intensity and the environmental impacts in terms of energy consumption of water systems within the urban water cycles. Understanding the nexus of energy and water will help in achieving reduction in energy consumption and greenhouse gas emissions by adopting efficient systems. The growing urban water demand and current linear management systems make water resource management a critical concern in cities. According to the Mc Kinsey report published in 2009, the demand for water will outstrip supply by around 40% and about half the world's population will live in water- scarce areas by 2030. The signs of urban water chaos have already started to show up. The other important resource in functioning of a city is energy which is highly dependent on water and vice-versa.

Energy is currently derived from non-renewable resources and the percentage of renewable in total energy is projected to grow significantly. Water sector is one of the most energy intensive sectors. Energy consumption in water depends upon factors such as topography, climate, seasonal temperature, average rainfall, demand of water and the technologies used. (Wakeel Rana, Chen, Hayat, & Ahmad, 2016). India was reported to be the largest consumer of energy for water supply compared with other municipal services because of water being supplied over long distances, rising population density, and climate change (Liu, Ouedraogo, Manghee, & Danilenko, 2012). Energy is consumed for extraction of water, raw water treatment, distribution, waste-water collection treatment and recycling. Groundwater is more energy intensive as compared to surface water. At times, 40% of total energy of certain countries is used up for pumping groundwater. Pumping from greater depths increases the energy demand of the water sector (Hoff, 2011). In Indian cities, on aggregate basis the majority of energy is consumed for water supply than for wastewater treatment because the amount of water supplied is far more than the wastewater treated in the WWTPs or STPs.

The study conducted in 2019 was an attempt to map the energy and GHG footprint of the water supply system along the life cycle of water. The primary and secondary data was collected from the government water agencies and simulations were run for the model on the material flow analysis tool. The city of Bhubaneswar has 67 wards which were taken as the area of study. The city has been divided into three water supply zones PHEO-1, PHEO-2 and PHEO-3, the data collected pertain to these three zones. These zones have been reorganized into WATCO-1 and WATCO-2, and for all the official purposes these offices were visited. The operation and maintenance of these water supply zones is currently done by WATCO.

The study finds that the city of Bhubaneswar extracts 78.5% of its water from surface water, while 21.5% is extracted from ground water and this amounts to a total of 305 MLD. Surface water is transferred to the water treatment plant, from where it is conveyed to the reservoirs but groundwater is directly transferred to the reservoirs. The water is distributed from the reservoirs to the households. The total consumption of water is 240.64 MLD out of total extracted water because 21% are the physical losses. Currently, wastewater is not being treated and is disposed untreated in the nearby drains. The total annual energy consumption by the water supply system accounting for water extraction, conveyance, treatment and distribution is 64.9 GWh. Water treatment consumes 45.24% (29.36 GWh) which accounts for the maximum energy consumed by the water supply system and boosting water in the distribution system consumes 19.158 GWh (29.52%) of the total energy. Water extraction consumes about 16.38 GWh (25.24%) which includes 19.51% (12.66 GWh) for surface water and 5.73% (3.718 GWh) for groundwater, as Bhubaneswar is mostly dependent on surface water to meet its water demand.

During this study, an attempt has been made to map the energy and GHG footprint of the water supply system along the life cycle of water. The primary and secondary data collected from the public sector sources and simulations are run for the model on the material flow analysis tool. This water energy nexus study is an approach to look at the water supply system in a holistic way, wherein, environmental implications and social equity aspects of the whole system can be understood better and possible areas of intervention for increasing efficiency and circularity in the most cost-effective and socially relevant ways can be explored. This approach needs to be implemented by both supply and demand side of the value chain, to achieve long term self-sustaining relation between the natural ecosystem and anthropological activities for development.

# STUDY OBJECTIVES

This study builds upon a volumetric analysis of water flows across the whole urban water supply system of Bhubaneswar, that was conducted in 2018 to understand total flows, leakages and unaccounted for water, access of water to all citizens of the city, wastewater and sewage network, sewage treatment infrastructure and functional capacity, and the status of post-consumer water. Through this study it was found that there is tremendous scope of revamping the supply and treatment infrastructure and it led to the idea of analysing the energy consumption and associated GHG emissions of the system and the untreated wastewater. So, in the current phase the study focused on analyzing and identifying the opportunities of enhancing the system efficiencies.

The objectives of the study are:

1. To assess the energy consumed by the urban water system starting from the water extraction till the final wastewater disposal.
2. To assess the environmental impacts of the urban water systems by estimating the GHG emissions.

# STUDY AREA

The city of Bhubaneswar is the capital of the state of Odisha, India. Bhubaneswar lies on the eastern coastal plain of India. The average rainfall of Bhubaneswar is 1.5 cm. Bhubaneswar was chosen as one of the study areas as the city has high baseline water stress of greater the 80% (WRI, India water Tool, 2018) and a high NRW according to the Smart City proposal.

The city of Bhubaneswar has 67 wards which are taken as the study area of the study. The city has been divided into three water supply zones PHEO-1[1], PHEO-2 and PHEO-3, the data collected pertain to these three zones. These zones have been reorganized into WATCO-1[2] and WATCO-2, for all the official purposes. The operation and maintenance of these water supply zones is currently done by WATCO.

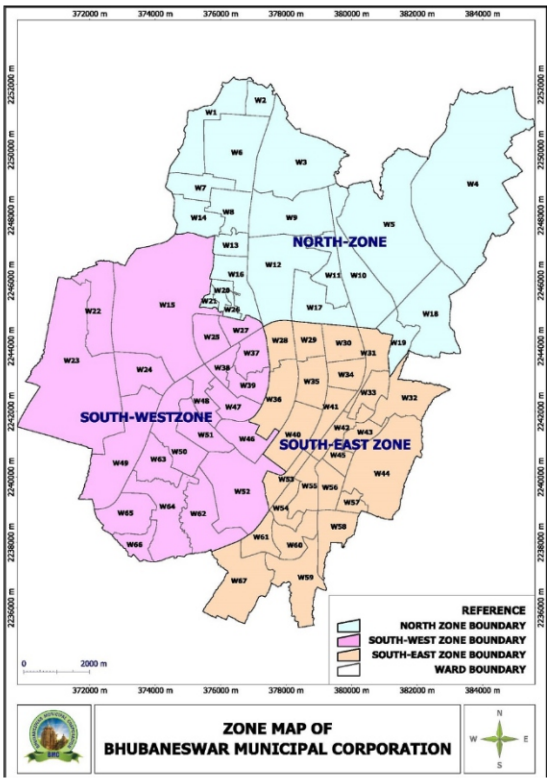



Figure 1: Map of Bhubaneswar water supply zones

*Source: Website of Bhubaneswar Municipal Corporation, map available at https://www.bmc.gov.in/bmc/zones-wards*

[1]Public Health and Engineering Organization
[2]Water Corporation of Odisha

# ANALYSIS FRAME

During the study for mapping urban water flow in Bhubaneswar conducted in 2018, it was found that the city lacks the real time data on non-revenue water and how much water is consumed by households, the base line water stress was more than 80%, the non-revenue water was 35% due to leakages and unaccounted for water consumption, with no sewer connections and treatment of sewage. So, for an effective sustainable urban water system, the natural and anthropological parts of the urban water system have been analyzed from the lens of resource sufficiency, efficiency & equity, and operational performance of the infrastructure.

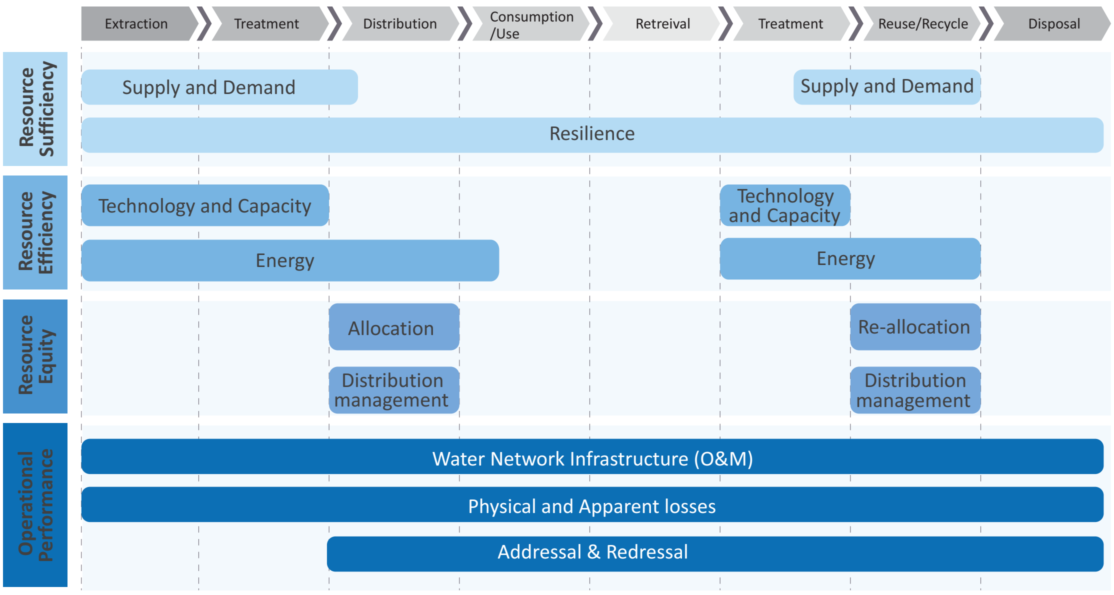



Figure 2: Analysis Frame

The four lenses through which the water flows in the Bhubaneswar city is analyzed are:

Resource Sufficiency: This refers to the ability of ensuring continuity in consumption without constraints on the supply. The main drivers of increased self-sufficiency are identified as shortage of available water, constrained infrastructure, high quality water demands and commercial and institutional pressures. Research studies have demonstrated that increase in self-sufficiency ratios can be achieved up to 80% with contributions from recycled water, sea water desalination and rainwater collection.

Resource Efficiency: Resource efficiency is defined as the ratio of outputs (in terms of economic, social & environmental benefits) and resource inputs. It is an innovative approach to resource consumption by reducing the total environmental impact of the production and consumption from raw material extraction to final use and disposal. It plays a pivotal role in introducing sustainable production and consumption patterns to residents of the city as well as municipal governments on the opportunity to improve resource efficiency, decrease $CO_2$ emissions, reduce environmental risks and safeguard ecosystems. In this report we explore the energy use and the environmental impacts of the urban water systems in the city of Dehradun.

Resource Equity: This refers to ensuring equitable access to water and the benefits from water use, to women and men, rich and poor, across diverse social and economic groups which involves issues of entitlement, access, and control.

Operational performance: This refers to the performance of the urban water system which is measured against standard or prescribed indicators of effectiveness, efficiency, and environmental responsibility such as cycle time, productivity, waste reduction and regulatory compliance.

# METHODOLOGY

## 1. ESTIMATION OF ENERGY CONSUMPTION OF URBAN WATER SYSTEM:

The study of water-energy nexus is accomplished through data available from public records and confirmed through interviews and discussions with concerned municipal officials. Initially a literature survey was conducted to develop an understanding on water-energy nexus and energy use in the urban water systems in different countries. This study derives the framework of analysis from the reviewed studies, which helped in identifying the data points required to be collected from the officials of government water departments and agencies. The data was collected by stakeholder interviews with the officials of WATCO. The details of the pump (pump-wise rated capacity (HP), hours of pumping, MLD water for pumped) installed for the water extraction and water distribution was collected from Orissa Water Supply and Sewerage Board (OWSSB). The data on energy consumption by water treatment plants was received as energy bills of the plant from WATCO-1 and 2. Details on the installed capacity and the load capacity of the sewerage treatment plant and sewerage pumping station were received from OWSSB.

The data on energy was received from water utility assets developed by JICA and on volume of water pumped from the summary sheet from PHEO-I, II, III. The pump-wise total energy consumption for water extraction is calculated as the power times the number of hours a particular pump is used in a day[3]. The power of the pump is converted into kW and accounted for the efficiency 52% (PWC; Jalakam Solutions, 2018). This gives the pump-wise energy consumption of each pump. The pump is used every day, hence an annual figure for energy consumption is calculated using the daily figure. The value of discharge in MLD is collected from the WATCO, and for conveyance of water extracted through groundwater pumps all the water is distributed through reservoirs to the households.

The extracted surface water is transferred for water treatment. Through the monthly energy bills of water treatment plants collected from the WATCO-1 and WATCO-2 annual energy consumption in water treatment is calculated.

For calculation of power consumption by water distribution, the pump-wise total energy consumption is calculated as the power times the number of hours a particular pump is run. The power of the pump is converted into kW and the power of the pump is accounted for the efficiency losses and the efficiency of 52% is considered referring interview with the officials, this gives the pump-wise energy consumption. The pump is used every day and hence an annual figure for energy consumption is calculated using the daily figure.



[3]Information from WATCO

## 2. ESTIMATION OF GHG EMISSION OF URBAN WATER SYSTEM:

The GHG emission of the urban water system in each of the zone is estimated by using a material flow analysis software UMBERTO tool. This tool uses the Ecoinvent 3.5 data base which provides well documented process data for thousands of products to account for the environmental impacts. The database gives the emissions according to Indian scenario. The emissions are accounted according to per unit of input energy and volume of the water in the system at each stage from groundwater and surface water extraction to consumption. The figure shows a picture of user interface of UMBERTO tool. The Umberto® solution is used for modelling and assessment of all types of material and energy flow systems, to identify improvement potentials, conduct scenario analysis and to develop models for alternative processes. This tool ensures robust data collection and analysis, it is credible MFA tool for expert validity, provides visual representation of data and helps to identify specific pain points in the urban water management system. The processes starting from water extraction till the consumption of water is depicted using boxes. The intermediate output from each process is shown using yellow circles. While the red circle shows the output of the system. In the model the grey arrows are proportional to the water flow and pink arrows are proportional to the energy input in the system.

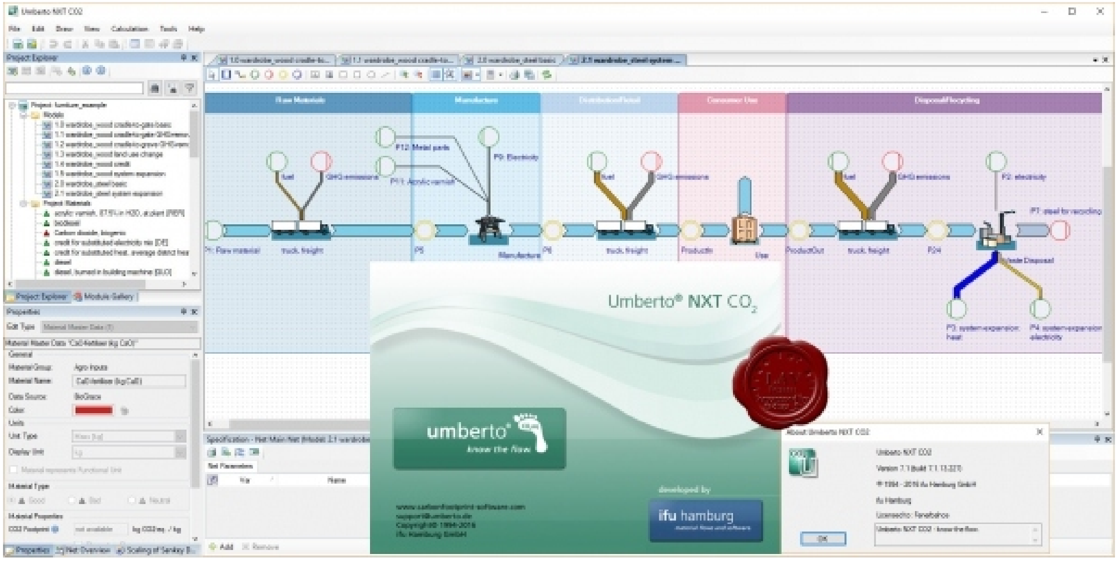



Figure 3: User Interface of Umberto tool

# FINDINGS OF STUDY OF URBAN WATER SUPPLY SYSTEM

## I. WATER SOURCES AND FLOW

The study finds that the city of Bhubaneswar extracts 239.29 MLD (78.5%) of its water from surface water, this water is pumped from water sources including Daya, Kuakhai and Mahanadi rivers, while 65.33 (21.5%) is extracted from ground water and this amounts to a total of 305 MLD. Surface water is transferred to the water treatment plant, from where it is conveyed to the reservoirs but groundwater is directly transferred to the reservoirs. The water is distributed from the reservoirs to the households. The total consumption of water is 240.64 MLD out of total extracted water 305 MLD because 21% are the physical losses[4]. Currently, water is not being treated hence 100% of water is disposed untreated in the nearby drains.

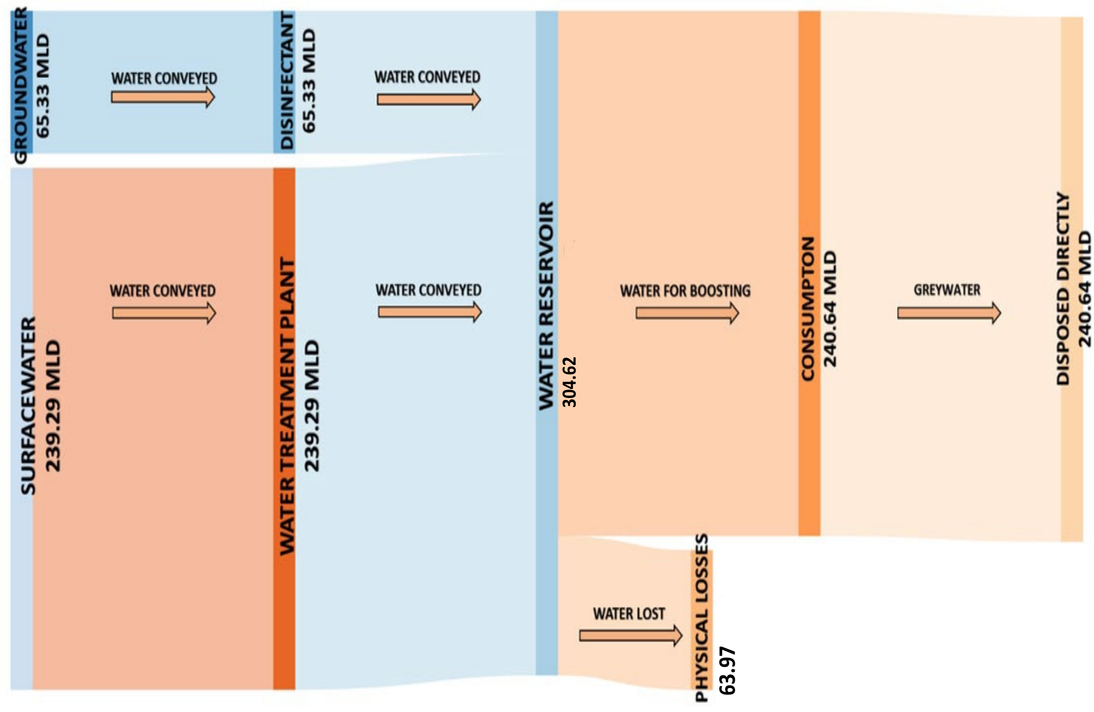



Figure 4: Sankey diagram of water flow through urban water supply system in Bhubaneswar

[4]Standard loses of the system as mentioned in the documents collected from NRW Reports

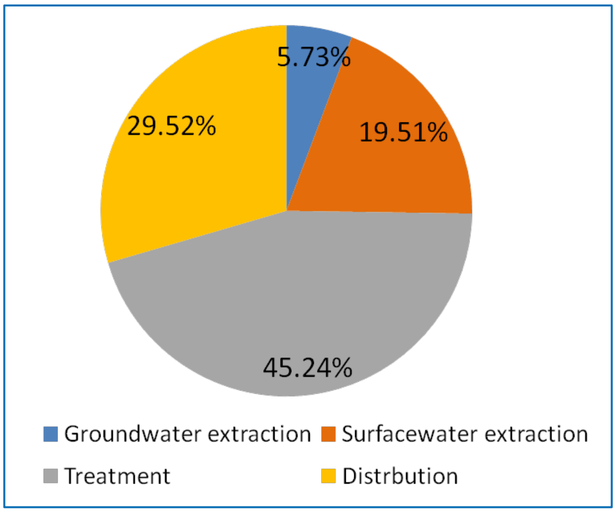
Table 1: Findings of urban water supply system in Bhubaneswar

| Parameters | Quantum |
|---|---|
| Baseline water stress | >80% |
| Total water extracted | 305MLD |
| Ground water extraction | 21.5% (65.33 MLD) |
| | Total quantity is stored in reservoirs and later boosted for supply to households |
| Surface water extraction | 78.5% (239.29 MLD) |
| | Total quantity sent to WTP, then to reservoirs and later boosted for supply to households |
| Non-revenue water | 21% (63.97 MLD) |
| Revenue water | 79% (240.64 MLD) |
| Wastewater | 240.64 MLD |
| Wastewater treatment | 0% |
| Reuse of treated water | 0% |

*Source: Data collected in 2019 from WATCO and OWSSB*

## II. TOTAL ENERGY CONSUMPTION IN THE URBAN WATER SYSTEM

The total annual energy consumption for the water supply system accounting for water extraction, conveyance, treatment and distribution is 64.9 GWh. Water treatment consumes 29.36 GWh (45.24%) which accounts for the maximum energy use in the water supply system. This is followed by 19.158 GWh (29.52%) energy consumption for boosting water in the distribution system. Water extraction consumes about 16.38 GWh (25.24%) energy in the urban water systems, including 12.66 GWh (19.51%) consumed by surface water extraction and only 3.72 GWh (5.73%) consumed by ground water extraction as Bhubaneswar is mostly dependent on surface water to meet its water demand.




Graph 1: Proportion of total annual energy (GWh) consumption at stages of the urban water supply system

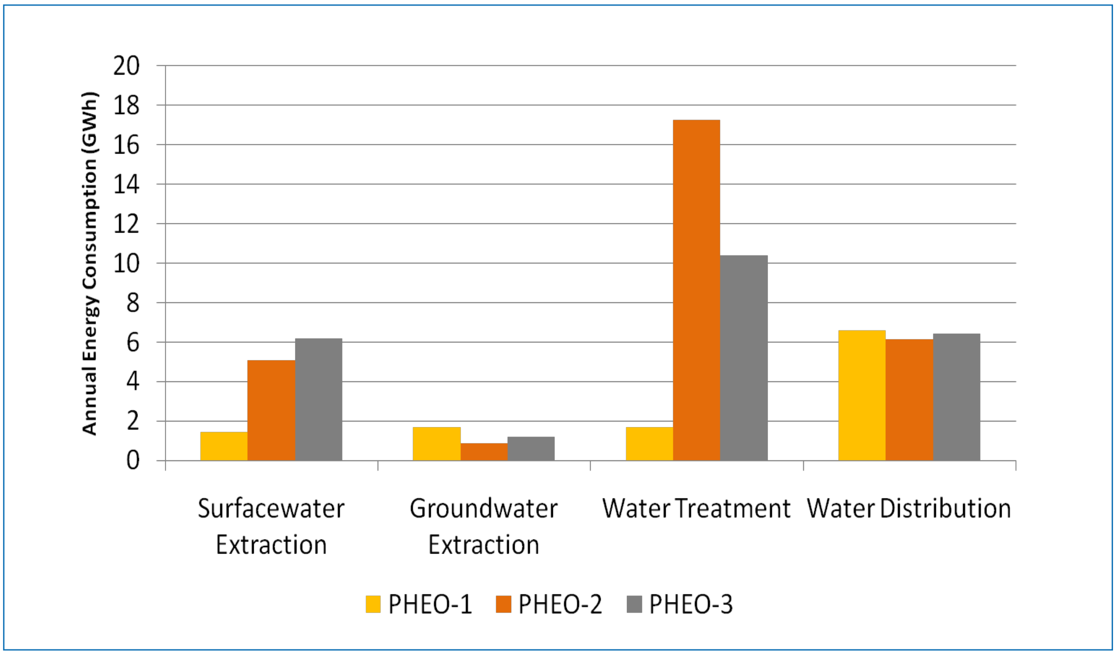
Table 2: Total annual energy consumption by different stages of urban water system

| Urban Water System Stages | Total Annual Energy consumption (kWh) |
|---|---|
| Groundwater extraction | 37,13,998.55 |
| Surface extraction | 1,26,57,340.00 |
| Water treatment | 2,93,44,284.00 |
| Distribution(boosting) | 1,91,47,630.98 |
| **Total** | **6,48,63,253.53** |

*Source: Data collected in 2019 from WATCO and OWSSB*

## III. ZONE WISE ENERGY CONSUMPTION OF THE URBAN WATER SYSTEM

Bhubaneswar is divided into three water supply zones called as PHEO-1, PHEO-2 and PHEO-3. The energy use for the PHEO sub-division-II is the highest at around 29.0 GWh, followed by PHEO sub-division-III at 24.2 GWh and PHEO sub-division-I at 11.6 GWh. Comparing the annual energy consumption of the four components of the water supply for the three zones, it is found that the energy consumption for water treatment is highest for PHEO-2 at 17 GWh followed by PHEO-3 at 10.1 GWh. For distribution, all the zones have almost same energy consumption which is second highest as the distribution is majorly by boosting pumps. The annual energy consumption is higher for surface water as compared to groundwater extraction because Bhubaneswar extracts 78.5% of the water through surface water sources.




Graph 2: Total annual energy (GWh) consumption by different PHEO zones across the stages of the urban water supply system

## GROUNDWATER

Groundwater is not conveyed to the water treatment plant. It is chlorinated after extraction and either directly pumped for distribution or sent to the reservoirs prior to distribution. Extraction of groundwater is energy intensive as water is pumped from the depth of approximately 50 meters. This groundwater is transferred to the storage (clear water reservoirs or overhead tanks), from where it is distributed. There are a total of 287 pumps accounting for 21.5% of the total water supply in Bhubaneswar. The energy intensity for boosting extracted water to overhead tanks and clear water reservoirs for supplying to the colony is $16 \times 10^{-5}$ kWh/l. The energy use per unit discharge is the highest for PHEO Division-II followed by Division-III and Division-I.

## SURFACE WATER

The surface water accounts for 78.5% of the total water being supplied. A total of 239.29 MLD is extracted from the surface water sources; this water is pumped from five major water sources including Daya, Kuakhai and Mahanadi rivers.

Table 3: Different source of surface water

| Division | River | Transport | Quantity (MLD) | Feeding WTP |
|---|---|---|---|---|
| Division-I | Dayanadi, Kuakhai, Naraj and Spring tank | Pumped | 24.50 | Bhusani, High level, Chandrasekharpur |
| Division-II | Kuakhai | Pumped | 88.05 | Palasuni |
| Division-III | Mahanadi | Pumped | 126.74 | Mundali |
| | **Total** | | **239.29** | |

Surface water extracted is sent for water treatment and the total water being treated is 239.29 MLD. The annual energy consumption by WTPs at different zones is given below in the table.

Table 4: Total annual energy (GWh) consumption by Water Treatment Plants

| Water Treatment Plants | Capacity (MLD) | Amount treated (MLD) | Annual Energy Consumption (kWh) |
|---|---|---|---|
| Bhusani (PHEO-I) | 20.46 | 24.50 | 12,49,200.00 |
| High level (PHEO-I) | 6.80 | | 2,88,480.00 |
| Chandrasekharpur (PHEO-I) | 5.00 | | 1,49,604.00 |
| Palasuni (PHEO-II) | 81.83 | 88.05 | 1,72,58,400.00 |
| Mundali (PHEO-III) | 115.00 | 126.74 | 1,03,98,600.00 |
| **Total** | **229.09** | **239.29** | **2,93,44,284.00** |

## IV. WATER DISTRIBUTION NETWORK

The total length of distribution network in the city is 2054.73 km in addition to 275.99 km of rising mains from tube wells. In several cases the distribution lines are buried under the road. In Bhubaneswar, water distribution is through centrifugal pumps (boosting pumps) in the water distribution system.

### GROUNDWATER & SURFACE WATER

Groundwater and surface water are stored in the reservoirs, and through the reservoirs the water is distributed to the colonies. 21% of water is lost due to reservoir overflows and distribution through pipelines due to dilapidated pipes (PWC; Jalakam Solutions, 2018). The energy intensity for boosting per unit of water is highest for PHEO-I (39.8 x $10^{-5}$ kWh/l) follow by PHEO-III (24 x $10^{-5}$ kWh/l). Considering a calculated 34% loss due to NRW (PWC; Jalakam Solutions, 2018) the total water reaching for consumption is 240 MLD. The total projected population of Bhubaneswar is 1,962,308. The total water reaching each connection is 3,947 liter per day (including residential and commercial connection). Water tankers supply approximately 254 MLD to the city of Bhubaneswar, with the highest supply of 131 MLD in PHEO-I, 93 MLD in PHEO-III and 30 MLD in PHEO-II.

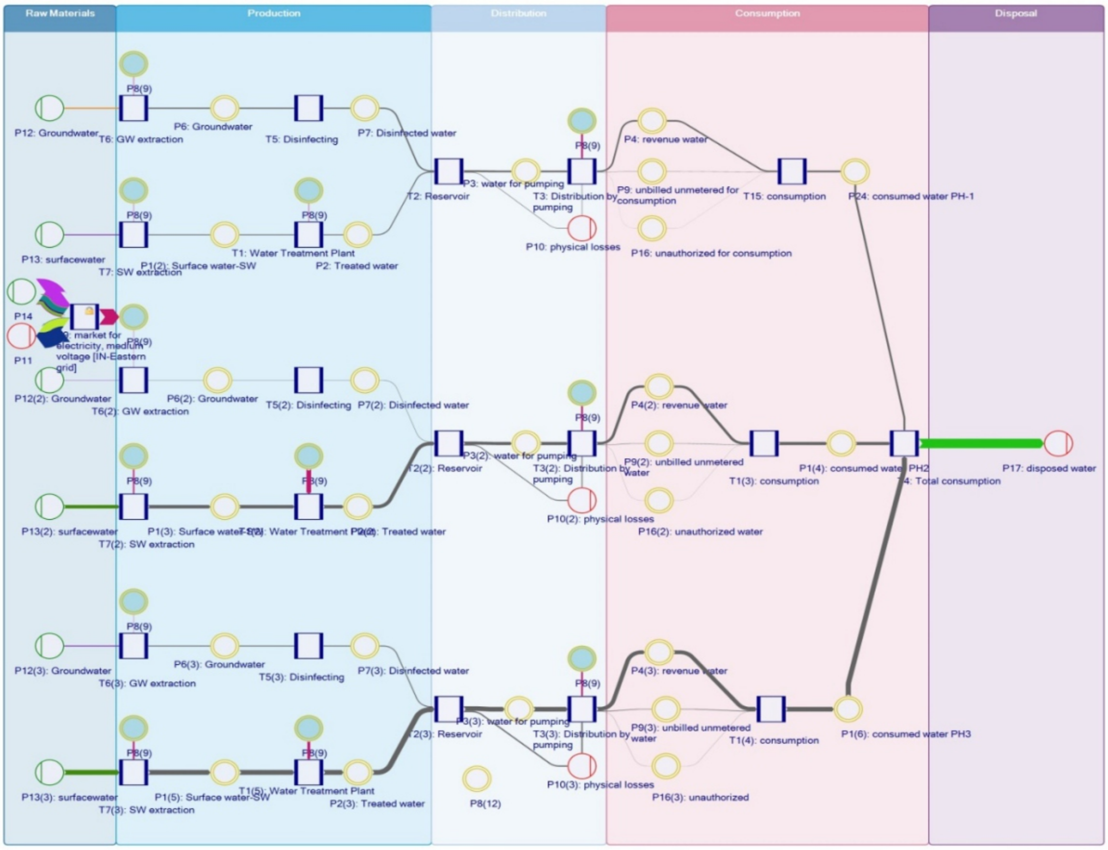
## V. SEWAGE TREATMENT

There are total 6 STP's constructed in the city of Bhubaneswar, but wastewater treatment plant has not started operating and there is no reuse.

## VI. ZONE WISE TOTAL ANNUAL GHG EMISSION OF URBAN WATER SYSTEM

The GHG emission of the urban water system in each of the four zones is estimated by using a material flow analysis software UMBERTO tool. This tool uses the Ecoinvent 3.5 data base which provides well documented process data for thousands of products to account for the environmental impacts. The database gives the emissions according to Indian scenario. The emissions are accounted according to per unit of input energy and volume of the water in the system at each stage from groundwater and surface water extraction to consumption.

Total annual GHG emission of urban water system in each of the three zones have been calculated using the UMBERTO tool wherein water and energy are input materials into the system. The processes covered are starting from water extraction till the consumption of water. The total annual GHG footprint of the urban water system of Bhubaneswar (including GHG emission of disposal 5,00,95,282.69 kg $CO_2$ eq.) is 1.54 lakh tonne $CO_2$ eq. The picture 1 shows the Umberto model of total urban water supply system of Bhubaneswar and Table 6 shows the zone wise total annual GHG emissions in four zones of urban water system.




Picture 1: Umberto model of total water supply system including all zones

Table 5: Zone wise total annual GHG emissions in four zones of urban water system

| Zones | Total Annual GHG Emission (kg $CO_2$ eq.) |
|---|---|
| PHEO-I | 18,291,717.36 |
| PHEO-II | 47,089,171.25 |
| PHEO-III | 38,875,390.20 |
| Disposal | 50,095,282.69 |
| **Total** | **1,54,351,561.49** |

# CITY WORKSHOP

As a part of our project initiative, a city level stakeholder workshop was held on 21st November 2019 in Bhubaneswar. It provided a platform for multiple stakeholders from both government and private sector to come together and deliberate over the most prominent water issues faced in Bhubaneswar city. Officials from the WATCO departments participated and shared their views over the initiatives currently undertaken within the system and some future plans on water management. The primary subject of discussion was how water and energy are interrelated and assessment of the non-revenue water of the city. The non-revenue water is a matter of concern within the city of Bhubaneswar. Multiple physical losses across the water distribution network and lack of connectivity contribute to the growing NRW within the city. To reduce the carbon footprint of the water supply and distribution of the city, the city must reduce it's non-revenue water. At present, the wastewater treatment systems are yet to be fully functional in the city. There is a plan to build more fecal sludge treatment plants within the city and state. During discussions, the need to move towards a sustainable water system which includes energy efficiency across the overall water infrastructure and re-use of water fostering water circularity and water conservation practices were identified. There is also a growing need to build capacity within the wastewater sector to initiate awareness on the significance of sewer connections across households. Most citizens are hesitant and apprehensive to get sewer connections due to lack of funds or presence of already existing septic tanks. The reuse of treated wastewater is inadequate in the city as compared to its potential within the city or outside. On the technological front there is a need of exploring avenues for re-use of treated wastewater by collaborations between the city water departments and solution providers. Whereas, on social front, there is need to engage citizens for active participation through awareness campaigns by which importance of judicious use of water and significance of reusing treated wastewater will be promoted. Many conservation practices are followed in the city, and they need to be accepted at domestic and institutional level such as rainwater harvesting and ground water recharge and storage.


Picture 2: Photos of Bhubaneswar city workshop held on 21 November 2019
at The New Marrion Hotel in Bhubaneswar

# WAY FORWARD

The analysis of findings of the study indicate that the city's urban water supply system has tremendous scope for improving the services efficiency and resource-sufficiency, equity and resilience being four components of systems on it's end and citizen's active and collaborative participation with ownership on the consumer end. Citizens are both demand centres and generators of post-consumption wastewater, so their role even becomes more significant as they can sustainably consume water at their houses, provide feedback, and opinions to city government water agencies. Investments are required to increase the wastewater treatment capacity and to increase the reuse of water. This study provides a systemic understanding of the water systems which would facilitate decision making process.

**Integrated Systemic Approach** - An integrated systemic approach and inclusion of all city stakeholders and actors is thus required to achieve sustainable and healthy water for all, giving an equal importance and attention to all the components of urban water system. The institutional and individual capacity building is required for upgrading the knowledge, skills and management of the systems and for self-sustaining.

**Capacity Building** - The line department officers should be oriented towards the integrated systemic approach and trained on new age IT systems and tools like material flow analysis software. These tools help in digital drawing and visualizing the entire life cycle of water flow along with the mapping the resource, energy and emission footprints at each node of the network. This enables departments in decision making for planning and executing periodic monitoring and system upgradation.

**Non-Revenue Water** - Methodologically addressing the issue of non-revenue water including maintaining a real time data on physical losses and illegal tapping into the supply water, mending leakages in the system would ensure no losses. This would have an added benefit for improving the water quality which is affected due to old pipelines. Learning from city of Surat can be adopted which has a non-revenue water cell and adopted a systemic approach of leakage mapping and leak repairs in the system along with a city-wide water audit. As a part of the action plan, Surat Municipal Corporation (SMC) initiated two major activities, a) water audit of core city area and b) initial leakage mapping exercise. These initiatives have led to a reduction of leakages over a period of seven years.

**Energy Efficiency** - The total energy consumption of the urban water systems is high. So, the energy efficiency needs to be improved which in turn will reduce carbon footprint. In the long term there is a need to diversify to water source other than groundwater. In the short term there is an urgent need to revamp the infrastructure of urban water system. With real time periodic mapping of leakages the energy saving can be achieved by preventing idle running of pumps and motors. There are opportunities for achieving energy efficiency in the water supply infrastructure through installation of efficient pumps and motors adjustable to varying loads, helping in supplying continuous water at adequate pressure and hence reduce the energy consumption and associated emissions, and maintenance cost. The case of Watergy project implemented in Pune by the Pune Municipal Corporation (PMC) which achieved savings of water, energy and cost, with an additional 10% of water delivered to communities without adding any new capacity is one of the cases that can be referred to.

**Wastewater Treatment and Reuse** - Measures to increase the spread of sewerage network should be undertaken such that wastewater reaches the sewerage treatment plant, this would reduce the emissions released by untreated water. Also, measures to encourage the reuse of treated wastewater should be undertaken. Best practices from both domestic and international cases can be learnt. The Michelson Water Reclamation Plant (WRP) in USA is one such case that was built to supply treated water to the community. To increase its capacity IRWD merged with the Los Alisos Water District and maximized the supply of drinking water. The total capacity of two plants is 20.5 million gallons per day with 12 storage reservoirs and 15 pumping stations to supply recycled water by 300 miles of pipelines to entire community. This treated water caters to the need of population of 3.16 lakhs in the area. Irrigation of residential property, landscape & food crop irrigation, toilet & urinal and cooling towers are few non-potable applications of this treated water. This treated water caters to the need of population of 3.16 lakhs in the area. At macro level, the benefits achieved were reduction in the need to source the water from Colorado River and Northern California, making IRWD drought resilient.

**Citizen Awareness Generation** - There is a need for including citizens of city with more ownership and collaborative participation. Citizens are both demand centres and generators of post-consumption wastewater, so their role even becomes more significant as they can sustainably consume water at their houses, provide feedback, and opinions to city government water agencies. These campaigns would help in reaching out to various set of stakeholders, academic, research, implementing & decision making institutions, associations, think tanks, activists, women groups, about rainwater harvesting or other conservation technique as an alternate source of water, water conservation, sustainable consumption, wastewater treatment and reuse, need of metering, aimed at behavioral change amongst the citizens.

**Integration of New Age Packaged and Cost-effective Solutions** - The new age packaged and cost-effective solutions having low resource and emission footprints are to be integrated in the areas of revamping infrastructure, digitalization of mapping & monitoring, reliable data collection and analysis, and harvesting solutions for building resilience. A detailed research needs to be conducted to find the best practices around the world which has been implemented to address the identified problems of the urban water system. The research would require exploring key players (government and other organizations) involved in the management of systems and new generation solution providers.

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