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The Role of 3R in Achieving Smart Cities: The Case of India

(Short Background Paper for Plenary Session 2 of the Programme)

Final Draft

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Short Background paper

on

The Role of 3R in Achieving Smart Cities: The Case of India

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Table of Contents

Contents

Table Of Contents	2
Summary/ Abstract.....	3
1. Introduction.....	4
1.a Waste.....	4
1.b Waste Scenario in India.....	5
2. 3R and 3R Status in India.....	6
3. Smart City	8
3.a Smart cities in India: Government of India Vision	9
3.b Essential Components of Indian Smart Cities	9
3.c Smart City with Zero Waste: Role of 3R	10
4. Suggestive Measures to Develop the Smart Cities	11
5. Conclusions	13
6. The Way Forward Section:	14
Acknowledgement.....	14
7. References.....	15

Summary/ Abstract

Adoption of the 3R policy is an initiative lately adopted by the Government of India in order to develop the smart cities in India. The importance of the 3Rs for the preservation and effective utilization of natural resources has been realized and acted upon by the government. Production from waste is one of the key focuses which can offer a multi-fold benefit of development, waste management and sustainability of environment. Smart City Mission by India is a significant step towards achieving growth and development while simultaneously countering the detrimental environmental effects of urbanization and population increase. High level infrastructure, technology and sustainability of the environment are the key attributes of a 'smart city'. Though there exists no robust definition for smart city, the Indian government is working towards the achievement of the smart cities with four pillars of comprehensive development – institutional, physical, social and economic infrastructure. India being a diversified country, poses a difficult target for the development of smart cities, due to the unavailability of a universal indicator to measure the level of smartness in the Indian cities. The Government of India is undertaking a modified approach compared to the worldwide approach towards building of smart cities due to diversified geographical and population distribution along with the available natural resources. The government has proposed the Area-based development which includes retrofitting, redevelopment, Greenfield development and Pan-city initiative as the strategic components. This report includes an interesting approach including the 3R policy towards the achievement of the Indian smart cities, mentioned as the 'Thirty key Smart Goals', which covers the near achievement of smart cities with sustainable development. The document focuses on how the integration of the 3R strategy, alternative energy and the Smart City Mission can offer a great pathway for the creation of a smarter and greener India.

1. Introduction

The world's cities occupy just 3 per cent of the Earth's land, but account for 60-80 per cent of energy consumption and 75 per cent of carbon emissions. We live in a world where one in five people still lacks access to modern electricity and three billion people rely on coal, wood, charcoal or animal waste for cooking and heating. Thus, energy is the dominant contributor to climate change, accounting for around 60 per cent of total global greenhouse gas emissions [1]. India also, as part of the urbanization is not much far behind in this aspect of environmental degradation. The widespread urbanization along with the population increase eventually has led to high energy demands. Currently most of our energy demands are satisfied by fossil fuels. Although it's hard to say that we could actually run out of these buried treasures, but with the current trend of fossil fuel consumption, the environment is sure going to be devoid of fresh air or palatable water. One cannot simply ignore the deteriorating condition of the environment in India. It's not just the demands that have increased; there has been tremendous pressure on land, water and air due to the huge waste generation in India. The right thing to do at this hour would be to utilize what is generated as waste in order to meet the ever increasing energy demand, while reducing the burden on our planet's atmosphere. Urban population is expected to rise from 54% in 2014 to 66% in 2050[2], which will further lead to immense stress on city services and infrastructure. Reduction of waste can be initiated by green production and sustainable consumption. We need to explore the waste utilization opportunities for energy production or as feedstock for other commercially and domestically useful products.

To overcome the present crisis of waste accumulation leading to adverse environmental effects, there has been immense work going on for the conversion of wastes to energy (WtE), chemicals and a host of other useful substances. Also, those wastes for which there is a lack of apt technology to valorise it, have been researched upon, such that their disposal doesn't add to the GHG problems or cause other environmental pollution.

In order to meet with the problems of environmental deterioration caused by fossil fuel consumption, while simultaneously competing with the world for high class infrastructure and technology, the Indian Government has started a Smart City Mission which aspires to give a decent life to the Indian citizens.

This article focuses on the current 3R status of India, its role in the establishment of Indian Smart Cities and suggestive alternative energy pathways in order to build Smart Cities with minimum environmental degradation, i.e., a 'Green Approach to Building of Smart Cities by including PPP (Public Private Partnerships)', which would prove to be a beneficial approach.

1.a Waste

As, per the current scenario, wastes are substances that uphold the potential to be converted to useful commodities by means of processing. This is different from the dictionary definition of waste which would be an unwanted or useless substance. But seeing the current scenarios, most wastes can neither be classified as useless nor as unwanted. Based on their sources, wastes can be categorized as municipal solid waste, biomedical waste, nuclear waste, E-waste, industrial waste and agricultural wastes. Among these, it is the municipal solid waste (MSW) and agricultural waste that hold a great potential for producing bioenergy in India [3-4].

Table 1. Classification of wastes

Classification of Wastes	
• Based on Nature	Solid, liquid and gas
• Based on Sources	Municipal or urban waste, Industrial wastes, agricultural waste, E-waste, Nuclear waste, Biomedical waste and others.
• Based on Properties	Biodegradable /organic wastes and Non-biodegradable/inorganic wastes
• Based on potential risks	Hazardous and Non-hazardous

Apart from the classification mentioned in Table 1, an important classification of wastes, based on the available treatment processes, is recyclable and non-recyclable wastes.

Recyclable wastes include all those substances that are capable of undergoing appropriate processing in order to be used for its originally intended or different purpose. These include many constituents of the municipal solid waste. A recyclable property of waste is something that has to be completely exploited in order to obtain a greener planet. **Non-Recyclable wastes** include those substance that are unfit to be used as it is or as processed goods, due to absence or lack of suitable technology.

Before handling the waste, it is absolutely important to know the risk associated with the particular waste. For instance the nuclear waste is a kind which needs to be handled with care and is classified under the hazardous wastes. Hazardous wastes are considered dangerous and can cause potential harm to our health or environment. Some industrial solvents waste, some biomedical wastes, pesticide wastes etc are all included in hazardous wastes.

1.b Waste Scenario in India

As per the World Bank database, the current global MSW that is being generated is approx. 1.3 billion tonnes per year which is expected to increase to approx. 2.2 billion tonnes per year by 2025. With about 62 million tonnes of garbage being generated by the 377 million people living in urban India, India is the one of the largest generator of garbage [5]. Out of this figure, a large amount of waste is discarded in an unsatisfactory manner. In addition to this, India being an agricultural country, several tonnes of agro wastes is produced in India every year, most of the excess after being used as fodder, is burnt by the farmers or simply discarded due to lack of available technology to utilize the enormous potential of the lignocellulosic biomass; biomass is an organic matter derived from the living organisms or their by-products. All of this negligence leaves us with a deteriorating effect on the environment, health, aesthetics and wastage of the useful wastes.

Solid waste management is one of the most basic facilities provided by the municipal corporation of India. But, it is one area which is neglected and poorly handled to a large extent. Figure.2 gives a view of the basic waste management hierarchy. The hierarchy of waste management is a concept that gives us the flow from the most desirable to the most avoidable mode of waste handling. It points to the promotion of waste avoidance over waste disposal into landfills [6]. The hierarchy consisting of the '6Rs', starts with landfill disposal, which is the least desirable option that should be resorted only if no other method of waste management is applicable to the substance to be discarded. Then comes recovery, which includes both, energy recovery from waste to be used for electricity or as heat and also

recovery of other useful substances before the waste can be disposed into landfills or other by other methods. Then comes the 3R, which is basically considered a subset of the Waste management hierarchy. The top most position in the hierarchy is occupied by 'Prevention' which always remains the most desirable management method, but difficult to obtain because of the rapid urbanization and population increase.

2. 3R and 3R Status in India

Waste remains one of the greatest hurdles in achieving a decent, healthy and sustainable environment. One of the old, but high potential solutions to this waste menace is the incorporation of the 3Rs, i.e. Reduce, Reuse and Recycle. It's been quite some time since several countries around the globe have included the 3Rs into their national policies. The 3Rs adopt an integrated network of waste generation, collection, processing and manufacture. The ultimate outcome of the 3Rs will be reduction in the amount of wastes being generated and maximal use of the waste from various sources, so as to mineralize the burden on Earth's environment.



Fig.1. Waste management hierarchy [7]

- i. **Reduce:** Waste minimization is an elimination process in which the amount of waste produced in society is reduced, eliminating the generation of harmful and persistent wastes, thus supporting the efforts to promote a more sustainable society. One of the most effective ways to manage waste is to avoid its generation.
- ii. **Reuse:** It not only brings down the amount of waste generated, but it also leads to decrease in the further production of goods, which in turn leads to decrease in the burden on natural resources.
- iii. **Recycle:** Recycling is the conversion of waste materials into reusable products including heat and energy, which creates scope for production and consumption

with reduced burden on our natural resources. It reduces the environmental degradation caused due to waste generation and disposal. Recyclable materials include aluminium, batteries, concrete/demolition waste, glass, other metals, paper, PET, other plastics and electronic wastes.

Providing a sustainable environment and sanitation including solid waste management are included in the two of the core infrastructure elements in the Smart Cities Mission. The 3Rs thus can be a great approach towards attaining these goals. For effective implementation of the 3Rs, there has to be enhanced communication between several sectors involved in waste generation, collection, processing and the manufacturing sector. This can be achieved by integration of a widespread IT network which can be handy in effective operation of collecting the segregated waste, transport of waste to the processing plant and then further transport from the processing plant to the manufacturing industries. In order to serve the cause for sustainability, we can think of having collaboration with the municipal corporation and various industries with bio-refineries that can further valorize the waste.

As far as the Reduce and Reuse aspect of the 3Rs is considered it has to be given the head start by changing policies for the manufacturing industries. Apart from this there has to be increased awareness to implement these practices at the household levels. The Ministry of Urban Development's prescience of the National Urban Sanitation Policy (NUSP) states that 'All Indian cities and towns would be totally sanitized, healthy and inhabitable and ensure and sustain good public health and environmental outcomes for all citizens with a special focus on hygiene and inexpensive sanitation facilities for the urban poor and women [8].

With the support of the Municipal Solid Waste (Management & Handling) Rules, 2016 of the Ministry of Environment & Forest, the Ministry of Urban Development aims to guide all the urban areas in the country towards Sustainable Municipal Solid Waste Management, adopting the features of waste minimization at source with an emphasis on the 3R principles of reduce, reuse and recycle; with proper systems of segregation, collection, transportation, processing, treatment and disposal in complete harmony with the environment, thereby leading to the achievement of the aim of NUSP. The policies under NUSP, the National Environmental Policy, Swachh Bharat Mission along with the Waste Management and handling rules for different types of wastes, all favor the 3R concept. Apart from the Government policies and projects, there are several non-governmental organizations like, the Indian Pollution Control Board (Garbage Recycling Program) that are working towards achieving the goals of the 3Rs [9].

In order to give a push to MSW Management in cities, Government of India has sanctioned the 12th and 13th Finance Commission Grants and funds were also allocated for improvement of MSWM under flagship projects like JnNURM, UIDSSMT from 2005 onwards. Funds for MSWM projects are also available from State Government funds. Many Urban Local Bodies (ULBs) have put in place systems of door to door collection, transportation, treatment and a safe disposal of waste. However, despite encouraging pilots and achievements, most ULBs continue to face challenges not only in the areas of appropriate and/ advanced collection & transportation systems, technology selection and disposal methods but also in sustainable financial management of MSWM [9]. As there has been a revision of the waste management rules after 16years (Management and Handling Rules,

2016), there is a wide scope for India to achieve the desired sustainability within coming 15-20 years.

The major challenges which are holding India back from a greener future are given in Figure.3. In spite of such high value objectives on document, India has a long way to go when it comes to efficient waste management.

3. Smart City

Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically. However, many challenges exist to maintaining cities in a way that continues to create jobs and prosperity while not straining land and resources. Common urban challenges include congestion, lack of funds to provide basic services, a shortage of adequate housing and declining infrastructure. The challenges cities face can be overcome in ways that allow them to continue to thrive and grow, while improving resource use and reducing pollution and poverty. The future we want includes cities of opportunities for all, with access to basic services, energy, housing, transportation and more (UN Sustainable Development Goal No. 11). A smart city can be vaguely, defined as an urban area with excellent infrastructure and a highly developed information technology, to provide a decent quality of life and a healthy, clean and sustainable environment to its citizens. It won't be wrong to, say that there is no unique and robust definition to it, as the conceptualization of Smart City can be totally different, but interrelated depending on the level of development, willingness to change and reform, resources and aspirations of the residents of the city.

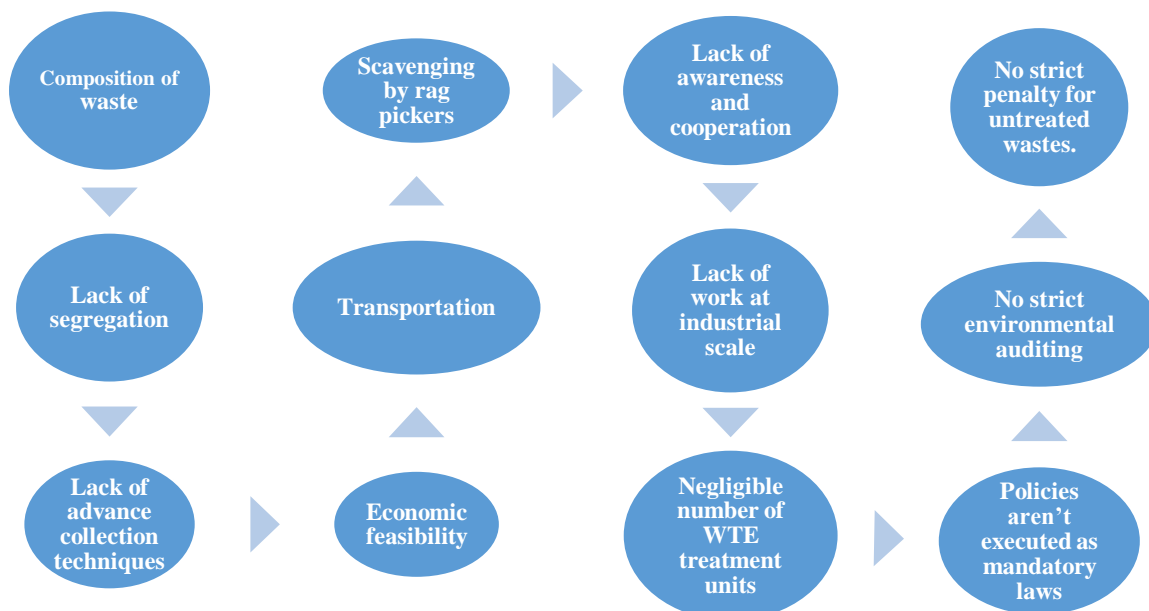


Fig.2. Waste management areas in India to be acted upon

3.a. Smart cities in India: Government of India Vision

A smart city would have a different connotation in different countries. But, when it comes to an Indian smart city, it can be defined as a city with a well established infrastructure, technology, accessibility, and resource availability that could match with the cities in the developed nations. In addition to the above mentioned key points, one of the major objectives of an Indian smart city would be to provide a safe, hygienic and decent life to the Indian citizens by exhibiting sustainable environmental practices. Apart from this, as mentioned in the guidelines of the Smart City Mission in India, in the visualization of any city dweller in India, the picture of a smart city contains a wish list of services and infrastructure which describes his or her level of ambition. To provide for the aspirations and needs of the citizens, urban planners ideally aim to develop the entire urban eco-system, which is represented by the four pillars of comprehensive development-institutional, social, physical and economic infrastructure. This can be a long term goal and cities can work towards developing such extensive infrastructure incrementally, adding on layers of 'smartness' [4].

Smart Cities Mission is an urban renewal and retrofitting program by the Government of India with a mission to develop 100 cities all over the country making them citizen friendly and sustainable. In the approach of the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart Solutions'. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities. The Smart Cities Mission of the Government is a bold, new initiative. It is meant to set examples that can be replicated both within and outside the Smart City, catalyzing the creation of similar Smart Cities in various regions and parts of the country [10].

3.b. Essential Components of Indian Smart Cities

As mentioned in the Smart City Mission guidelines, the major components include, assured electricity supply, sanitation, including solid waste management, efficient urban mobility and public transport, affordable housing, especially for the poor, robust IT connectivity and digitalization, good governance, especially e-Governance and citizen participation, sustainable environment, safety and security of citizens, particularly women, children and the elderly, and health and education. Seeking expertise from different sectors, the government presents 'Smart Solution' to achieving the above mentioned objectives which is included in Figure.3[10].



Fig.3 Smart Solutions As per the guidelines in Smart City Mission [9]

3.c. Smart City with Zero Waste: Role of 3R

As mentioned in the UN 2030 Agenda for Sustainable Development, about 828 million people live in slums today and the number keeps on rising

Even though a mere 3% of the total land on Earth is occupied by the cities, as mentioned earlier the cities account for three-fourth of the total world carbon emissions and also form the major segment of energy consumption(60-80%)[1]. Although urbanization leads to efficiency gains and technological innovations, as already mentioned, it also leads to immense pressure on fresh water supplies, sewage, the living environment, and public health. Hence there is a requirement for smart cities that would make a sustainable use of the natural resources [1].

The 3R based Smart City approach provides a straightforward approach toward achieving a 3-fold benefit:

- Efficient Waste Management; no city can be smart without smart waste management
- Sustainability of environment; the main aim of smart city is the comfort of its citizens, which comes with a healthy and sustainable environment.
- Circular Economy; no waste produced should be actually wasted as with apt technology every waste can be a useful commodity.

4. Suggestive Measures to Develop the Smart Cities

The Government of India has laid out certain strategies for area based development under the Smart City Mission [10], which can be summarised as follows:

- **Retrofitting** will introduce planning in an existing built-up area to achieve Smart City objectives, along with other objectives, to make the existing area more efficient and liveable. In retrofitting, an area consisting of more than 500 acres will be identified by the city in consultation with citizens. Depending on the existing level of infrastructure services in the identified area and the vision of the residents, the cities will prepare a strategy to become smart. Since existing structures are largely to remain intact in this model, it is expected that more intensive infrastructure service levels and a large number of smart applications will be packed into the retrofitted Smart City. This strategy may also be completed in a shorter time frame, leading to its replication in another part of the city.
- **Redevelopment** will effect a replacement of the existing built-up environment and enable co-creation of a new layout with enhanced infrastructure using mixed land use and increased density. Redevelopment envisages an area of more than 50 acres, identified by Urban Local Bodies (ULBs) in consultation with citizens. For instance, a new layout plan of the identified area will be prepared with mixed land-use, higher FSI and high ground coverage. Two examples of the redevelopment model are the Saifee Burhani Upliftment Project in Mumbai (also called the Bhandi Bazaar Project) and the redevelopment of East Kidwai Nagar in New Delhi being undertaken by the National Building Construction Corporation.
- **Greenfield development** will introduce most of the Smart Solutions in a previously vacant area (more than 250 acres) using innovative planning, plan financing and plan implementation tools (e.g. land pooling/ land reconstitution) with provision for affordable housing, especially for the poor. Greenfield developments are required around cities in order to address the needs of the expanding population. One well known example is the GIFT City in Gujarat. Unlike retrofitting and redevelopment, greenfield developments could be located either within the limits of the ULB or within the limits of the local Urban Development Authority (UDA).
- **Pan-city development** envisages application of selected Smart Solutions to the existing city-wide infrastructure. Application of Smart Solutions will involve the use of technology, information and data to make infrastructure and services better. For example, applying Smart Solutions in the transport sector (intelligent traffic management system) and reducing average commute time or cost to citizens will have positive effects on productivity and quality of life of citizens. Another example can be waste water recycling and smart metering which can make a substantial contribution to better water management in the city.

There has been immense work going on by both the government and the science sector, in order to achieve a greener India. Some of the plenty measures can be seen in Mumbai, Surat.

By implementing PPP (Public Private Partnership) for waste collection and dividing the city into 52 sanitary wards, Surat is now seen as one of the cleanest India Cities[11]. Similarly Mumbai’s Slum Sanitation Program was a great success. These agenda have to be similarly set for the other cities in order to reach the expected standard of living[12].

It would be only helpful to also follow the models proposed in other places of the world in order to achieve their respective smart city objectives. Those models can be studied and acted upon to the appropriate Indian context. Some such replicable cases have been mentioned below:

Barcelona (Spain) is one of the high ranked cities when it comes to Smart Cities. The Solar Thermal Ordinance was issued in 1999, making it a compulsory requirement for new buildings and rehabilitated buildings to use solar energy systems for hot water supply. Targets for the ordinance included private and public buildings [13].

Los Angeles Adaptive Reuse program, 1991 is one measure towards building of smart cities, whereby old unused or energy demanding buildings were adaptively reused, instead of entire demolition and starting from scratch process to build newer energy efficient buildings. This was successful because of the PPP initiatives [14]. New York is yet another Smart City whose model for use of smart data modeling techniques to analyze traffic patterns and pollution status can be replicated in India [15]. Curitiba in Brazil offers a great example for promotion of recycling through the programme “Garbage that is not Garbage” aligned with “Green Exchange” programme that buys the garbage that targets both social and environmental purposes at the same time. Garbage classification and recycling system includes the homeless and the rehab [16].

Bangkok is another city whose initiatives hold a great significance in the Indian context. Slum management is one of the essential needs for development of Indian Smart Cities. The Bangkok government effectively involved the slum inhabitants in setting up well manage households, i.e., the citizens were themselves involved in order to build them a smarter city [17].

When it comes to India, there exist several key issues that have to be taken care of in order to achieve a smart city as per the Indian Scenario. From the observations of the current status in India and global scenario of smart cities, the following thirty key smart goals (Figure.5) can be considered as a stepping stone and could pave a straight way to create the smart cities in India.

Table.2 Thirty key Smart Goals

S. No.	Smart Goals Including The 3R Policy
1	Proper communication and management between the municipal authorities and other institutions involved in the waste management.
2	Establishment of a full proof plan addressing all the requirements in a Smart City.
3	Encouragement of Public-Private Partnership.
4	Coming to an agreement between the existing situation in the city and the ideal smart city perspective.
5	Quick and economically feasible actions and measures.
6	Overcome the technological constraints.

7	Availability of proper financing for smart cities.
8	Surveillance for city cleanliness, waste management etc.
9	Improved accessibility to resources and technology.
10	Congestion of system and networks to be effectively addressed.
11	Intelligent energy management solution for building of smart city infrastructure and also for waste management.
12	Affordable, equitable and environmentally sustainable access to alternative energy.
13	Brainstorming of solutions based on existing data.
14	Seeking solutions from technology companies to address the various challenges.
15	Minimum emission from industries and other infrastructures currently present, as well as the future establishments.
16	Use of sensors and computer networks to monitor the smart city pollution, traffic etc.
17	Energy auditing in each and every sector.
18	More sewage treatment plants.
19	Better handling of biomedical and hazardous waste (example. Plasma pyrolysis).
20	Integration of co-processing and waste treatment.
21	Circular economy model rather than the linear mode of, 'Take, Make and Dispose'.
22	Meeting of the 2030 Agenda for sustainable development.
23	Capacity building of officials of State Govt. and ULBs in 3 critical areas of urban rejuvenation (as per NITI Aayog), i.e., (1) Urban Planning and Governance, (2) Water, Wastewater and Solid Waste Management and (3) Public Financing of Urban Infrastructure [18].
24	Work based on the Singapore Model, for water management.
25	Rain water harvesting on a city level(already being planned in Bengaluru).
26	Bioenergy to be given a special status. Lignocellulosic wastes to be effectively utilized as biomass for energy production. More biogas plants to be installed.
27	Solar Energy Utilization to be given importance in all the infrastructures. Green buildings to be made mandatory wherever possible.
28	Smart city should be covered with solar street lights, replacing the conventional ones, particularly, in cities with good insolation. Increased use of solar vehicles, solar paint and solar distillation to be incorporated in suitable industries.
29	Wind energy to be exploited in appropriate places.
30	Make the 3R policy an important component of the Smart City Mission.

5. Conclusions

We need to focus on accelerating the connected, interactive and data driven solutions in advanced waste management, waste treatment, environmental protection, energy and mobility that addresses the unmet needs in urban areas in India, by seeking solutions from the developed technologies through physical and through digital connectivity. There has to be encouragement for the Public-Private Partnerships in meeting the objectives of achieving a smart city.

A smart city has to provide a safe and more efficient place to live and work, with minimum impact on the environment. Intelligent energy management solutions should be adopted in the development of Smart city infrastructure and buildings with the objective to increase the use of the produced solar energy. A collaborative work involving the 3R strategy, alternative energy and the Smart City Mission, can thus prove to be a great venture in India. The

coordinated efforts along with the specific indicators can contribute to achieve the sustainable development goals (SDG no.11) by creating smart cities.

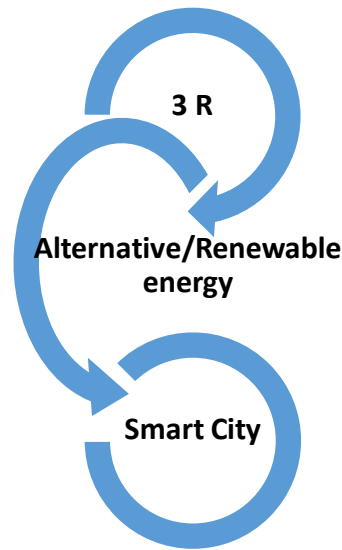


Fig 4An illustration for the integration of 3R, alternative energy and Smart City

Make 3R an integral part of the Smart City Mission in order to obtain cities with ‘zero waste’. In addition, we have to give a head start to the alternative/renewable sources of energy to meet the ever increasing energy demands, while causing minimum damage to the environment. Bioenergy, solar energy, hydrothermal, geo-thermal energy, wind energy etc. have great potential to be exploited in India because of the surplus availability of the respective resources. The only area to work upon would be the development of suitable technology in order to make the entire alternative energy process more accessible, economically feasible and competitive when compared with the conventional coal based energy.

6. The Way Forward Section:

Whether the Universal Indicators are possible for proposed smart cities in India?

Whether the 3R policy will be common or variable with respect to cities located in different locations?

What are the short, medium and long terms goals to achieve the objectives of 2030 Agenda as per SD Goal number 11?

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