Project Habitat for Humanity- ECOSTP

August-December 2021

Team Details	
Director	Jyotsna Varkey
Project Lead	Sakshi Singh
Consultant	Kavith L.R
Consultant	Naina Kumari
Consultant	Saivaishnavi S
Consultant	Vigneshwaran M

Indian Institute of Technology, Madras

INDEX

I. Sustainable Development Goals:

ECOSTP addresses six UN Sustainable Development Goals (SDGs) which are: -

- **Good Health and Well-Being (SDG 3)**
- **Clean Water and Sanitation (SDG 6)**
- **Decent Work and Economic Growth (SDG 8)**
- **Industry, Innovation and Infrastructure (SDG 9)**
- **Sustainable Cities and Communities (SDG 11)**
- **Responsible Consumption and Production (SDG 12)**

<u>Methodology</u>

We have numbers of targets for each goal which in turn can be verified by the indicators. All the SDGs have both outcome-oriented targets and Means of Achieving targets. For the analysis purpose we have assigned a binary variable called 'relevant factor' for each of the indicators. If the company is following the indicator, we have assigned 1 as relevancy factor, 0 otherwise. After analysing for each indicator we have calculated the number of indicators and targets are getting achieved.

Clean Water and Sanitation (SDG 6)

To ensure availability and sustainable management of water and sanitation for all.

Target	Indicator	Data Required	Relevance with the goal
Safe and affordable drinking water	Proportion of population using safely managed drinking water	NA	1
end open defecation and provide access to sanitation and hygiene	Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water	a) 452 ML b) 64 ML	1
improve water quality, wastewater treatment and safe reuse	Proportion of domestic and industrial wastewater flows safely treated	a) Domestic : 320 ML b) Commercial: 132 MLD	1
	Proportion of bodies of water with good ambient water quality	452 ML	1
increase water-use efficiency and ensure freshwater supplies	Change in water-use efficiency over time	a) Gardening to Flushing b) Flushing to Bathing water	1
	Level of water stress: freshwater withdrawal as a proportion of	40%	1
implement IWRM	Degree of integrated water resources management	NA	1
	Proportion of transboundary basin area with an operational	NA	0
protect and restore water-related	Change in the extent of water-related ecosystems over time	NA	0
expand water and sanitation support to developing countries	Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan	Only 1 project (Pushpalok - Partly funded by TN Govt)	1
support local engagement in water and sanitation management	Proportion of local administrative units with established and operational policies and procedures for participation of local	5-10%	1
			9
		Total	11

Decent Work and Economic Growth (SDG 8)

To foster sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all.

Target	Indicator	Data Required	Relevance
sustainable economic growth	Annual growth rate of real GDP per capita	Growth rate of EcoSTP	1
diversify, innovate and upgrade for economic productivity	Annual growth rate of real GDP per employed person		1
promote policies to support job creation and growing enterprises	Proportion of informal employment in non-agriculture employment, by sex	Employee Data	1
improve resource efficiency in consumption and production	Material footprint, material footprint per capita, and material footprint per GDP		1
	Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	Use local raw material	1
full employment and decent work with equal pay	Average hourly earnings of female and male employees, by occupation, age and persons with disabilities	Employee Data	1
	Unemployment rate, by sex, age and persons with disabilities	Employee Data	1
promote youth employment, education and training	Proportion of youth (aged 15–24 years) not in education, employment or training	Employee Data	1
end modern slavery, trafficking, and child labour	Proportion and number of children aged 5–17 years engaged in child labour, by sex and age		1
protect labour rights and promote safe working environments	Frequency rates of fatal and non-fatal occupational injuries, by sex and migrant status		1
	Level of national compliance with labour rights (freedom of association and collective bargaining) based on International Labour Organization (ILO) textual sources and national legislation, by sex and migrant status		1
promote beneficial and sustainable tourism	Tourism direct GDP as a proportion of total GDP and in growth rate		0
	The proportion of jobs in sustainable tourism industries out of total tourism jobs		0
universal access to banking, insurance and financial services.	Number of commercial bank branches per 100,000 adults and (b) number of automated teller machines (ATMs) per 100,000 adults	Employee Data	1
	Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider		1
Increase aid for trade support	Aid for Trade commitments and disbursements		0
develop a global youth employment strategy	Existence of a developed and operationalized national strategy for youth employment		0
			13
		Total	17

Industry, Innovation, and Infrastructure (SDG 9)

To build resilient infrastructure, promote sustainable industrialization, and foster innovation

Target	Indicator	Data Required	Relevanc
Develop sustainable	Proportion of the rural population who live within 2 km of an all-season road		0
	Passenger and freight volumes, by mode of transport		0
Resilient and inclusive infrastructures	Manufacturing value added as a proportion of GDP and per capita		0
	Manufacturing employment as a proportion of total employment		0
Promote inclusive and sustainable industrialization	Proportion of small-scale industries in total industry value added		0
	Proportion of small-scale industries with a loan or line of credit		0
Increase access to financial services and markets	CO2 emissions per unit of value added	Co2 emission by Ecostp in the water treatment process	1
Upgrade all industries and infrastructures for sustainability	Research and development expenditure as a proportion of GDP		1
	Number of Researchers (in full-time equivalent) per million inhabitants		1
Enhance research and upgrade industrial technologies	Total official international support (official development assistance plus other official flows) to infrastructure	**~500 bn industry**	1
Facilitate sustainable infrastructure development for developing countries	Total official international support (official development assistance plus other official flows) to infrastructure	**Sustainable sanitation for both commercial and residential infrastructure growth**	1
Support domestic technology development and industrial diversification	Proportion of medium and high-tech industry value added in total value added	**Using local technology for application globally**	1
Universal access to information and communications technology	Proportion of population covered by a mobile network, by technology		0
			6
		Total	13

Sustainable Cities and Communities (SDG 11)

To make cities inclusive, safe, resilient, and sustainable

Target	Indicator	Data Required	Relevance with the goal
Safe and affordable housing	Proportion of the urban population living in slum households	Applicable, but work in progress	1
Affordable and sustainable transport systems	Proportion of population that has convenient access to public transport, by sex, age and Persons With Disabilities	NA	0
Inclusive and sustainable urbanization	Ratio of land consumption rate to the population growth rate	NA	0
	Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically		1
Protect the world's cultural and natural heritage	Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by the source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)	NA	0
Reduce the adverse effects of natural disasters	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population. Indicators measured here report mortality rates internally displaced persons, missing persons and total numbers affected by natural disasters	NA	0
	Direct economic loss in relation to global GDP, damage to critical infrastructure and the number of disruptions to basic services, attributed to disasters	NA	0

Target	Indicator	Data Required	Relevance with the goal
Reduce the environmental impacts of cities	Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities	Impact on Sewage water treated for cities protecting water bodies	1
	Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)	Impact on Sewage water treated for cities protecting water bodies	1
Provide access to safe and inclusive green and public spaces	Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities	NA	0
	Proportion of person victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months	NA	0
Strong national and regional development planning	Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) ensure balanced territorial development, and (c) increase local fiscal space	NA	0
Implement policies for inclusion, resource efficiency and disaster risk reduction	Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030	NA	0
	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	NA	0
Support least developed countries in sustainable and resilient building	Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings using local materials	Sustainable sanitation for buildings	1
			5
		Total	15

Responsible Consumption and Production (SDG 12)

To ensure sustainable consumption and production patterns

Target	Indicator	Data Required	Relevan
Implement the 10 tear framework of programs on Sustainable Consumption and Production patterns.	Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies		1
Achieve the sustainable management and efficient use of natural resources	Material footprint, material footprint per capita, and material footprint per GDP	**Reuse and recirculation of treated water to avoid depletion of fresh water (natural source)**	1
	Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	**Construction / implementation using local material available**	1
Reducing by half the per capita global food waste at the retail and consumer levels and the reduction of food losses along production and supply chains, including post-harvest losses	Food Loss Index which focuses on losses from production to consumption level	NA	0
	Food Waste Index this indicator is a proposal under development	NA	0
Achieving the environmentally sound management of chemicals and all wastes throughout their life cycle	Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement	**No chemicals to treat wastewater**	1
	Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment	**No chemicals to treat wastewater**	1

Target	Indicator	Data Required	Relevan
Reducing waste generation through prevention, reduction, recycling and reuse	National recycling rate, tons of material recycled	**Water recycled for reduced use of fresh natural source**	1
Encourage companies to adopt sustainable practices	Number of companies publishing sustainability reports	**25% (used for IGBC certification)**	1
Promote public procurement practices that are sustainable	Degree of sustainable public procurement policies and action plan implementation	**Construction / implementation using local material available**	1
Ensure that people everywhere have the relevant information and awareness for sustainable development.	Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment	**Participation in global forum and other media (BBC circulation)**	0
Support developing countries to strengthen their scientific and technological capacity	"Installed renewable energy-generating capacity in developing countries (in watts per capital		1
Develop and implement tools to monitor sustainable development impacts	"Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability"	**Online monitoring of :** **a) Treated water** **b) Power saved**	1
Remove market distortions, like fossil fuel subsidies, that encourage wasteful consumption	(a) Amount of fossil-fuel subsidies as a percentage of GDP	**Reduction in :** **a) Coal consumption (by power usage reduction)**	1
	Amount of fossil-fuel subsidies as a percentage of GDP; and (b) amount of fossil fuel subsidies as a proportion of total national expenditure on fossil fuels"	Fossil fuels consumption in EcoSTP	1
			12
		Total	15

Good Health and Well-Being (SDG 3)

To ensure healthy lives and promote well-being for all at all ages.

Target	Indicator	Data Required	Relevance wit
Reduction of maternal mortality	Maternal mortality ratio. The maternal mortality ratio refers to the number of women who die from pregnancy-related causes while pregnant or within 42 days of pregnancy termination per 100,000 live births	**Helps address health risks like:** **a) Blue baby syndrome** **b) All water related health issues**	0
	Percentage of births attended by personnel trained to give the necessary supervision, care, and advice to women during pregnancy, labour, and the postpartum period; to conduct deliveries on their own; and to care for newborns	**Helps address health risks like:** **a) Blue baby syndrome** **b) All water related health issues**	0
Ending all preventable deaths under 5 years of age;	Under-5 mortality rate. The under-5 mortality rate measures the number of children per 1,000 live births who die before their 5th birthday	**Helps address health risks like:** **a) Blue baby syndrome** **b) All water related health issues**	1
	Neonatal mortality rate. The neonatal mortality rate is defined as the share of newborns per 1,000 live births in a given year who die before reaching 28 days of age	**Helps address health risks like:** **a) Blue baby syndrome** **b) All water related health issues**	1
Fight communicable diseases	Number of new HIV infections per 1,000 uninfected population		0
	Tuberculosis per 100,000 population		0
	Malaria incidence per 1,000 population		1
	Hepatitis B incidence per 100,000 population		0
	Number of people requiring interventions against neglected tropical disease		0
Ensure reduction of mortality from non-communicable diseases and promote mental	Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease		0
	Suicide mortality rate		0
Prevent and treat substance abuse;	Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders		0
	Harmful use of alcohol, defined according to the national context as alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol		0

Target	Indicator	Data Required	Relevance wit
Reduce road injuries and deaths			0
Grant universal access to sexual and reproductive care, family planning and education	Percentage of married women ages 15–49 years whose need for family planning is satisfied with modern methods of contraception		0
	Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1,000 women in that age		0
Achieve universal health coverage; and reduce illnesses	Coverage of essential health services	**Addressing all water borne issues**	1
	Proportion of population with large household expenditures on health as a share of total household expenditure or income	**Addressing all water borne issues due to bad sanitation**	1
Deaths from hazardous chemicals and pollution	Mortality rate attributed to the household (indoor) and ambient (outdoor) air pollution	**a) Reducing deaths of STP operators due to operational activities b) Reducing Antibiotic resistant bacteria and Antibioitic Resistant**	1
	Mortality rate attributed to unsafe water, sanitation, and lack of hygiene.		1
	Mortality rate attributed to unintentional poisoning		1
Implement the WHO Framework Convention on Tobacco Control;	age-standardized prevalence of current tobacco use among persons aged 15 years and older		0
Support research, development and universal access to affordable vaccines and medicines;	Proportion of the target population covered by all vaccines included in their national program.		0
	Total net official development assistance (ODA) to medical research and basic health		0
	Proportion of health facilities that have a core set of relevant essential medicines available		0
Increase health financing and support health workforce in	Health worker density and distribution.		0
Improve early warning systems for global health risks.	International Health Regulations (IHR) capacity and health emergency preparedness		0
	Percentage of bloodstream infections due to selected antimicrobial resistant organisms		0
			8
		Total	28

To sum up final relevant factors in terms of indicators and targets for each SDGs, following table has been presented:-

SDG No.	Name	No. of Targets	Relevant Target	Ratio	Total Indicators	Relevant indicators	Ratio for indicators	Final Preference
12	Responsible Consumption and Production	11	9	81.82%	15	12	80.00%	1
6	Clean Water and Sanitation	8	6.5	81.25%	11	9	81.82%	2
8	Decent Work and Economic Growth	12	9	75.00%	17	13	76.47%	3
9	Industry, Innovation and Infrastructure	9	5	55.56%	13	6	46.15%	4
11	Sustainable Cities and Communities	10	3.5	35.00%	15	5	33.33%	5
3	Good Health and Well-Being	13	2.87	22.05%	28	7	25.00%	6

After the analysis, the top 3 SDGs comes out to be:

- Responsible Consumption and Production (SDG 12)
- Clean Water and Sanitation (SDG 6)
- Decent Work and Economic Growth (SDG 8)

II. Impact Metrics:

ELECTRICITY:

Idea behind calculating electricity savings was that ; EcoSTP does not consume any electricity while a conventional STP would consume electricity so the difference between the electricity consumed by a conventional STP vs EcoSTP is Electricity consumed by using conventional method subtracting zero(which is the electricity consumed by EcoSTP) is the total electricity saved by somebody opting for EcoSTP

List of electricity consumption when using Conventional electricity:

- Used for machines in STP.
- Others like lights are insignificant.

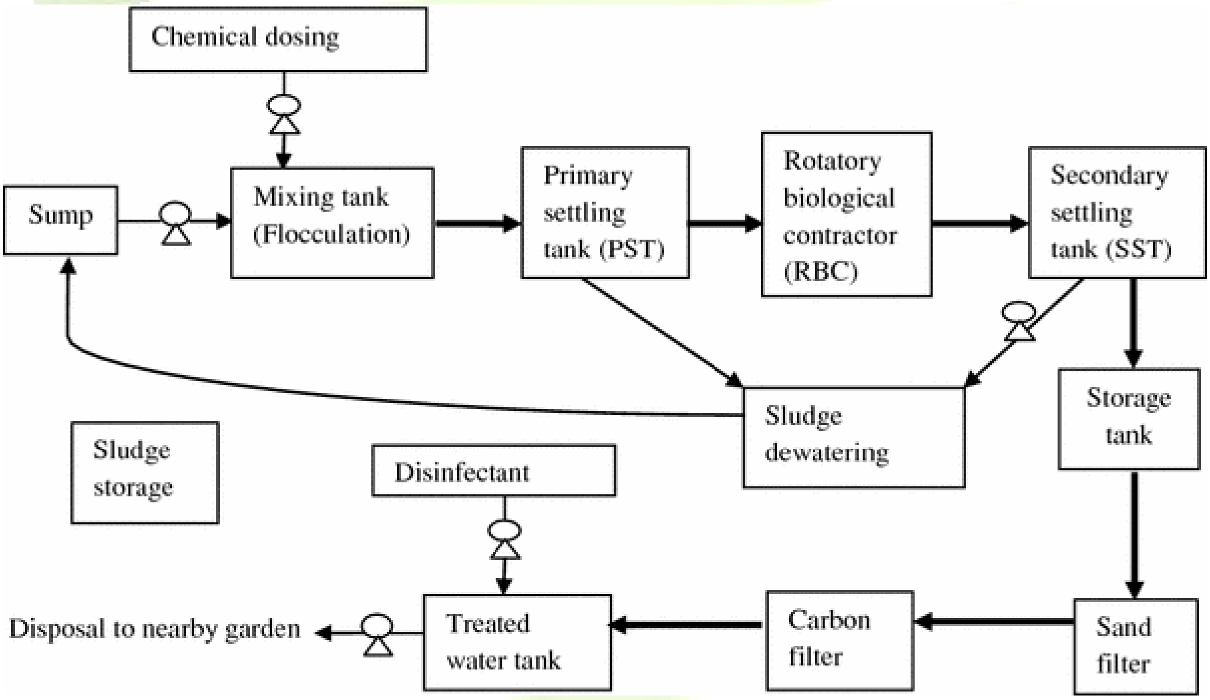
Indian Context: Data from the Excel shared, Assumption of 246 KW for every 11KLD(m3) based on experience – It is approximately close but a little over estimated compared to the study. It still depends on the amount of wastewater flow / day

Base number from Research paper:

The purpose of this paper is to identify a base number which can be used to calculate the amount of electricity consumed. (In terms of KWh/m3 of water treated).
This base number is also verified by several other Conventional STP research papers.

Context of the experiment: (Similar to a house setting with a kitchen and Bathrooms)

The WWTP is located at TERI University, which is in an institutional area at New Delhi, India. The plant has a design capacity of 25 m3/day and is operated for 12 hours a day. The actual flow of wastewater during the study period is found to vary between 19 and 23 m3/day. Primary sources of wastewater are: a hostel having 60 residents, administrative block of the University and a kitchen. The plant has been designed for reuse of water for non-potable applications. It uses physico chemical treatment methods using coagulants such as caustic soda and aluminium sulphate as primary treatment and filtration, adsorption and disinfection as tertiary treatment. Biological treatment based on rotating biological contactor (RBC) is used as secondary treatment. The dried sludge is used in a nearby horticulture park and the treated water for watering plants. Fig. shows the wastewater treatment scheme.



The treatment plant has the following units:

1. Sump tank: reinforced cement concrete, rectangular shape underground tank, size (3 × 2 × 2) m, having two submerged sludge pumps (one as standby) each of 0.75 kW motor for feeding raw wastewater.
2. PST: rectangular shaped MS tank, size (3 × 1 × 2.25) m, fitted with one SS turbine plate stirrer with 0.19 kW motor.

3. Chemical dosing tanks: three tanks each of 100 l capacity with total 3 dosing pumps (1 pump as standby) having 0.19 kW motor.
4. RBC: tank of size (2 × 0.8 × 0.8) m; discs fitted with a worm gear motor of 0.19 kW.
5. Disinfectant tanks: two tanks each of 100 l capacity with total 3 dosing pumps (1 pump as standby) having 0.19 kW motor.
6. SST: tank of size (3 × 1 × 2.25) m, fitted with SS turbine plate stirrer 0.19 kW motor and single stage Monoblock recirculation pump of 0.38 kW.
7. Sand filter and carbon filter: 200 l capacity, fiberglass reinforced plastics (FRP) vessel with manual multiport valve.
8. Treated water tank: RCC rectangular, (3 × 2 × 2) m, having one centrifugal regenerative pump of 0.75 kW.

Methodology and data collection

Energy consumed during the treatment process is observed to be in the form of electrical energy.. Energy consumption is calculated in terms of kWh/m^3 of wastewater treated. Primary data have been collected through field monitoring and corroborated with historical data through discussions with plant operators. Log-books and records of transactions and consumptions are also referred for validation. Field monitoring has been done for 15 days spread over 2 months during June–July, 2011. Equal representation of weekdays and weekends is considered for the monitoring days. Time measurement is done using a stopwatch.

Estimation of electrical energy input

The electrical energy input is estimated by considering the electrical load of the pump/motor (kW), time in hours (h) for which the motor is operated and total amount of wastewater treated (Eq. 1).

$E_p = P \times T / Q$ -------------------(1)

where, E_p is the electrical energy kWh/m^3, Q the total flow of wastewater in m^3/day, P the rated power of the electrical motor in kilo Watt (kW), and T is the operation hours in a day (h/day).

The motor efficiency is assumed as 80 % .

Table shows the average of values as obtained in the field.

Table 2 Details of mechanical equipment specification

From: Energy pattern analysis of a wastewater treatment plant

Treatment unit	Type of equipment	No. of working units	*P* (kW)	*T* (h/day)
Raw water collection sump	Pump	1	0.75	6.5
Primary treatment	Stirrer	1	0.19	11.75
Chemical dosing tanks	Pump	2	0.19	2.4
RBC treatment	Motor	1	0.19	11.75
Secondary treatment	Stirrer	1	0.19	12.25
	Recirculation pump	1	0.38	5.45
Disinfectant tanks	Pump	2	0.19	2.1
Treated water sump	Pump	1	0.75	5.95

The electrical energy consumption per cubic meter of wastewater treatment is found to be 0.80 kWh/m3. It is commensurate with the findings of several other studies on WWTPs. The values vary in the range of 0.26–0.84 kWh/m3 . The evidence from the literature suggests that the electrical energy consumption can vary by a factor of 1.6 depending upon the choice of the technology and the scale of operation. The major source of electrical energy consumption is in the pump house (79 %) where raw wastewater pumps and treated water pumps have a significant share. Biological treatment process consisting of RBC process consumes 11 % of the total electrical energy consumption.

Reference:
https://link.springer.com/article/10.1007/s13201-012-0040-7

Input:

0.8 KWh/m3		
Electricity		
Electricity needed	**0.80**	**KWh/m3 (Base number from research Papers)***
Primary Input		
m3/day	8.10	m3/day (Converting 135 LPCD per head to m3/day)
No of Families	15.00	(60 Residents according to the study with 4 per family
No of days/month	30.00	days/month
Secondary Input		
No of families in a colony	15.00	(Assuming 15 Families per colony)
Tertiary Input		
Amount of wastewater treated in a city	20000.00	m3/day (According to the latest data, Convert the MLD to m3/day)
Presentation Input		
Amount of Electricity consumed in a household	6.00	Kwh/day

Output:

Primary Output	12.96	Kwh/month per family (0.8*8.10*30/15)
Secondary Output	194.40	Kwh/month per Colony
Tertiary Output	480000.00	Kwh/month per City
Amount of Electricity saved per day for a family	0.43	Kwh/day (12.96/30)
Percentage of Electricity saved by EcoSTP to the average daily consumption of house hold electricity	7.20%	The Amount of electricity used in a conventional STP per day at primary level to the Amount of electricity a family uses per day in whole

For Primary level, We take the building code value of 135 LPCD per head of water used (8.10 m3/day)(http://dasta.in/wp-content/uploads/2015/04/CB_Code_2002.pdf) multiplied by 0.8 KWh/m3 and then multiplied by 30 days and divided by 15 (No of families assumed to be in a building). On which we get 12.96 KWh/month per family on converting it to per day we get 0.43 KWh/day.

For Secondary level, Given that we already assumed to have 15 families in a surrounding. Multiply 12.96 into 15. On which we get 194.4 KWh/month.

For tertiary level, According to https://www.downtoearth.org.in/news/waste/india-s-sewage-treatment-plants-treat-only-a-third-of-the-sewage-generated-daily-cpcb-79157 the amount of water treated on a city level is 20000 m3/day. On multiplying 0.8 KWh/m3 into 30 days into 20000 m3/day, We get 480000 KWh/month per city.

Presentation:
We compare the Electricity saved per day per family to electricity consumed per day per family household and that turns out to be 7.20%.

COAL:

The Amount of Coal saved is The Amount of Coal consumed to produce the electricity needed to run the conventional STP- Zero (As EcoSTP does not consume any electricity)

Base number from Research paper:

The prevailing baseline emissions based on the data for the FY 2019-20 are shown . The calculations are based on generation, fuel consumption and fuel quality data obtained from the power stations. Typical standard data were used only for a few stations where information was not available from the station. Cross-border electricity transfers were also taken into account for calculating the CO2 emission baseline.

Table 4: Weighted average emission factor, simple operating margin (OM), build margin (BM) and combined margin (CM) of the Indian Grid for FY 2019-20 (not adjusted and adjusted for cross-country electricity transfers), in t CO_2/MWh

	Average	OM	BM	CM
Excluding cross-border power transfers	0.80	0.96	0.87	0.92
Including cross-border power transfers	0.79	0.96	0.87	0.91

Average is the average emission of all stations in the grid, weighted by net generation.
OM is the average emission from all stations excluding the low cost/must run sources.
BM is the average emission of the 20% (by net generation) most recent capacity addition in the grid.
CM is a weighted average of the OM and BM (here weighted 50: 50).

According to the Gov of India data- The amount of coal used to generate electricity is 0.80 t CO2/MWh (Excluding the cross border transfers)

Reference:
https://cea.nic.in/cdm-co2-baseline-database/?lang=en

Input:

Coal		
The amount of coal used to generate electricity is	0.80	Tonnes/MWh*
	0.73	**Kg/Kwh**
Presentation Input		
Amount of Electricity consumed in a house hold	6.00	KWh/day
Amount of Coal needed to produce electricity for a family	4.35	Kg/day

Output:

Primary Output of Coal Consumed	9.41	Kg/month per family
Secondary Output of Coal Consumed	141.09	Kg/month per Colony
Tertiary Output of Coal Consumed	348359.04	Kg/month per City
Amount of Coal burning saved per day for a family (By saving electricity)	0.31	Kg/day per family
Percentage of Coal consumed to the average daily consumption of house hold electricity	7.20%	The Amount of Coal used to produce electricity of a conventional STP per day at primary level to the Amount of Coal needed for a family to get the electricity it needs for a day

For Primary level, We multiply 0.73 Kg/KWh into 12.96 KWh/month (primary output of electricity) which is equal to 9.46 Kg/month per family and 0.78 Kg/day

For secondary level, We multiply 0.73 Kg/KWh into 194.40 KWh/month (secondary output of electricity) which is equal to 141.09 Kg/month per surrounding assuming 15 families of 4.

For tertiary level, We multiply 0.73 Kg/KWh into 480000 KWh/month (Tertiary output of electricity) which is equal to 348359.04 Kg/month per city

Presentation:
For calculating Amount of Coal needed to produce electricity for a family we multiply 0.73 Kg/KWh (Converted 0.8 tonnes/MWh) into 6 KWh/day (Amount of Electricity used by a household per day we get 4.35 Kg/day.

With 4.35 Kg/day being the amount of CO_2 produced per household. Comparing it to 0.78 Kg/day for a family, We get it to be 7.20%.

CO2:

CO_2 Saved by opting for EcoSTP is the Amount of CO_2 produced by Opting for conventional method- Zero (Which is the amount produced by EcoSTP)

Base number from Research paper:

Amount of CO_2 saved by opting for EcoSTP is Amount of CO_2 generated in traditional approach- Zero (As EcoSTP does not use chemical or mechanical methods)

Carbon Footprint For the estimation of carbon footprint, following types of carbon emissions was taken into consideration

a. Fugitive Emissions: The on-site emissions from a WWTP into the atmosphere are known as Fugitive emissions. This emission happens because of the biological degradation of organic matter. IPCC-2006 Guidelines for National Greenhouse Gas Inventories are used to calculate the fugitive emissions for CH_4 and N_2O gases respectively .Global warming potential was used for converting the emissions into a CO_2 equivalent.

b. Off-site Carbon Emissions: The GHG emissions generated from electric use inside the WWTP are called off-site carbon emissions. These emissions are calculated by Eq. (1.3).

   $Ge = El \times \text{Country Emission Factor}$ (1.3)
   Where, Ge= Off-site carbon emissions ($kgCO_2eq/m^3$),
   El= Electrical energy (kWh/m^3),
   Country emission factor = 0.98 $kgCO_2$ /kWh
   (Mentioned below)

   Amount generated from coal usage due to electricity used:
   Weighted average:
   The weighted average emission factor describes the average CO_2 emitted per unit of electricity generated in the grid. It is calculated by dividing the absolute CO_2 emissions of all power stations by the total net generation. Net generation from

so-called low cost/must-run sources is included in the denominator. In India, hydro and nuclear stations qualify as low-cost/must-run sources.

Table 5: Weighted average specific emissions for fossil fuel-fired stations in FY 2019-20, in t CO_2/MWh

Coal	Diesel	Gas*	Lignite	Oil
0.98	0.58	0.43	1.36	-

* Only gas-fired stations that do not use any other fuel. Stations that use naphtha, diesel or oil as a second fuel are excluded from the weighted average.

Note: Stations for which assumptions had to be made are included in this analysis (see Section 4 for details).

Note: The average consumption of electrical energy per cubic meter of wastewater treatment is 0.24 kWh/m3 . The value is in line with the results of several other WWTP studies and values range between 0.2–0.84 kWh/m3. (So We take 0.8kWh/m3)

c. Indirect carbon Emissions: Indirect carbon emissions are the emissions embodied in construction materials and chemicals. Indirect carbon emissions embodied in chemicals is calculated by Eq. (1.4)
   Gch = =(∑ Wi x EFi)/ Q -------(1.4)
   Where,
   Gch= Total carbon emissions from chemicals (kgCO2eq/m3),
   i = Chemical type,
   Wi = Quantity of ith chemical used (kg/day),
   EFi = Carbon (CO2eq) embodied in i th chemical (kg/kg)
   Q =Daily average sewage inflow to the STP (m3 /day).

   (a)+(b)+(c) = Total CO2 produced by a conventional method

Carbon Footprint of WWTP according to the experiment done in the research paper:

Fugitive Emissions ($kgCO_2eq/m^3$)		Indirect Carbon Eissions ($kgCO_2eq/m^3$)	
CH_4	N_2O	Chlorine	Polymer
0.002846	0.036857	0.312	1.227
0.0016115	0.0208655	0.115	0.685
0.003341	0.043256	0.484	1.852
0.002162	0.027991	0.186	0.973
0.001671	0.021631	0.125	1.021
0.001777	0.02301	0.146	1.163

For 6 Plants:
- Fugitive emissions from the WWTP is 0.187019 kgCO2eq/m3
- Indirect carbon emission is 8.289 kgCO2eq/m3

Taking Average : For 1 Conventional STP:
a) Fugitive emissions from the WWTP is 0.03117 kgCO2eq/m3 . (0.187019 / 6)
b) Off-site carbon emissions from the WWTPs is 0.784 kgCO2eq/m3 (Taken the newly calculated value and Latest country emission factor ie 0.98*0.8)
c) Indirect carbon emission is 1.3815 kgCO2eq/m3. (8.289/6)
Total = 2.19 kgCO2eq/m3

Note: For Offsite Carbon emission, the latest emission factor of 0.98 is used instead of 0.8 which was for the previous year

Country Emission Factor

- https://cea.nic.in/cdm-co2-baseline-database/?lang=en

Research paper used for reference:
https://www.researchgate.net/publication/337812267_GREENHOUSE_GAS_EMISSIONS_FROM_WASTEWATER_TREATMENT_PLANT

Input:

CO_2		
Fugitive emissions/ STP	0.03	KgCO2eq/m3
Offsite emissions		
Country Emission Factor	0.98	
	0.78	KgCO2eq/m3
Indirect carbon emission	1.38	KgCO2eq/m3
Total	**2.20**	**KgCO2eq/m3 (Base number from research Papers)***
Primary Input		
m3/day	8.10	m3/day (Converting 135 LPCD per head to m3/day)
No of Families	15.00	(60 Residents according to the study with 4 per family
No of days/month	30.00	days/month
Secondary Input		
No of families in a colony	15.00	(Assuming 15 Families per colony)
Tertiary Input		
Amount of wastewater treated in a city	20000.00	m3/day (According to the latest data, Convert the MLD to m3/day)
Presentation Input:		
Amount of CO2 due to Domestic Aviation (per year)	6710461000	KgCO2 /year
Total no of Urban centres in India (2011 census)	8000	
Amount of CO2 produced by considering all the urban centres (per year)	12652819200 0	Kg CO2/year

Output:

Primary	35.59	KgCO2eq/month per family (2.196*23*30/15)

Secondary	533.79	KgCO2eq/month per Colony
Tertiary/ Month	1318002	KgCO2/town per month
Tertiary/ Year	15816024	KgCO2/town per year
Total CO2 produced by treating All urban centre water using Conventional method	19	

For Primary level, We take the building code value of 135 LPCD per head of water used (8.10 m3/day)(http://dasta.in/wp-content/uploads/2015/04/CB_Code_2002.pdf) multiplied by 2.19 KgCO2eq/m3 and then multiplied by 30 days and divided by 15 (No of families assumed to be in a building). On which we get 35.59 KgCO2 eq/month per family.
For Secondary level, Given that we already assumed to have 15 families in a surrounding. Multiply 35.59 KgCO2 eq/month into 15 families. On which we get 533.79 KgCO2 eq/month.

For tertiary level, According to https://www.downtoearth.org.in/news/waste/india-s-sewage-treatment-plants-treat-only-a-third-of-the-sewage-generated-daily-cpcb-79157 the amount of water treated on a city level is 20000 m3/day. On multiplying 2.19 KgCO2/m3 into 30 days into 20000 m3/day, We get 1318002 KgCO2/month per city.

Presentation:
From https://knoema.com/atlas/India/topics/Transportation/CO2-Emissions-from-transport/CO2-emissions-from-domestic-aviation we get that amount of CO2 due to Domestic Aviation (per year) is 6710461000 KgCO2 /year .

On converting the tertiary level CO2 reduced by opting for EcoSTP per year is 15816024 KgCO2/town per year and multiplying it to 8000 (the total number of cities in India as per 2011 census- https://iussp.org/sites/default/files/event_call_for_papers/Urban%20transition%20India_IUSSP%202013.pdf) we get Amount of CO2 produced by considering all the urban centres (per year)- 126528192000 Kg CO2/year

Comparing this value with the CO2 due to Domestic Aviation (per year) we get,
The Total CO2 produced by treating water of all cities in India using Conventional method for a year is 19 times the amount of CO2 due to Domestic Aviation (per year). And this amount would be saved by opting for EcoSTP.

WATER:

The goals were to calculate the amount of water recycled and reused by the use of ecoSTP. Final goal was that, with these two datas and the urban water consumption trend , find the amount of groundwater saved.
The amount of water consumed by a person in an urban household is 135LPD.

From Research Papers , it was found that excluding water for Drinking and Cooking , rest all water can be recycled. This amounts to 125 LPD or 92.8% of the water consumed by a person in an average urban household.
Recycled water from ecoSTP can be reused for activities such as Toilets, Car Wash etc. This amounts to 18.7% or 31LPD .
So all of this recycled water amounts to saved ground water.
It is also a fact that 50% of an Urban Household's water needs is satisfied by groundwater. So 67 LPD comes from Groundwater. But now 31LPD of the 67LPD is saved.
Hence upto 50% of Groundwater is saved by the use of ecoSTP.

Dashboard:
Now that we have the base number for

- Electricity saved = 0.8KWh/m3 of water treated
- Coal saved = 0.8 tCO_2/MWh of electricity needed for conventional STP
- CO_2 emission reduced = 2.19 $KgCO_2eq/m^3$

We calculate the values for primary, Secondary and tertiary levels

Water :
Input

Water Usage	**Quantity**	**Unit**	**Remarks**
Total Water Used by the Home	135	LPD	This value can be changed as required
Activity wise Split			
Bathing	38.07	LPD	From the data in the paper. Snapshot to the left.
Cloth Washing	25.11	LPD	
Utensil Cleaning	22.005	LPD	
House Cleaning	9.855	LPD	
Drinking and Cooking	9.72	LPD	
Toilets	27	LPD	
Car Wash + Misc	3.24	LPD	
Amount of Water Coming from Ground without ecoSTP	62.64	LPD	50% of Total Use except drinking and cooking
Recycled Water	125.28	LPD	Except Drinking and Cooking
Reused Water	30.24	LPD	Toilets and Car Wash. Change the formula as and when the water is resued for other activities
Ground Water	30.24	LPD	Assumed to be same as Reused

Saved				Water
Amount of Water Coming from Ground with ecoSTP		32.4	LPD	Initial Ground Water - Reused
Percentage Groundwater Saved		48.27586207	%	EcoSTP uses 50% less groundwater

Presentation:

50%	**EcoSTP Clients use upto 50% less groundwater**

MONEY:

When considering Money savings, the logical route was to compare the ECOSTP with a conventional STP and ascertain the difference in expenditure. While monetary savings occur within the other impact metrics as well (like the money saved due to less electricity and coal usage for instance), it is an indirect gain. When looking at the direct money savings, three major aspects were included- the Capital Expenditure, Operating costs and also the Land Savings to be considered. The capital expenditure also includes & Construction expenses which includes Cement, Steel, Pipes, Sand and Labour costs. The Operating Costs involves the Operator salary, cost of maintenance of Mechanical Equipments and Power involved for running the STP.

When it comes to the amount saved because of land savings is also very significant. In case of Conventional STP, not only the space used for STP, but the area around it also becomes unusable due to odor issues. However, The entire STP space with ECOSTP can be reclaimed. This provides the concerned party with more value for land space. The actual amount saved depends upon the actual geographical location and the real estate prices there.

For the purpose of comparison, one of the most common types of STPs, the Activated Sludge Process (ASP) STP was chosen to compare against the ECOSTP as an average. The Capital expenditure including Civil construction costs for ECOSTP was estimated at Rs 50,000/KLD. An estimate of the average CapEx of Activated Sludge Process (ASP) treatment type STP as ascertained by multiple studies was 15-20% lower than ecoSTP capex. These costs do not vary drastically according to the size of the STP; the latter can be modified according to the requirement.

The Average operational cost identified per KLD for the ASP STP was around Rs.6000/-. In comparison, for the ECOSTP, desludging costs of Rs. 2,00,000 once in 2 years is the primary Operating expense. We are also accounting for a 10% year on year cost increment considering breakdowns, wear and tear and depreciation of the mechanical parts for a conventional STP. A similar 10% increment has been applied for the ECOSTP from Year 5 onwards.

Type of STP	**Cost per KLD**
ECOSTP (per KLD)	50000
Conventional STP (per KLD)	42500
Size of STP	**in KLD**
ECOSTP	100
Conventional STP	100
O&M Cost per KLD	**Cost per KLD**
Conventional STP	6000
ECOSTP	Desludging costs of Rs. 2,00,000 once in 2 years is the primary Operating expense

The savings from the Lifecycle costs are ascertained as follows- this is explained and presented in the dashboard.

	Conventional STP	**ECOSTP**		
CAPEX	4250000	5000000		
O&M Expenditure	**in Rs.**	**In Rs.**	**Yearly Savings in Rs**	**Savings in Lifecycle Costs in Rs**
Year 1	600000		500000	
Year 2	660000	200000	560000	310000
Year 3	726000		626000	936000
Year 4	798600	200000	698600	1634600
Year 5	878460		768460	2403060
Year 6	966306	220000	856306	3259366
Year 7	1062937		952937	4212303
		220000		

Year 8	1169230		1059230	5271533
Year 9	1286153		1165153	6436686
Year 10	1414769	242000	1293769	7730455
Total O&M Expenditure	9562455	1082000	**8480455**	**7730455**
			Sum of yearly savings	**Total savings over life cycle costs**

Output

Savings after 2 years (in Rs)	310000.00
Savings after 5 years (in Rs)	2403060.00
Savings after 10 years (in Rs)	7730454.76

Presentation
The money savings have been presented in the form of the number of children that can receive a full and proper education (from grades 1-12 in school) in India. The Estimated basic cost of education for a child in India is Rs. 1,10,000 at the basic level, especially considering the more marginalised sections of society.

No of children that can receive a complete education in India (Grade 1-12) with the 10 year savings	**70**

References:

https://cdn.cseindia.org/userfiles/arunabha.pdf
http://nopr.niscair.res.in/bitstream/123456789/41040/3/JSIR%2076%284%29%20249-254.pdf
https://cdn.cseindia.org/userfiles/Advanced-Water-Treatment.pdf
https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sesp/4S/India/g_rath_costs.pdf
https://www.financialexpress.com/economy/how-much-it-takes-to-educate-people-in-india-cost-of-education-revealed-in-four-charts/1778220/

HEALTH

Of the various impact metrics, health is comparatively a tougher metric to measure the impact of since it is qualitative to an extent. It is difficult to attribute certain health conditions to an STP without considering multiple other variables including pre-existing health issues, genetic conditions, lack of substantial proof of ill-health etc. An Exhaustive list of Health savings was taken to be measured on the basis of the health issues caused by conventional STPs to both the Operators who work on them and the households situated around it. This was also measured according to aspects of the metrics that were considered under the Environment but were applied to a human health perspective. Potential submetrics included issues caused by the Chemicals Used, Presence of Bacteria, existence of bad odours due to gases released, sludge formation and the presence of mosquitoes and flies.

Of these, multiple Potential hazards for operators and workers were identified- some of which are listen below:

- Exposure to different types of microorganisms and chemicals- increased risk of infection, especially of hepatitis A.
- Reports of respiratory symptoms, fatigue, headache- possible due to inflammation, or endotoxin in Gram-negative bacteria
- Higher incidence of headache, tiredness, and nausea were exposed to culturable bacteria
- General malaise, weakness, acute rhinitis, and fever accompanied by gastrointestinal symptoms due to increased aerosol inhalation.

Similarly when considering the ill-effects on the households surrounding them, we found out that a malfunctioning STP close to a residential complex can lead to two major issues.

- The issue of intensifying terrible odors
- Possibility of a health hazard, as the aerators within the STP constantly throw up droplets of water in the air which could lead to the spread of contagions

ECOSTP subverts the health risks associated with normal STP's. The minimal maintenance required, lack of chemicals, odors or sludge mean that one can avoid even unintentionally exposing themselves to multiple health triggers

ENVIRONMENT

The major pollutant release from the waste water treatment process by traditional approach are:-

<table>
<tr><th>Activity</th><th>Emission sources</th><th>Odorous pollutants</th></tr>
<tr><td rowspan="8">Urban sewage treatment units</td><td>Sewerage uplifting units and/or draining from tanker trucks</td><td rowspan="13">H_2S
NH_3
Sulphurous organic compounds
Reduced sulphurous organic compounds
Amines
Indole and Skatole organics
Fatty volatile acids
Other organic compounds</td></tr>
<tr><td>Pre-treatment</td></tr>
<tr><td>Primary sedimentation</td></tr>
<tr><td>Biologic oxidation</td></tr>
<tr><td>Nitrification</td></tr>
<tr><td>Denitrification</td></tr>
<tr><td>Secondary sedimentation</td></tr>
<tr><td>Final treatment</td></tr>
<tr><td rowspan="5">Sludge treatment and energy production units</td><td>Thickening</td></tr>
<tr><td>Mechanic treatments</td></tr>
<tr><td>Thermal dewatering</td></tr>
<tr><td>Anaerobic digestion</td></tr>
<tr><td>Biogas production</td></tr>
</table>

A research conducted by University of Santiago de Compostela and University of the West of England, UK for the dispersion of air pollutants such as Ammonia (NH3) and Hydrogen Sulphide (H2S) emitted by a municipal wastewater treatment plant (WWTP) over one year. As per the report, the human perceptible thresholds are 0.00041ppm (0.6µg/m3) and 0.037 ppm respectively for H2S and NH3.

Emission of these gas in different source process is shown in the table:-

Table 2: Emission factors from WWTP units calculated for both gases.

Source	NH_3 (g/s)	H_2S (g/s)
D1: new sludge post-thickener	3.17 E-06	9.59 E-09
D3: new sludge pre-thickener	1.37 E -05	4.13 E-08
D4: sludge uplifting at sedimentation	1.87 E-05	5.46 E-08
D5: activated sludge uplifting	9.04 E-03	9.92 E-06
D6: sludge uplifting from equalizer pool	2.18 E-03	1.2 E-05
D7: re-circulation sludge uplifting	7.41 E-03	3.76 E-05
D8: thickener	5.94 E-06	1.78 E-08

Table 3: Emission factors from dewatering units calculated for both gases.

Source	NH_3 (g/s)	H_2S (g/s)
D2: new centrifuge room	2.23 E-01	2.74 E-03
D9: present centrifuge room	2.61 E-01	3.21 E-03
D10: drying beds	1.93 E-03	2.38 E-05

Vector-borne Diseases

- Traditional Sewage Treatment Plants use open water sources such as ponds, lakes, etc.
- Mosquitoes are the most abundant vectors with more than 100 species in these water bodies. Also, other species that have been identified by researchers include Diptera (52%), Hemiptera (24%), Ciclopodidade (12%), Hydracarina (9.5%), Coleoptera (0.77%), Aranida (0.67%), Hymenoptera (0.58%), and Odonata (0.48%).

Flora and Fauna Impact

- Since waste always contains organic matter, a landfill will attract insects, birds and animals.
- The food in the landfill can also contribute to the growth of unnaturally large populations of some species, which will in turn contribute to the displacement of other species, and so imbalance the local ecosystem.
- Large landfills with associated roads can create barriers that disturb feeding and breeding patterns of fauna, and in other ways occupy vital habitats of flora and

fauna.

- During the construction phase of preparing a landfill area, or building a major waste processing plant, an increased temporary demand for water and energy may arise. If fuel from nearby woods is used, vulnerable vegetation can be damaged.
- Dumping of hazardous waste in sea and lakes can have serious consequences for flora and fauna. Toxicants may also enter into food chains and ultimately affect the health of humans.