| THE ALL- GIRLS ECO-PROGRAMME | # Localized Energy Solutions for Peri-urban Regions |
|---|---|

Written by: Garima Goswami, Mugdha Zadkar, Chithra Nair Rajendran, Shiny Lohani & Vedangi Deo.
Reviewed and edited by: Nour Rashid

## ABSTRACT

The urban-rural fringe or peri-urban regions, regions located on the periphery of a metropolis and nearby rural areas are seldom planned. More often, they tend to show rapid growth in a short span of time and have large energy as well as resource demands. In this paper, we focus on three major issues faced in these urban fringes: improper street lighting, waste management problems and erratic power supply. We propose sustainable solutions for tackling these issues like smart solar-piezo poles, intelligent auto-water sprinklers, energy production from solid waste, and demand supply management methods. The peri-urban regions outgrow to become urban areas in a few decades, so, investment in the development of these regions will definitely pay off in the future.

## INTRODUCTION

Rural population is declining due to the migration to urban areas for better job opportunities and improved living standards. Urban population surge has added hefty pressure on infrastructure and energy requirements. The extravagant living costs in the cities drive most migrants to reside in the urban fringes. The intermediary regions between the urban and rural areas are called the peri-urban or fringe regions [1]. The inhabitants of the peri-urban areas have to deal with unhygienic conditions, poor infrastructure, garbage disposal and load shedding (to name a few) on a regular basis. The urban poor in certain peri-urban regions of India do not have access to basic amenities like proper sanitation, roads, street-lighting and energy supply [2,3].

The peri-urban regions form the transition between urban and rural areas. So, they serve as affordable areas for waste disposal from the cities. Heavy metals and waste accumulation leads to food and water contamination exposing the inhabitants to various health related issues [4]. Many countries are trying to reduce carbon emissions and promote clean energy. Considering a longer time frame, the peri-urban areas are the future urban cities and hence intelligent development projects for these areas will enable swift expansion of the urban regions.

In this paper, we discuss the major problems faced by peri-urban regions in terms of energy needs and waste management. We also propose possible solutions to deal with the problems and ensure better living standards for the inhabitants of these regions.

## ANALYSIS OF CURRENT SCENARIO AND PROBLEMS

Peri-urban regions often do not fall under the jurisdiction of the urban municipality and hence remain the most overlooked regions. The inhabitants travel to cities daily for work and business. The roadways linking the cities and peri-urban towns have unsatisfactory roadway infrastructure, minimal street cleaning and lighting. These form sites for accidents and increased crime rates. Current practices use traditional energy sources for street lighting. As a move towards sustainability, solar-powered street lights have been installed in certain cities. However, fluctuating weather conditions hinder guaranteed energy supply throughout [5]. Clean energy sources like solar panels are limited only to larger-grid-based systems for power generation.

Lack of strict government policies and municipal services renders these areas vulnerable to waste disposal [6]. Inefficient waste management has led to issues in water sanitation in the outskirts of various cities [7]. Guwahati does not have an integrated drainage system, except for certain parts of the city. Most of the industry and household sewage is released directly into nearby water bodies without treatment. Patna has no specified landfill site and most of the solid waste is dumped in heaps on the sides of the new bypass road [8]. It also has an open sewage system causing several health problems. This untreated sewage water is mostly released into the Ganges, which is also the source of drinking water for the city! In 2019 the city of Chennai, one of the wettest major cities in the world, ran out groundwater – its main source of drinking water. It is estimated that if Demand-Supply management techniques were to be used for drinking water in Chennai, the gap between the demand and supply could be reduced by about 40% [9].

About 80% of the energy needs are fulfilled from fossil fuels, out of which more than 50% energy comes from coal powered thermal power plants [10]. India is heavily dependent on conventional sources of energy. The energy requirements in semi-urban regions are hardly fulfilled by sustainable means. Roadway transportation forms a major source of carbon emissions.

This study focuses on proposing solutions for three main problems observed in peri-urban regions of India: (i) Improper on-road lighting and street light management (ii) Waste garbage heaps and (iii) carbon emission on the roadways.

## PROPOSED SOLUTIONS

**(i) Smart Solar-Piezo poles:** We propose using a smart streetlight which can be controlled based on traffic flow and daylight. The poles will be powered with solar and piezoelectric sources. The PV module will produce DC electricity from solar radiations and a charge controller can regulate the voltage and current. A battery will store the energy for supply during increased demands. Various loads can be incorporated into the pole like lights, security cameras and Wi-Fi. Phone charging facilities can also be installed near major fuel stations. For calculations related to total power and energy consumption, please refer [11]. Sensors can be incorporated for showing the temperature and pollution levels. Smart devices for controlling light intensity based on traffic flow can save energy. About 20 billion dollars' worth of electricity is wasted due to streetlights. Street lights are switched on manually, and remain on during day time. Darkness sensors and motion sensors can be attached to control lighting and automatically switch on and off the street lights [12].

Additionally, piezoelectric tile strips can be installed on the roads to produce electricity through movement on the roadway. Their integration with the solar-light pole will ensure energy supply during prolonged inadequate sunlight periods. Piezoelectric tiles are more cost effective compared to solar power. Number of units produced by solar power in a year with an installation of 1 KW is 1752, compared to 42573 units produced from one piezoelectric tile in a year [13].

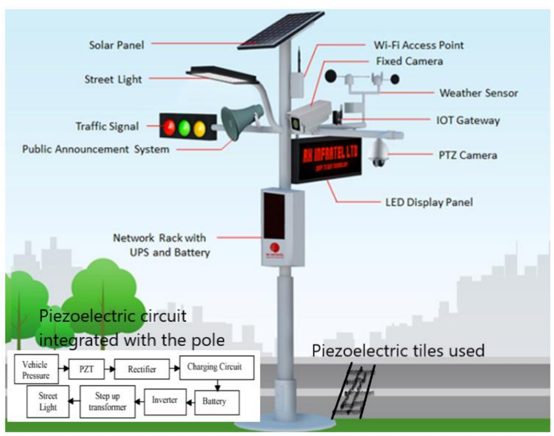


Figure 1. Smart Solar-Piezo poles

**(ii) Intelligent auto-water sprinklers:** India is a country blessed with a fulfilling monsoon; making rainwater an adequate natural resource. However, often these rainwaters end up in the drain, get soaked underground or may result in semi-flooding. According to a notice from the Office of Ministry of Road Transport and Highways, Government of India [14], the average annual rainfall in India is about 1100 mm and the total annual volume of run-off from a 1 km long National-Highway with run-off efficiency as 80% (say) is: 1000 m x 7 m x 80 x 1100 mm = 6160 cubic meters = 61,60,000 liters (Data from 2013) [15,16,17,18]. The central government had sought details for such structures around the national highways from all states.

We propose a system of underground tanks on low lying areas or areas near to housing societies along the highways or depleted water bodies found along highways. The tanks would be fed from the rainwater harvested through drains formed along roadsides and rooftops of buildings of peri-urban regions. We propose a block of three tanks: first tank for collection, second tank with a sand bed filter to clear the rainwater harvested, and the third tank with smart sprinklers and integrated controllers with sensors designed to work at specific times of the day as needed. A case study of Goa University shows how the rainwater harvesting system has been successfully implemented and the ratio of aquifer recharge to runoff collection was estimated to be around 83% [19]. The water sprinklers will also help in passive carbon capture through growing of green vegetation in the adjoining area. [20] shows that the annual $CO_2$ sequestration by three grass species (Cynodon dactylon Pers., Festuca arundinacea Schreb. and Zoysia matrella L) with irrigation treatment was about 2.5 kg-$CO_2 \cdot m^{-2} \cdot yr^{-1}$. Therefore, the amount of carbon capture would depend on the type of vegetation planned, density of vegetation, maintenance of vegetated areas and many other factors. Our proposed system will not result in carbon emission as it is not totally a green-roof model. Study of Chicago shows that green vegetation may also help in fighting the problem of air pollution through capture of other pollutants [21]. The proposed project may aid in fighting the problem of road-dust in arid-peri-urban areas [22].

**(iii) Energy recovery from combustion of solid waste:** The combustion process used in the United States can be effectively integrated in the peri-urban regions of India [23]. In the process, solid wastes sent to the Municipal Solid Waste (MSW) combustion facility are sorted and sent to combustion chambers. The heat produced by the confined and controlled burning is used to convert water to steam, which is then sent to the turbine generator to produce electricity. The ash residue produced in this stage is of two kinds - Fly Ash and Bottom ash. These consist of fine particles, and silica and other chemical residues respectively. The Fly Ash is treated using a flue gas cleaning system, and Bottom ash is sent to landfills. The toxic air (concentrated in carbon and other dense gases) produced in this process could be diverted into a carbon capture system to filter the air and obtain solid carbon to be stored in underground carbon storage facilities etc. Alternatively, it could be converted into liquid carbon solution that could be produced into crude synthetic carbon to be used as fuels - either 60 to 70% lesser atmospheric carbon emissions [24].

**(iv) Demand Supply Management (DSM) for Water Supply:** Water and energy crises are twin crises. Using Demand-Supply Management (DSM) methods for the water supply (industry and households) can help reduce energy demands in cities like Chennai [8,9,25]. Conventional approach to meet the growing water demands has been to install more desalination plants, increase groundwater extraction or transport water from faraway regions. This creates a surge in energy demand. Instead, we advocate alternate solutions to increase water supply. For example, Chennai receives an annual rainfall of 1352.7 mm, with the number of rainy days increasing significantly [26]. Implementing better rainwater harvesting methods would increase groundwater supply. Due to pollution and contamination, the water of the rivers flowing through the city remains a largely untapped and wasted water resource. Implementing stricter industry regulations and better waste-water treatment techniques can help curb contamination and recover rivers and abandoned lakes. Meeting local water needs significantly reduces energy demands for water transport and production.

## CONCLUSION

The peri-urban regions are the urban areas of the future and investing in the development of these regions is crucial. The paper suggests using smart solar-piezo street lights in the roadways and developing an intelligent auto-sprinkler based on rainwater harvesting. These technologies will be cost-effective, clean and energy-saving. The waste problem in the peri-urban areas can be tackled by energy production from combustion of solid waste as suggested in the paper. Demand-Supply Management techniques to manage water and energy can contribute to better utilization of local resources. The methods suggested in the paper are clean, sustainable and will help reduce carbon emissions as well as deal with energy crises.

## References


[1] Aijaz R. India's Peri-Urban Regions: The Need for Policy and the Challenges of Governance. ORF Issue Br 2019:1–12.

[2] Dhingra C, Gandhi S, Chaurey A, Agarwal PK. Access to clean energy services for the urban and peri-urban poor: a case-study of Delhi, India. Energy Sustain Dev 2008;12:49–55. https://doi.org/10.1016/S0973-0826(09)60007-7.

[3] ETSU. A Review of Energy Utilisation in Peri-urban Production Systems 1996.

[4] Birley MH, Lock K. Health And Peri-Urban Natural Resource Production. Environ Urban 1998;10:89–106. https://doi.org/10.1177/095624789801000120.
[5] Buragohain T. Impact of Solar Energy in Rural Development in India. Int J Environ Sci Dev 2012;3:0–4.
[6] A. S. Peri-urban interface of Indian cities: growth, governance and local initiatives. Econ Polit Wkly 2005;40:129–36.
[7] Hui R, Wescoat JL. Visualizing peri-urban and rurban water conditions in Pune district, Maharashtra, India. Geoforum 2019;102:255–66. https://doi.org/10.1016/j.geoforum.2018.01.008.
[8] Vishal Narain PB and PA. The Shadow of Urbanization:: The Periurban Interface of Five Indian Cities in Transition. East West Cent 2014;3:1–46.
[9] Murugesan A, Bavana N, Vijayakumar C, Vignesha D T. Drinking Water Supply And Demand Management In Chennai City-A Literature Survey. IJISET-International J Innov Sci Eng Technol 2015;2:715–28.
[10] CSO. Energy statistics 2019 (twenty sixth issue) 2019:1–123.
[11] How to design and calculate Solar Street Light system? n.d. https://www.engoplanet.com/single-post/2017/08/21/how-to-design-and-calculate-solar-street-light-system (accessed August 25, 2021).
[12] Bhairi MN, Kangle SS, Edake MS, Madgundi BS, Bhosale VB. Design and implementation of smart solar LED street light. Proc - Int Conf Trends Electron Informatics, ICEI 2017 2018;2018-Janua:509–12. https://doi.org/10.1109/ICOEI.2017.8300980.
[13] Anand H, Singh BK. Piezoelectric energy generation in India: An empirical investigation. Energy Harvest Syst 2021;6:69–76. https://doi.org/10.1515/ehs-2020-0002.
[14] Recharging groundwater acquifers. https://morth.nic.in/sites/default/files/circulars_document/Rain%20Water%20Harvesting%20and%20Artificial%20recharging%20along%20National%20Highways%20Standard%20Operating%20Procedure.%20on%203rd%20September%202019..pdf
[15] Active Water Harvest Calculations | Rainwater Harvesting n.d. http://039655e.netsolhost.com/WaterWise/rainwater_harvesting_calculator.html (accessed September 7, 2021).
[16] Taghvaeian S, Moss JQ. Oklahoma Cooperative Extension Service Malarie Gotcher Extension Associate. 2019.
[17] KSCST : Rainwater Harvesting from Roads, Parks & Layouts n.d. https://www.kscst.org.in/rwh_files/rwh_locate.html (accessed September 7, 2021).
[18] India: annual rainfall volume 2019 | Statista n.d. https://www.statista.com/statistics/834443/india-annual-rainfall-volume/ (accessed September 7, 2021).
[19] Goa University shows state how to harvest rainwater | India Water Portal n.d. https://www.indiawaterportal.org/articles/goa-university-leads-way (accessed September 7, 2021).
[20] CO2 Payoff of Extensive Green Roofs with Different Vegetation Species _ Enhanced Reader.pdf. 2019.
[21] Yang J, Yu Q, Gong P. Quantifying air pollution removal by green roofs in Chicago. Atmos Environ 2008;42:7266–73. https://doi.org/10.1016/j.atmosenv.2008.07.003.
[22] Haul Road | Environmental Protection Department n.d.

https://www.epd.gov.hk/epd/english/greenconstruction/poll_pro/haul_road.html (accessed September 7, 2021).

[23] Kaplan PO, Decarolis J, Thorneloe S. Is it better to burn or bury waste for clean electricity generation? Environ Sci Technol 2009;43:1711–7. https://doi.org/10.1021/ES802395E.

[24] Zhang Y, Lu X, Ji X. Carbon dioxide capture. 2019. https://doi.org/10.1002/9783527818488.ch15.

[25 Bavana N, Murugesan A, Vijayakumar C, Vignesha T. WATER SUPPLY AND DEMAND MANAGEMENT SYSTEM: A CASE STUDY OF CHENNAI METROPOLITAN CITY, TAMIL NADU, INDIA 2015;3.

[26] Climate Application and User Interface Group n.d. https://imdpune.gov.in/hydrology/rainfall variability page/rainfall trend.html (accessed August 25, 2021).