INTEGRATED APPROACH FOR FUTURE SUSTAINABLE URBANISATION

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ABSTRACT

Maharashtra's urban communities are facing demographic, cultural and environmental challenges typical of many other urban communities across India. Increasing population, pressure on infrastructure, increase in migration and changes in social habits has affected many cities of Maharashtra; this change has been accompanied with stigma and neglect, all representative of the relative inflexibility of the urban form. A research study is conducted on sustainable community design and ideal residential housing from a global perspective in order to accumulate new insights and technical expertise that can be utilised in developing future urban settlements of Maharashtra.

The purpose of the study is to create a flexible set of guidelines that account for variability. It allows users to determine intervention points through condition resolution. This study illustrates how stated explicit infrastructure objectives can be translated into design interventions in a variety of conditions and multiple scales. In addition to outlining techniques and intervention points, the study also includes few permutations of how these techniques could be synthesised and employed at the neighbourhood scale.

As part of our overall approach to the study, following principles for design, planning, and development of urban communities are addressed in the study; Integrated infrastructure system, Energy efficiency, Waste water management, Balanced habitat, Sustainable community, etc.

Keywords: *Ecological; Energy Efficiency; Future Urban Communities Sustainable; Integrated Infrastructure Systems.*

1. INTRODUCTION

Maharashtra, a state that covers an area of 307,713 Sq.km i.e. 9.84% of the total geographical area of India, is the third most urbanised state with 45.23% among other major Indian states like Tamil Nadu (48.45%) and Kerala (47.72%) as per 2011 Census of India. Urbanisation is an integral part of economic development. Most modern economic activity takes place in cities, and growth in productivity and income is easier in an urban context. Economic growth influences the urbanisation while urbanisation in turn affects the rate of economic growth (Census, 2011). In many parts of the world, urbanisation is accelerated as a new global economy that is increasingly changing the face of our planet. Managing urban growth has become difficult and complex, leading to one of the most important challenges of the 21st Century (Cohen, 2003).

As the urban population and incomes increase, demand for every key service such as water, transportation, sewage treatment, low income housing will increase five- to sevenfold in cities of every size and shape. And if India continues on its current path, urban infrastructure will fall woefully short of what is necessary to sustain prosperous cities (Mckinsey Global Institute, 2010).

The next few decades will be critical in shaping the urban infrastructure in India as investments flow to cities for expanding their infrastructure networks. India faces a unique challenge of closing the deficit in urban infrastructure and services, while at the same time making a transition to a more sustainable path. However, this deficit may well be a boon in disguise, as it could serve as an opportunity to leapfrog to more sustainable, less energy and resource-intensive forms of infrastructure (Wankhade, 2012).

Understanding the above facts and observations, it becomes necessary for Indian states and cities to develop and adopt innovative methods and technologies that can address the future issues of highly

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urbanised states. This study is attempting towards evaluating the potential of adopting some innovative techniques at the neighbourhood level that can be multiplied to city level and further to the states of India.

2. PROBLEM IDENTIFICATION

Today looking at the state of living conditions in various Indian cities and the different processes that take place in rapidly urbanising cities are causing problems for the natural environment, social and economical conditions of humans, both locally and globally. This problem needs to be addressed by proposing innovative and sustainable solutions. The question is how? How are we going to address these issues on an urban scale to make our cities more sustainable and energy efficient?

3. RESEARCH QUESTION

The most fundamental question that comes to our minds is how can cities be redesigned to make them more diverse, flexible and energy efficient? This further leads to specific research questions such as;

- What are different energy efficient tools of urban designing that can address the issues of water and waste water management of future cities?
- What are alternate and innovative ways to address future energy demands of ever growing cities of India?
- Can systems like biogas plants be used on a larger scale to meet the energy demands?
- Can we integrate various innovative techniques, methods, systems or processes that can be developed into a module at unit level which can be multiplied at neighbourhood level and further can be multiplied at city level to address some issues of future urbanisation?

The exercise would aim at addressing the above mentioned research questions and derive an integrated module for a sample study area.

4. METHODOLOGY

In order to explore different innovative techniques of sustainability for future cities of India, I have considered a sample neighbourhood in a city of Pune, Maharashtra. The approach would be to address the issues at the neighbourhood level, which can be further implemented at city level. The idea is to find the actual implementation of these techniques in an existing city which is rapidly urbanising. The tools used for analysis are simple maps (Map Source: Google Earth) and industry standards with its mathematical evaluation. Following are the sustainability concepts that are tested in the study:

- Grey water management
- Urban bio gas generation system
- Solar farms
- Urban integrated infrastructure system

Figure 1 shows the demarcated neighbourhood in Pune approximately 600,000m^2 area or 0.6 km^2 as a study area.

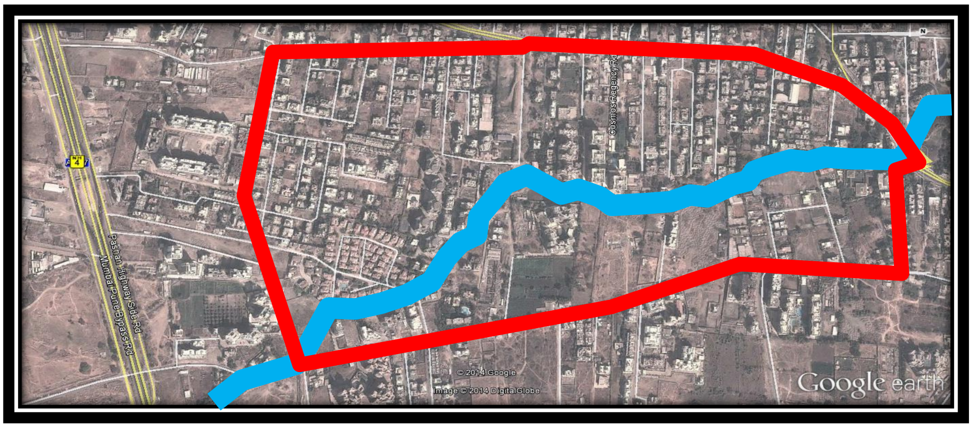


Figure 1: Study Area Demarcation
Map Source: Google Earth

5. GREY WATER MANAGEMENT

Grey water is also known as sullage. It is the wastewater generated from dish washing, laundry, sinks and bathing, for example. It consists of all of the water waste of a household with the exception of toilet water which is called black water (Ecolife, 2011). Fundamentally, the re-use of grey water requires a re-thinking of how we build today. The work begins within the building, separating the grey water from the sewer lines. This may seem like a design problem, but it is also an infrastructural problem. Once separated from the sewage system grey water can be treated naturally or through treatment and can be integrated into gardens, parks and natural habitats (Reschke, 2014).

In the sample neighbourhood shown above in the Figure1, from primary survey we have found that there is a mix of high density and low density developments which have large open spaces in between. Despite the area of green spaces there is a distinct disconnect between the human living environment and the natural. The use of grey water not only nourishes the environment, but enhances the community spaces. By separating grey water and strategically exposing grey water piping at designing interventions, the community can enjoy the sights of the natural environment in the neighbourhood.

5.1. GREY WATER GENERATION

Figure 2 shows the grey water intervention in the sample area. The demarcated area has around 5000 inhabitants, i.e. approximately 1250 households (Pune city sanitation Plan, 2012). As per the standard UDPFI (Urban Development Plans Formulation and Implementation, 1996) guidelines water consumption for domestic use is 200 lpcd (Litres per capita per day) and out of this 80 percent water will generate as sewerage water i.e. grey water and black water together. Out of 80% most of the water is grey water accounting to 57.6 percent that makes the total grey water generated per person per day equals to approximately 92 litres (Pune city sanitation Plan, 2012).

Therefore, in above given Figure 2, total grey water generated would be 460000 litres per day and in a year it would be equal to 16.79 million litres, i.e. a very large quantity of water that goes as waste from a very small area as demarcated in the sample Figure One can evaluate how much water is generated as grey water by the entire population of a city. Out of this 50 percent can be treated and reused further through very simple treatment units because it doesn’t contain any sewage accounting total grey water to 8.39 million litres annually (Reschke, 2014).

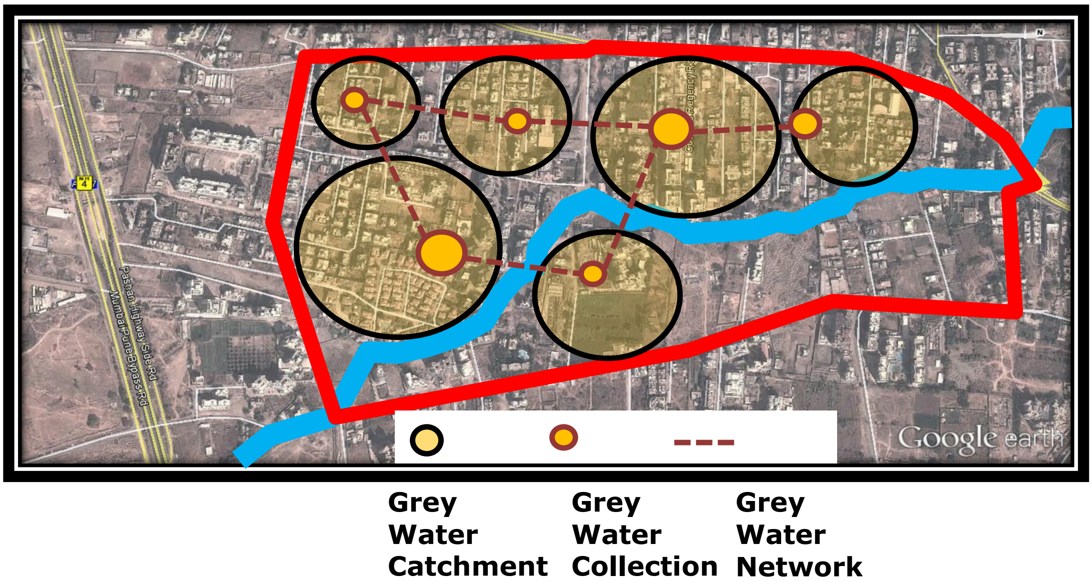


Figure 2: Grey Water Management
Map Source: Google Earth

5.2. GREY WATER USE

The Figure 2 shows the catchment, collection and network of grey water. This network is developed on the basis of available vacant plots and the distance from households forming a cluster. There is a scope for developing more precise network based on slope, collection capacity, soil strata, etc. This collected grey water can further be treated at neighbourhood treatment plant for reusing. After a little treatment the grey water can be primarily used for flushing our toilets. Everyday an average household flushes 280 litres of clean, treated water that can be easily replaced by the grey water. So the grey water generated from the above sample area can suffice the need of 832 households for flushing their toilets (Pune city sanitation Plan, 2012. Refer UDPFI Guidelines, 1996). The quantity generated by grey water is so large that it can be further integrated and used for certain industries too.

5.3. GREY WATER INTERVENTION

The above typology of grey water intervention shows how grey water can be integrated from households to a neighbourhood network. High density and building forms allow for the use of grey water for semi-private spaces; i.e. roof gardens and central courtyards. It can provide amenities of healthy lifestyle, reduce energy waste by maintaining cooler building temperatures, promote communal ownership and care for green spaces, demonstrate communal patterns of water usage and collective ecological footprint, may lead to ecologically competitive districts further benefiting the environment.

6. URBAN BIO-GAS GENERATION AND MANAGEMENT

Energy is the key input for socio-economic development of any Nation. The fast industrialisation and rapid urbanisation besides mechanized farming have generated a high demand of energy in all forms i.e. thermal, mechanical and electrical. The over exploitations of fossil fuels have been posing serious environmental problems such as global warming and climate change. While we have shortage of energy and more dependent on imports in case of petroleum, we are fortunate enough to be blessed with plenty of natural sources of energy such as solar, wind, biomass, etc. Biogas production is a clean low carbon technology for efficient management and conversion of organic wastes into clean renewable biogas and organic manure / fertiliser. It has the potential for leveraging sustainable livelihood development as well as tackling local and global land, air and water pollution (Ministry of New and Renewable Energy Report, 2011). The biogas solution integrates community level black water collection and processing for the production of biogas. Research conducted by Department of Civil Engineering, Punjab

Agricultural University shows that the sewage waste of approximately 15 persons (or nearly 4 families) could produce enough biogas to fuel the cooking needs of one conventional family.

6.1. BIO-GAS GENERATION

Table 1: Biogas Capacity

Capacity of Biogas Plant (cu.m)	No. of persons may be served	Quantity of Night soil (Kg)	No. of Persons
1	2-3	25	10-15
2	4-6	50	20-25
3	7-9	75	30-35
4	9-12	100	40-45
5	12-15	125	45-50
6	14-17	150	50-60

Source: Department of Civil Engineering, Punjab Agricultural University

The collection and processing systems of a biogas plant can be installed beneath the landscape in an array of density settings. The plot represented below appears on sample site, in various but similar forms, and is well-suited to this form of energy production.

6.2. BIO-GAS NETWORK AND USE

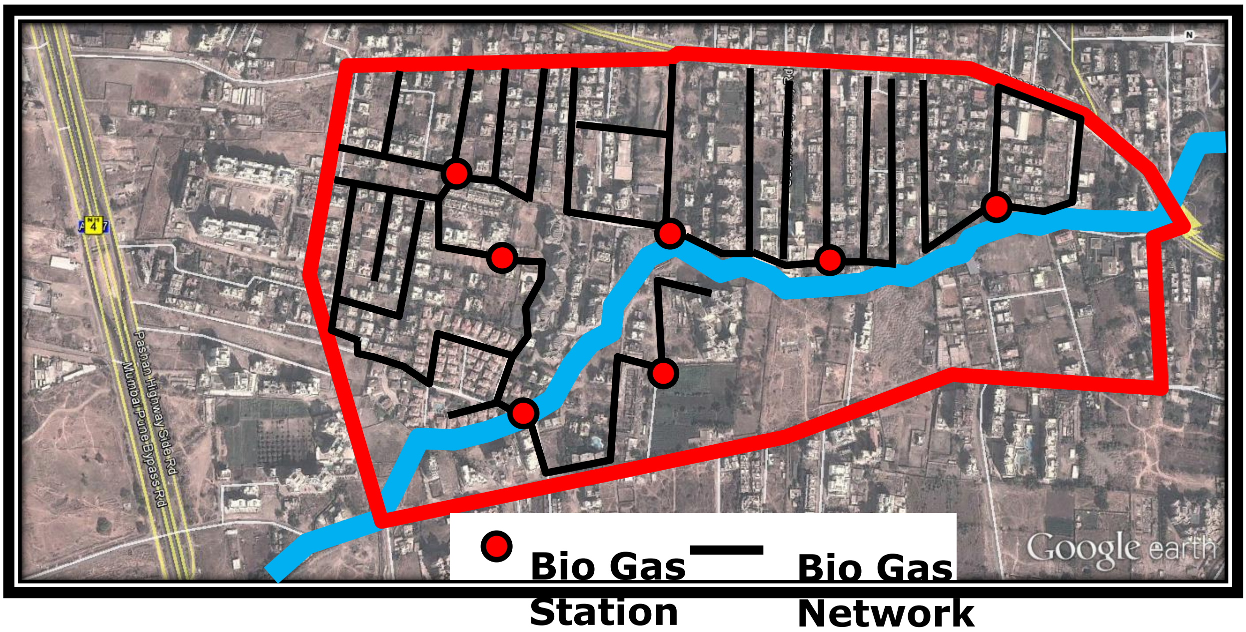


Figure 3: Bio Gas Network
Map Source: Google Earth

Referring to Table 1, for the demarcated sample area and for the population of 5000 (Pune City Sanitation Plan, 2012), we can develop many community level bio gas plants as shown in the Figure 3 totalling to the capacity of 600m^3. i.e. 1500 people can be served with their energy needs. The network shown in the Figure is approximate based on residing population in the study area, it will vary as per the living conditions, type of land use, waste generated etc.

7. SOLAR FARMS

The Shri Sai Baba Sansthan Trust at Shirdi in Nasik District of Maharashtra has world's largest solar steam system. The system is used to cook 50,000 meals per day for pilgrims visiting the shrine, resulting in annual savings of 100,000 kg of cooking gas and has been designed to generate steam for cooking even in the absence of electricity to run the feed water pump for circulating water in the system. The project to install and commission the system was completed in seven months and the system has a design life of 25 years. It is just 180 km from Pune, Maharashtra (Sasikumar and Jayasubramaniam, 2013).

7.1. SOLAR ENERGY AVAILABILITY

As per the Energy Resources Institute (TERI), Maharashtra has a relatively medium range of solar radiation. It is apparent from the map below that the western states have the highest levels of solar radiation, but Maharashtra ranges between 5.4-5.8 kWh/m^2 of the area.

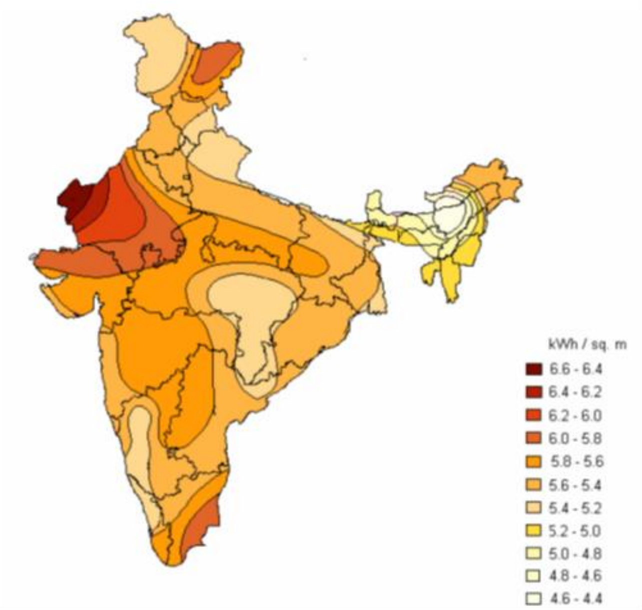
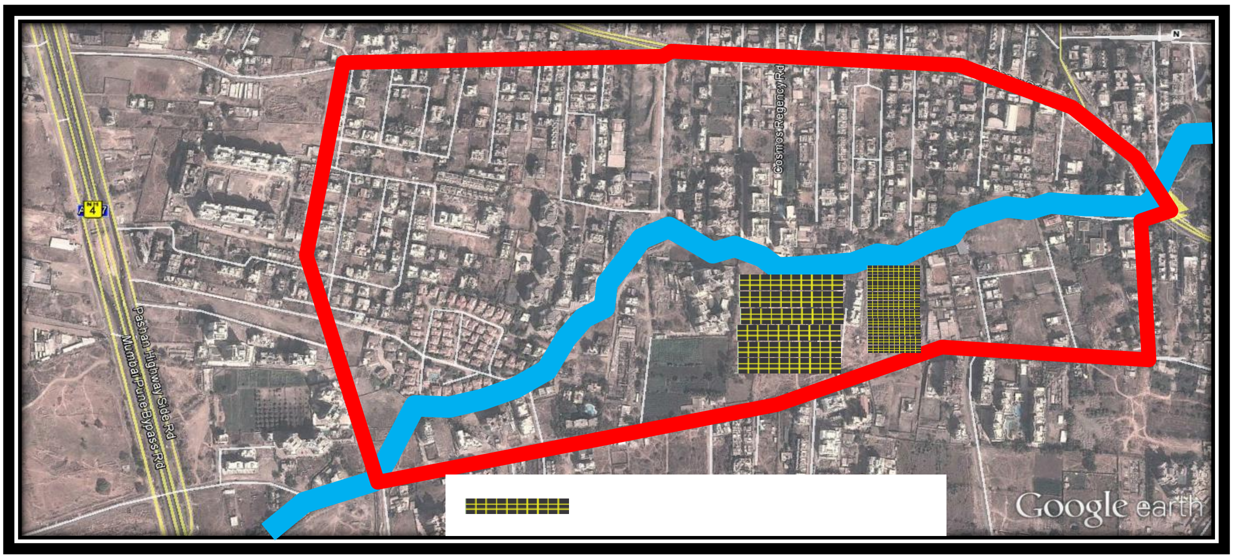


Figure 4: Solar Radiation on India
Source: TERI

Establishing solar farms adjacent to the neighbourhoods or towns they serve, and given adequate sun exposure, can often provide enough electric energy to power a small community. Depending on the size of the farm, excess energy can be sold back to utilities creating shared income for community members. Another benefit of sun farms is that they are highly adaptable to landscape. They can be built on flat sites or into sloped topography. Still, it is important that the photovoltaic panels face south in order to maximise solar gain.

7.2. USE OF SOLAR FARMS



Solar Farm Panels facing South

Figure 5: Solar Farms
Map Source: Google Earth

Solar farms that utilise topography and open space liberate community members from having to install photovoltaic panels on their individual homes, thereby alleviating individual maintenance responsibilities. In above shown Figure 6, in a typical demarcated neighbourhood, we can provide solar farms to meet community level energy needs. In the above case solar farms of approximately 11000m^2 can be provided, that can generate energy up to 66000 kWh in a day. The best location for a solar farm is sites that possess significant south-facing flatlands or slopes that are located at the edge of a community, town, or city

8. URBAN INTEGRATED INFRASTRUCTURE SYSTEM (UNIT LEVEL)

Infrastructure needs cannot be answered separately, integration of all services and utilities result in more efficient use of resources. Therefore, we should look at integrating various infrastructure services at a unit level or a household level and then further integrating with larger grid of community, neighbourhood or at a city level. A community design based on a modular residential block scalable to serve public and town-scale functions can be developed to manage rainwater run-off, grey water, wastewater, energy, and food production. The design is meant to explore a site-level application of the modules, with necessary non-residential systems to support the intervention on the town scale. Figure 6 shows how different energy efficient solutions can be integrated in one system at a unit or household level.

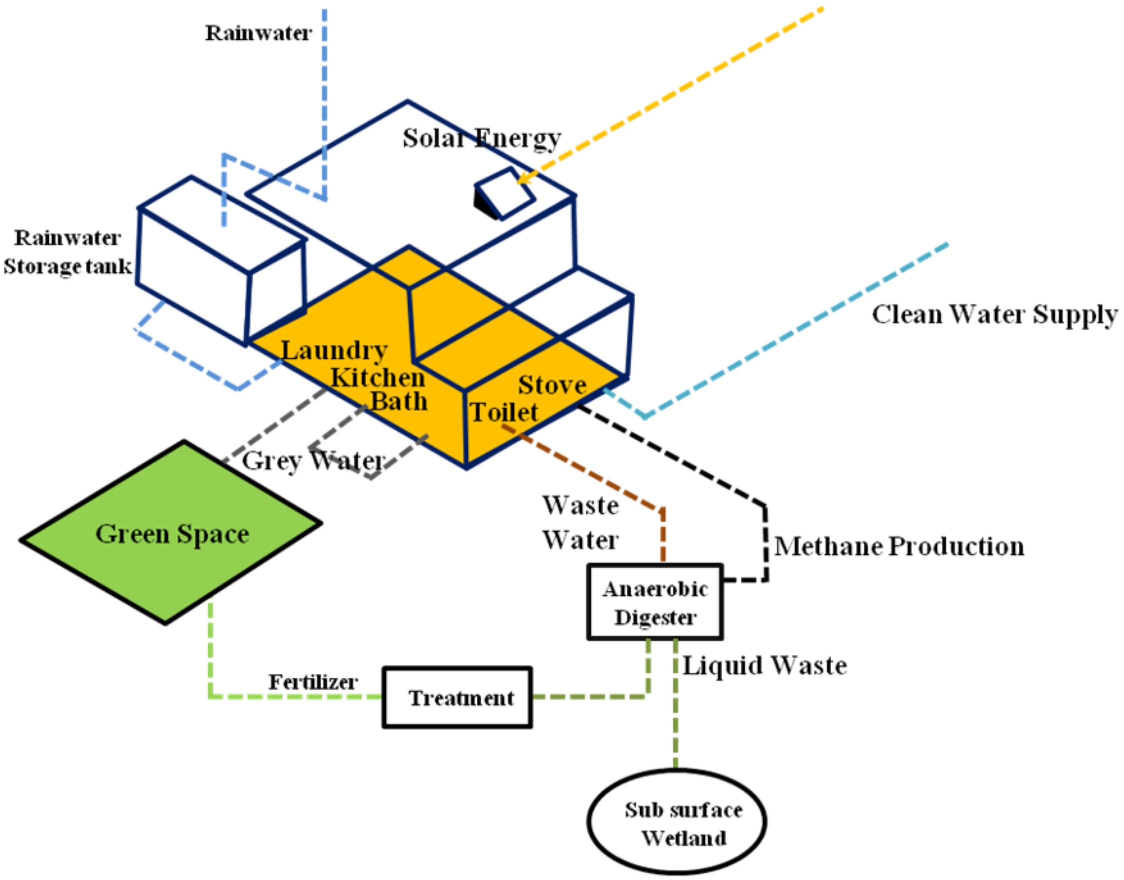


Figure 6: Integrated Infrastructure System

9. CONCLUSIONS AND OBSERVATIONS

All the above techniques can be developed into a standard feasible model and can be multiplied on the city scale to reap larger benefits. Integration potentially allows for more effective and efficient use of resources in order to achieve a given set of objectives. The observations and conclusions made in the study are;

- Grey water management can be used as one of the sustainable tools, which has potential to reuse water and be more efficient. A small neighbourhood of 5000 population has potential to generate 8.39 million litres of re-usable water annually. Grey water design typologies can be developed in different forms. They range in scale and usage from individual yards behind single family rural homes to intensive green roofs and courtyards on urban blocks. Furthermore, they range from individual use to communal use, whereby the exposure of grey water in the streets and in creative spaces for the community will also make the community more aware of their water consumption.
- The ultimate goal may be to create a community that is conscious and sensitive to water consumption; eventually this may even lead to healthy competition among communities. The innovative technique is intended to be used as patterns of use that may be adapted to a variety of different sites and integrated with other complementary city systems.
- Biogas systems has been primarily used in villages but findings in the study like, sewage waste of approximately 15 persons (or nearly 4 families) could produce enough biogas to fuel the cooking needs of one conventional family, is clearly indicating its use on urban scale starting at unit level or neighbourhood level. This system can be efficiently used and managed to meet the energy demands of future cities.
- Solar farms can be installed in open and barren land to tap maximum solar energy. In a state of Maharashtra, electricity of 5.4-5.8 kWh/m^2 of the area of solar panel can be taped.

- A unit level integration of various tools is a first step towards sustainability, but what is important is neighbourhood level integration of these units further integrating with the city's grid to meet energy needs and become sustainable urban form which would be more resilient.

A detailed implementation plan is required with a strong governance model to execute these techniques. It is very critical now to understand the need of urban innovation to sustain in the existing cities and to plan future.

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