

Developing a Circular Economy Model for Rural Sanitation

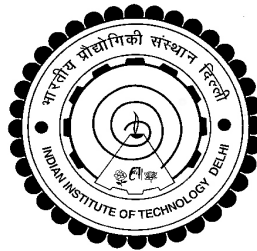
Research plan

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1.

1. Background

Over the years, the importance of rural sanitation has been increasingly recognized by civil society and Indian government. Many NGOs such as Gramalaya, SCOPE, AKDN are working in the areas of community inclusion and resource recovery in sanitation leading to several Open Defecation Free (ODF) villages in rural India. Simultaneously, Indian government has tried to improve sanitation infrastructure in rural area with its flagship schemes such as Nirmal Bharat Abhiyan and later Swachh Bharat Abhiyan. The number of toilets constructed every year in rural area by the government has been increasing over the years. In span of just 4 years (2012 to 2016), the number of toilets constructed per year more than doubled in rural India. (India Expenditure Budget) (Refer figure1).

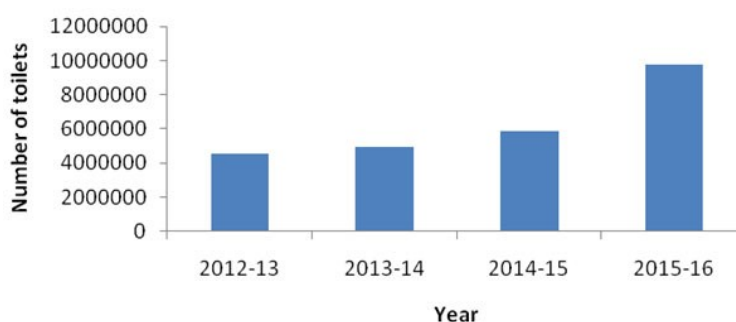


Figure 1 : Number of toilets constructed in rural India (Source: India Expenditure Budget, Vol 2, MDWS)

Despite this increased construction activity, 52% rural Indians do not have access to sanitation facilities (Swachhta Status Report, 2015). In fact, according to the recent UN report 2016, if India continues its effort in sanitation at same pace, it will achieve Millennium Development Goal (MDG) - 6 “*Ensure access to water and sanitation for all*” only by 2054! Therefore, it is necessary to accelerate the pace of improvement in sanitation infrastructure of rural India. Further, the usage of sanitation infrastructure already built is also essential.

Sanitation facilities built in several Indian villages have not been optimally utilized by the people (World Bank Report, 2016). The annual growth rate of toilet usage has been consistently lagging annual growth rate of toilet construction over the years (Refer figure 2). The current initiatives of government and NGOs are finding it difficult to ensure toilet usage.

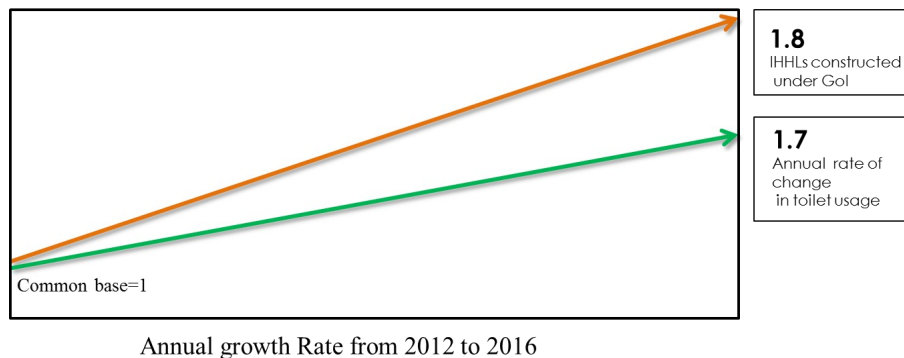


Figure 2 Gap between toilet construction and toilet usage (Source: World Bank Report, 2016; Union budget)

The root cause behind these problems of current initiatives could be traced to their linear approach towards rural sanitation. This linear approach is based on ‘take, make, dispose’ economic model in which treatment of organic waste is considered as cost and additional resources are used to dispose it. Such linear approach not only increases the cost of rural sanitation but also fails to provide adequate incentives to people to build, maintain and use sanitation facilities.

As improvement over this linear approach, present study proposes circular economy approach towards rural sanitation. The circular economy approach is restorative and regenerative in which nutrients from waste are restored and value added products are regenerated. It is a form of bio-mimicry in which nothing is waste; everything is resource from which useful products can be derived, similar to the way nature operates.

This circular economy approach has already been implemented in China, EU and South Africa, particularly in material cycle of waste management at policy level. For resource constraint country like India circular economy approach is necessity. The following plan will outline the research proposal to develop the circular economy approach towards rural sanitation in detail.

2. Literature Study

2.1 Understanding sanitation in Indian villages

Sanitation initiatives by Indian government and NGOs have widespread impact on rural sanitation. According to the recent statistics by Swachhata status report, 35% of villages are completely open defecation free. 65% of villages couldn’t achieve open defecation free status despite all institutional support (Swachhata Status Report, 2016). Interestingly, out of 35% of open defecation free Villages several villages were seen to go back to their old habit of defecating in open. Hence, it is imperative to identify reasons behind status of open defecation. There are various key factors for a village responsible for success and failure in achieving open defecation free status. This would give fair understanding of sanitation scenario in rural sector. Based on primary literature study, some probable factors responsible for achieving complete open defecation free (ODF) status, partial open defecation status and failure in achieving ODF status in villages are listed below;

2.1.1 Socio cultural Aspects

The problem of rural sanitation is complex due to social and attitudinal problems of village residents that includes gender inequality, caste related issues, social beliefs and advertisement messages etc. Gender inequality is a major concern in rural areas. Since men are the head of the family and decision makers in economic matters, women’s demand of toilet was not given priority whereas women form villages in Sikkim and Kerala do not face such problems because of their matriarchal society. (Routray, Torondel, & Clasen, 2017) Some villages have witnessed

serious cast related issues. For instance, in *Pokhri* village (Maharashtra) which was declared as open defecation free, some backward cast families claim that they are forced to defecate in the open as they are yet to receive funds for building toilets (Aditi, 2012). The government provides latrines that have soak pits and need to be emptied manually. Villagers think that only *Dalits* can do this work (Bansal, 2016). Majority of Hindu villages believe that defecating far from home is safe and good practice. Ideas about purity and pollution related to the Hindu caste system influence defecation behavior (Coffey, Gupta, & Hathi, 2017). In addition to this, advertisement messages are completely divorced from rural reality and does not respect or understand genuine constraints of people for not using latrines which includes feeling of claustrophobia in latrine, water unavailability, scarcity of money and long generational habit of defecating in open etc.

2.1.2 Economic barriers

Major constraints for construction of toilet are non-availability of sufficient money and land. People from economically weaker section believe spending on major needs rather than toilet (Sahu, 2016). For instance, in tribal village of Gujarat, It was observed that more than 90 percent families were indebted for expenditures in agriculture, small business ventures, health, house alteration and social events (Kapoor, Ramiseti, & Barot, 2016). Hence, it can be said that decision of toilet construction is dependent on per capita income of the household.

2.1.3 Distrust in government

Government subsidy is perceived as a matter of right. It is expected that rural people should come forward and take the advantage of the scheme. However, rural people are not very keen to claim. Typically, People are not confident that they will get the subsidy that government is offering for the toilet construction. People have heard about people having made toilets and not receiving funds for 2 to 3 years (Kapoor, Ramiseti, & Barot, 2016). Moreover, they are also afraid of closing the scheme (Water, Sanitation and Hygiene Annual Report, 2007). Rural people believe if the scheme like Swachh Bharat Abhiyan closes midway they will lose their subsidy.

2.1.4 Technical aspects

It's a common understanding among rural people that sanitation requires Rs. 40,000 to Rs.50,000 and government is offering only Rs.12,000. Lack of this knowledge discourages toilet construction decision among rural people as they think they have to spend extra amount for construction apart from government subsidy (Water, Sanitation and Hygiene Annual Report, 2007). As a result most of the time they don't prefer to build a toilet. Although government has published technological data on low cost construction of toilet, it is hard to reach out to rural household with this technique.

2.1.5 Access to water for latrine use

Lack of access to water for latrine use could be one of the reasons for open defecation. According to the NSS report, it is evident that only 42.5 per cent rural households were found to have access to water for use in toilets. In contrast, some of the researchers are of the opinion that lack of water is not to blame for India's open defecation rates. As per their opinion, many households that have piped water nevertheless defecate in the open (Kumar & Murgai). Hence it is needed to find out whether open defecation is dependent on access of water.

2.1.6 Lack of cadre of motivators

As it is already been seen, poor sanitation has direct impact on health. Often, rural people believe poor health and poor productivity is borne of factors other than sanitation. Lack of awareness of the linkages between sanitation and productivity makes it difficult to effectively implement most sanitation programs in rural India. To make society aware about linkages between health, sanitation and productivity some motivational and behavioral change work for improved sanitation is carried out by cadre of motivators. Hence their involvement is also correlated with open defecation in rural area.

2.1.7 Pit latrine

Affordable latrines, such as those recommended by the World Health Organization (WHO) and subsidized by the Indian government, have pits that need to be emptied manually. Rural people expect manual pit emptying with scavenging and other degrading forms of labour traditionally done by *Dalits* (Coffey, Gupta, & Hathi, 2017). Because of this, non-*Dalits* refuse to empty their own latrine pits. *Dalits* seek alternatives to the kinds of physically and ritually dirty jobs that have been used, for generations, to justify their oppression, exclusion, and humiliation. As a result, use of pit latrines recommended by Indian government actually discourages the use of toilet in rural area which in turn promotes open defecation.

2.1.8 Literacy rate

Education plays an important role in inculcating healthy habits. It is observed that educated people are sensitive towards sanitation and cleanliness as they are aware of unhealthy impacts of poor sanitation. In a family, particularly female's role is very crucial in ensuring good habits to family (Education, Health and Sanitation). Hence in rural area overall as well as female literacy rate have certain impact on open defecation habits. On the contrary, it is also noted that India has far higher open defecation rates than other developing regions where literacy rates are lower (Coffey, Gupta, & Hathi, 2017). It would be interesting to understand the relevance of literacy rate in transforming villages to open defecation free.

2.1.9 Government subsidies to individual

Despite allocating lot of funds into building toilets, many toilets remain unused. Allocation of subsidies could not assure sustainable toilet usage. Moreover, there is least correlation between funds allocated to states and their open defecation status. It is also been debated that toilet subsidies should be suspended and instead efforts should be towards securing collective behavior changeⁱ. Hence, the exact relevance of government's subsidies in toilet construction needs to be found out.

2.2 Case Studies

Presents research will attempt to solve sanitation issue at rural cluster level by adopting community driven approach, relevant faecal sludge management technology, livelihood generation strategies and circular economic business model. Based on above mentioned research approach, relevant case studies are selected which have substantial contribution in this domain. Selected case studies includes sanitation initiatives by 'Sanergy', 'SCOPE', 'Gramalaya', 'Blue diversion Autarky' and 'RADISA'.

2.2.1 Sanergy, Kenya

Sanergy model was introduced to improve unhealthy sanitation practices in Kenya where residents were forced to rely on unsanitary options like flying toilets and pit latrines that release untreated human waste into environmentⁱⁱ. Sanergy introduced affordable and high quality sanitation facilities. Local residents who purchase and operate these sanitation facilities are Fresh life operators (FLO). These operators became franchise partners who were provided fresh life toilets (FLT), training, access to financing, ongoing operational and marketing support, and a daily waste collection service by Sanergy.

Its working model includes 'waste collection' where waste from toilet is collected on daily basis; 'treatment' where waste is converted into useful products e.g. organic fertilizer, insect-based animal feed and renewable energy; and finally 'marketing of recycled products' where recycled product is transferred to East Africa due to high demand for such products. Stakeholders involved under Sanergy model are operators, Sanergy team, Environment, Sanergy Supporters and Community. Sanergy not only succeeded to set up 1,134 active Fresh Life Toilets in informal settlements but also created over 900 Jobsⁱⁱⁱ. Being in harmony with local community, Sanergy model has tackled unhealthy sanitation condition successfully in slums of Kenya but also ensured livelihood generation by adopting circular economic path.

2.2.2 SCOPE, Trichy

SCOPE is one of the Indian initiatives which primarily focus on developing suitable toilet technology for villages in Trichy. Due to high cost septic tank latrines and unfeasible pit latrines, SCOPE introduced Urine diversion dehydrating toilets (UDDT), Total Resources Recovery Toilet System (TRRTS) and Tiger worm toilet. UDDT is type of dry toilet with urine diversion. Separate collection of urine and faeces results in odor-free operation and pathogen reduction by drying^{iv}. This dried faeces and urine harvested from UDDTs can be used in agriculture. The TRRTS has five modules a flush out toilet, a bathroom, a urine diversion bowl, a cultivated wetland for treating grey water and a collection tank for mixing urine and treated grey water from the bathroom. This diluted urine was lead to the farm for irrigating crops^v. The faeces from the toilet, kitchen waste and cow dung were fed into the biogas plant. The biogas generator was used for cooking in the household kitchen. No waste was generated in the TRRTS and all waste was converted into environmentally friendly useful products.

SCOPE introduced Tiger worm toilets essentially for areas with moderate water table, and is similar to twin pit toilet technology. Apart from not polluting or contaminating water bodies, tiger worm toilets are far more effective than a septic tank as it leaves a smaller footprint of waste^{vi}. The tiger worm toilet is proved to be an income generating toilet, since the manure from this can be sold for Rs. 10 per kilogram. Sanitation initiative by SCOPE basically explores a range of faecal sludge management technology with nutrient recovery and attempts to generate livelihood for rural community.

2.2.3 Gramalaya, Tiruchirappalli

Gramalaya has been working in rural areas and slums of Tiruchirappalli district. The major initiatives of Gramalaya include Health and hygiene education, promotion of Self-help Groups among rural, urban and tribal women, construction of low-cost latrines and safe water supply through micro-credit. Gramalaya is encouraging different low-cost toilet models which are affordable and acceptable by the local communities depending upon the local situation and willingness of the people. It has constructed leach-pit toilets and pit latrines using locally available materials. But, in areas like tsunami affected coastal region, Gramalaya introduced eco-san toilets Mainly for Fisherman communities. Eco-san toilets are constructed above the ground-level with two chambers and two squat holes with urine separation facilities. The wash water is diverted to the kitchen garden and prevented from mingling with human faeces. The urine separated from the toilet is stored or drained using a mud pot. The alternate chambers are used and once filled would be used as a manure after one year period to the agricultural fields^{vii}.

Another major initiative by Gramalaya is community managed toilets which is maintained by SHE team AWASH Committees formed by the women members of self-help group of the respective slums (Sanitation and hygiene education team). The amount saved every month is pooled as a common fund for the particular slum towards health and sanitation related promotional activities. Key contribution of Gramalaya is in building community driven approach and appropriate faecal sludge management technology.

2.2.4 Blue Diversion AUTARKY

Blue diversion Autarky has not only developed safe, affordable and appealing toilets but also a business model. It covers all activities along upstream and downstream sanitation value chain. Upstream sanitation chain includes marketing, sales, operation and maintenance of toilet. Downstream sanitation chain highlights collection of urine and faeces, their transport to the off-site resource recovery plants, and the production and sale of marketable fertilizer end products. The business model relies on franchise approach where established private or public organization will act as a franchisor. Model also highlights the many small business and entrepreneurial talents that already exist in low-income countries. Many talented entrepreneurs will be able to become franchisees^{viii}. Blue diversion Autarky claims that business model will become financially sustainable at a certain scale and after their cost targets are reached.

2.2.5 REDISA

Recycling and Economic Development Initiative of South Africa (REDISA) was set up to deal with South Africa's waste tyre problem, and has significant input in recycling waste tyres. It is essential to study initiative by REDISA due to its innovative business model that deals with recycling tyres. REDISA receives revenue from a mandatory levy of about €0.20 on every kilogram of new tyre rubber placed on the South African market^{ix}. With this money, REDISA can pay individuals and small businesses who register as collectors of old tyres. The collectors pick up consignments of tyres from dealers or from dumps. For tyre dealers, the scheme offers a free-of-charge and convenient way of disposing of the stocks of waste tyres that they build up. Collectors deliver to REDISA recycling depots where they receive payment for the waste tyres. The environmental benefits of repurposing tyres in this way are clear, while the economic advantages are also considerable. In its two years of operation, REDISA has created 79 transport businesses, 52 co-operatives, 46 waste depots, and 2505 jobs. The REDISA initiative not only involves community but also ensures livelihood generation for them by adopting Circular economic model.

2.3 Key concepts

Present research attempts to solve the issue of rural sanitation by adopting Ecological sanitation techniques and builds circular economy framework for selected rural cluster with community inclusion. Hence it is needed to explore the key concepts of Ecological Sanitation, Circular economy and Community led total sanitation approach.

2.3.1 Ecological Sanitation

Ecological sanitation systems are systems which allow for the safe recycling of nutrients to crop production in such a way that the use of non-renewable resources is minimized (Kvarnström, Dagerskog, & Norstr, A policy brief by the SIANI Agriculture-Sanitation Expert Group, Sweden, 2012). In Ecosan Toilets, human excreta, urine and wash water are separated through specially designed toilet seats unlike the conventional water closets where all these are collected together. Urine and solid waste pass through the squat holes and are collected separately in the underground collection chamber. Once the chamber is full it is then emptied and the solid waste collected is dried for a period of six months while the urine is sprinkled on soil under cultivation. Dried solid waste and urine add nutrients to make soil more fertile leading to better harvests. Urea contained in urine sprinkled on soil improves Crop Resistance to diseases. Human waste sprinkled on soil minimizes the growth of weeds such as "tiger weeds". Human waste used as manure has no artificial fertilizer which may contain dangerous toxic chemical.

Eco-san toilets are suitable for rural areas with little or no access to water. These are proved to be income generating toilets through the sale of the solid waste to local farmers. They are durable and permanent as they do not require reconstruction once they get full like pit latrines. Moreover, manure from Eco-San toilets saves on costs incurred on the purchase of fertilizer since it is freely available. Ecological Sanitation could be "Environmental sanitation" as it has healthy impacts on environments. Ecosan systems can be implemented in a sustainable way and have a strong potential for "sustainable sanitation", if technical, institutional, social and economic aspects are carried out appropriately (Tilley, Ulrich, Lüthi, & Reymond, 2014). It can be unsustainable (financially) for example if there is too little user acceptance or if the costs of the system are too high for a given target group of users.

EcoSan concept is formulated through an approach that integrates circular economy concept (G. Langergraber, 2005). The Circular Economy replaces our current linear model of take, make and dispose, with a system that keeps products, components and materials at their highest utility and value at all times (Toilet Board Coalition, 2016). The Circular Economy comprises two cycles: technical (managing the stocks of finite resources) and biological (managing the flows of renewable resources). In India, to date industry has mainly focused on the technical cycle (metals & plastics) leaving the biological cycle (or bio cycle) largely untapped (Toilet Board Coalition, 2016). There is a potential to transform sanitation from undesirable cost into commercially valuable and self-sustaining system. Once demand for the recycled products being derived from the toilet is generated it will create self-sustaining sanitation businesses, and will encourage investment in sanitation. In this logic, toilet users will experience economic gains along with social and environmental gains (Toilet Board Coalition, 2016). If people valued the

materials they produce, more demand for toilets could be placed. Eventually Circular economic framework will discourage dependence on public and aid funding for sanitation.

2.3.2 Community Led Total Sanitation

Involvement of rural community in upstream and downstream sanitation value chain will ease out the process of application of Circular economy. Hence Community-Led Total Sanitation (CLTS) concept will be explored in this literature. CLTS is an approach which is based on the principle of triggering collective behavior change. In this approach, rural communities are facilitated to take collective action to adopt safe and hygienic sanitation behavior and guarantee that all households have access to safe sanitation facilities^x. It focuses on bringing a change in sanitation behavior rather than constructing sanitation infrastructure. This change in sanitation behavior is accomplished through a process of social awakening stimulated by facilitators. These facilitators are from within or outside the community. The CLTS approach concentrates on the whole community rather than on individual behaviors. Hence, Collective benefit from stopping open defecation can encourage a more cooperative approach where people decide together how they will generate a clean and hygienic environment that benefits everyone. The most important aspect of CLTS is that it does not rely on sanitation subsidies or service delivery from external agencies due to collective will and contribution of community.

2.3.3 Circular economy concept

A circular economy is restorative and regenerative by design. It aims to keep products, components, and materials at their highest utility and value at all times. The circular economy is a continuous, positive development cycle. It preserves and enhances natural capital, optimizes resource yields, and minimizes system risks by managing finite stocks and renewable flows. (Ellen Macarthur Foundation)



Figure 3 Linear Model (Source: Ellen Macarthur foundation)



Figure 4 Circular Model (Source: Ellen Macarthur foundation)

There is a lot of potential for circular economy in rural Indian context. Demand for the resources being derived from the toilet can create self-sustaining sanitation businesses and encourage investment in sanitation which will be less

depended on public and aid funding (Toilet Board Coalition, 2016). This demand will accelerate the implementation of improved sanitation for all and economic gains will ensure social and environmental gains. This has already been proved by the World Bank's Water and Sanitation Program. Its economics of sanitation initiative has showed that the economic gains from sanitation fall across society. It enhances the economy as a whole by reducing the burden of health and environmental issues. This initiative estimated the global benefit at \$260 billion (World Bank, 2016). The Circular Economy model can achieve this, through increased revenues, greater efficiency, and through monetizing some of the externalities. Currently, sanitation issue in rural India is being solved by only constructing a toilet. The environmental, social and economic aspects are being overlooked. Circular economic framework will not only ensure the open defecation free rural area but also comprehensive sustainable development.

3. Research Gap

Study, of current sanitation scenario in India and sustainable sanitation initiatives, indicates research gap in selected research domain. Government of India has rightly pointed out the rural sanitation problem and developed clear parameters for open defecation free villages. However, sanitation in rural India is seen as achieving open defecation free status through toilet block construction. Rural sanitation could be seen beyond. Resource recovery is less explored domain in India as collective acceptance is major limitation. As of now, there are few organizations in India, SCOPE and Gramalaya, have contributed in resource recovery in sanitation. There is a need to take closed loop sanitation technique at wide scale.

Further, rural community is an essential tool towards successful sanitation implementation. Their involvement ensures collective pride and responsibility encouraging households to adopt toilets. It leads to less dependence on government's subsidies. Particularly in India, it is highly needed to explore community involvement techniques in successful sanitation practice.

Next important component is economical cost of sanitation. There is lot of cost involved in not only allocating grants and subsidies to sanitation program but also in waste disposal. Instead, Sanitation could be seen as profit making model. Organizations including SANERGY and REDIDA are already working in similar lines of profit making models of Circular economy. Moreover, Countries including China, EU and South Africa have widely accepted Circular economy approach particularly in material cycle of waste management at policy level. In India, It is needed to explore applicability of Circular economy approach particularly in rural sanitation. This will not only ensure sustainable sanitation practice but also livelihood generation. Based on this research gap in rural sanitation, following research questions are framed. Present study orients along these questions.

4. Research questions, Aims and Objectives

5.1 Research Questions

The research questions to be addressed are;

1. On what attributes the success and failure of any sanitation program depends?
 - a. What is the most relevant factor to achieve open defecation status?
 - b. How to achieve social cohesion?
2. How to execute circular economy framework in selected rural cluster?
 - a. What does the circular economy concept entail?
 - b. Which stakeholders need to be involved and how?
 - c. How can demand for recovered products be created?
 - d. What are the drivers and barriers influencing the transition towards a circular economy?
 - e. How should change from linear to circular water and sanitation be managed?
 - f. How to address public perceptions associated with recycling and reusing of human waste?

5.2 Aim

To build a circular economic framework for selected rural cluster

5.3 Objectives

- To identify most relevant factors responsible to ensure sustainable sanitation
- To study sanitation scenario in selected rural cluster
- To propose circular economic model for selected rural cluster

5. Scope of this research

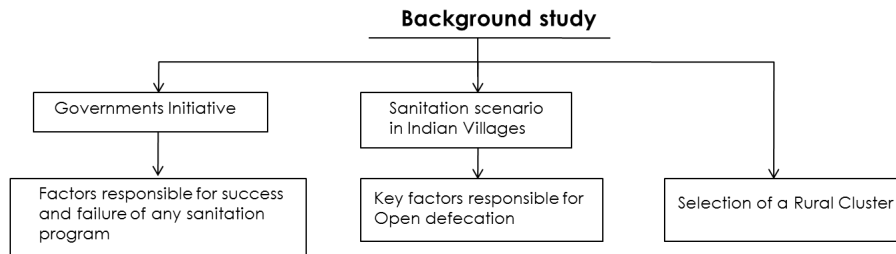
Present research explores the possibility of circular economy in sanitation at the level of clusters of villages. The scope of the study is limited to build a framework to recycle all kinds of organic waste at village clusters to make rural sanitation sustainable, demand driven, cost effective and environment friendly. In sanitation, the scope of research would be limited to four types of organic wastes, namely human fecal matter, household waste, agricultural waste and waste generated from agro-processing industries. The prime focus would be on Human fecal waste as it is less explored domain in India.

Current research study will attempt to understand sanitation scenario of Indian villages based on selected parameters: Government factors (HH Subsidies, distrust in government), Social factors (social conflicts, cast and untouchability, social beliefs, literacy rate), Economical factors (Per capita income, employment distribution, expense pattern) and technological factors (access to water for latrine, pit latrine, cadre of motivators, and existing type of toilets). Study also explores existing successful social organizations of Indian rural sector and key ingredients responsible for social cohesion in their cases. At selected village cluster level, scope of the study lies at capitalizing the village community in order to create suitable community led sanitation approach. Research will seek to generate a novel model to achieve social cohesion.

At technological level, the study would explore existing waste management technologies that could be implemented on selected village cluster. The study does not aim to find new waste management technology. Application of Circular economic model would be limited to selected cluster of villages. Proposed framework will aim to generate sustainable sanitation practice which will ensure social cohesion, open defecation free villages, and healthy environment and employment opportunities in sanitation model.

6. Research Methodology

7.1 Background study



7.1.1 Understanding factors responsible for success and failure of sanitation program

Research study demands to understand factors responsible for transforming villages to become an open defecation free. In order to get an exact idea of these key factors, villages are categorized into three types based on their rate of open defecation. ‘Type I’ category includes villages which are completely open defecation free e.g. *Atra(Uttar pradesh)*, *Churu (Rajasthan)* and *Koraput (Odisha)*. ‘Type II’ category includes villages which were open defecation

free in the past but after certain period villagers went back to their old habit of defecating in open e.g. *Parvarpoorab (Uttar Pradesh)*. 'Type III' category mainly comprises villages that failed to achieve open defecation free status despite substantial efforts put by government and NGOs e.g. *Kurali Sohana (Harayana)* and *Mai (Bihar)*. Initially the objective of the study is to understand key factors responsible for open defecation, and identify most relevant factors responsible for success and failure of any sanitation program. This would give fair understanding of sanitation scenario in rural sector. Based on primary literature study, some probable factors responsible for achieving complete open defecation free (ODF) status, partial open defecation status and failure in achieving ODF status in villages would be identified, and their correlation with status of open defecation will indicate most responsible ones.

7.1.2 Identification of key factors responsible for open defecation

In order to get to the basics of the current sanitation issue in rural India, it is essential to have accurate understanding of open defecation in Indian rural sector. Hence within selected villages, correlation analyses between dependent variable, status of open defecation and independent variables including government initiatives (subsidies and no. of toilet), Social factors (social conflict, cast, untouchability and behavioral aspects), Economic factor (per capita income), Educational factor (Literacy rate), Infrastructural factor (access to water source), Technological factor (pit latrine) will be carried out. The factors with higher R square value will be selected as key factors in achieving open defecation free villages. This analysis will lead to certain indications. Correlation factor between open defecation status and government initiatives will point toward the relevance of SBM-G. In addition, analysis will also lead to the certain questions such as,

How to achieve social cohesion?

How to achieve integrated policy approach?

What is the substitute for pit latrine?

After attaining basic understanding of open defecation, present research will shift its focus to onsite study of selected village cluster.

7.1.3 Selection of Cluster

Further sanitation research will be carried out in selected cluster of villages. Selection of the village cluster will be done based on total amount of waste generated within villages, socioeconomic background of the villages, climatic background and type of toilet already exists. Understanding the amount of waste generated in villages includes human fecal waste, household waste, agricultural and agro industrial waste that they are generating together. Waste amount at bulk will be preferred as it gives economies of scale to recycling business (Hingorani, 2011). It is also imperative to get an idea of socioeconomic background while selecting rural cluster as it plays a vital role in understanding common social and economic issues which could be tackled through sanitation proposal. Sanitation latrine proposals are also dependent on climatic factors for instance; coastal region may need different sanitation solution than delta region because of its unique climate and topography. Villages may have various kinds of latrines existed including IHHL (individual household latrine), shared latrines, community toilets and Public toilets. In order to propose latrine technology it is necessary to understand existing type of latrine.

7.2 Onsite baseline data collection

The purpose of the baseline data collection is to collect background information that is essential to determine the requirements for an adequate sanitation both from a technical point of view, and from the user's perspective as well. The gathered information will provide the details necessary for the design of the project.

7.2.1 Gathering technical information on Existing system

Here, the main objective is to collect information regarding the area's sanitation and water systems and their level of integration in the settlement structure. Technical requirements for the proposed system will depend on a thorough assessment of information regarding excreta and solid waste disposal practices, water supply, water availability, wastewater treatment, drainage, and fertilization/crop production practices in the area. Technical information on the existing system will cover issues which includes inventory of existing household level sanitation and water

technologies, hygiene practices, fertilizer use, and their perceived benefits. Description of the conditions of the existing sanitation and water system as well as their operation and maintenance procedures will also be collected.

7.2.2 Identifying the Socio–Economic Situation of the Settlement

The system requirements will also depend on the social and economic situation of the settlement which therefore it has to be identified. In designing feasible sanitation systems it is necessary to understand the user perceptions regarding sanitation and water infrastructure, their hygiene practices, economic possibilities and priorities. Hence, Primary data such as description of local physical conditions (e.g. population size, density, etc.), assessment of the community's resources, literacy and education level, land ownership and farming practices will be collected.

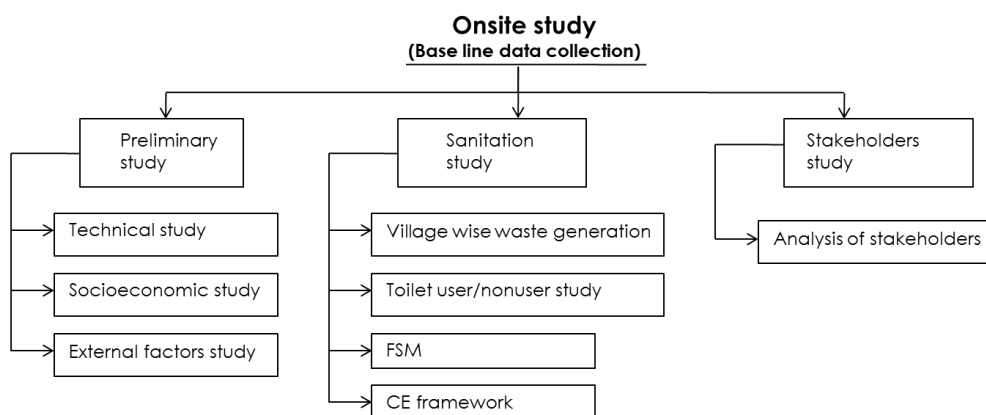
Successful implementation of any sanitation program highly correlated with social cohesiveness of community. Before implementing any sanitation solution, it is essential to ensure that society is cohesive despite various castes and political background. Therefore, Primary survey would be conducted to get an exact idea of social fabric of that community. There are various reasons for social conflict including political, caste related or other. It is important to identify exact reason through primary survey. Simultaneously, it is also important to understand villagers' inclination towards social cohesion. Based on their inclination towards social cohesion, present study would attempt to propose ways to achieve social cohesion. Once the social cohesion is ensured it would be easy to formulate sanitation technique.

Economic status is the major driver for toilet construction at village level. According to WASH survey conducted, it is seen that villagers' priorities are in the sequence of food, health and education. Sanitation is least bothered domain for them despite government subsidies. It is also observed that health related issues among children and adults are mainly because of poor sanitation conditions, and simultaneously major share of their expense goes into health sector. Hence in later part, expenses at household level would be understood through primary survey. In addition to expense pattern at household level, economic survey of existing employment structure i.e. villagers engage in primary, secondary and tertiary sectors will be understood through primary and secondary data.

7.2.3 Identification of External Factors

The assessment of settlement condition must look beyond sanitation and water issues to identify the external factors that drive decision making within the community. It also important to understand how these external factors can be accounted during the planning process. This includes not only the physical state of local water resources, but also the relevant legislation, existing policies and current management activities. Further external factors include: Local conditions (temperature, humidity, rainfall and its variation, evapotranspiration), Soil/ground conditions (type of soils, infiltration capacity, geology and topography), Water related characteristics (flooding, source of water, groundwater, risk of contamination) and Institutional factors (decision making power at local level).

7.3 Onsite sanitation study



7.3.1 Village wise waste generation study

Solid waste generated in rural areas is predominantly organic and biodegradable. For research purpose organic waste including domestic, agricultural, and Agro industrial wastes are considered. Domestic waste includes primarily kitchen refuse, leftover food, wet waste and faecal waste. Among all kinds of wastes, fecal wastes (toilet resources) are a major part of the bio cycle that is mostly untapped, therefore more holistic approach to bio cycle could include fecal waste being blended with food and farm waste (Toilet Board Coalition, 2016). Agricultural waste is preliminary originated from animals (excreta and byproducts of dead animals) and plants (leaves, stalks, stubbles and shells). In addition to waste listed above, agro industrial waste is also included in total amount of waste generated at rural cluster level. In recent years, the increase in agro industrial activity has caused an increase in sewer sludge, and concerns about the economic and environmental impacts of sludge disposal have started to emerge. The recycling of bio waste by incorporating it into agricultural and domestic waste is one of the recommended methods for the elimination of this waste (Matos-Moreira, Cunha, & Elvira Ló, 2012). The prime reason for blending agro industrial waste with agricultural waste and domestic waste, in addition to being economical, is that this method benefits the soil as a result of the incorporation of organic matter and nutrients. Later, existing waste disposal practices would be studied at selected village cluster level. To understand severity of existing waste disposal practices on environment, environmental impact assessment (EIA) would be carried out.

7.3.2 Toilet user/nonuser study

Behavioral aspect plays vital role to ensure the usage of latrine. Every user and nonuser of latrine will be studied to understand his/her motivation to use the toilet or defecating in open. There are multiple factors which play an important role in deciding toilet usage such as age, sex, caste etc. Primary survey would be conducted village wise to understand their behavior towards using or not using toilets. Moreover, the survey will also add clarity in user preferences in selecting toilet type.

7.3.3 Faecal Sludge management

The management of faecal sludge (FSM) is an area largely ignored by most developing countries, including India. In selected village clusters, potential to implement FSM will be studied. In order to perform this, techniques like, separating urine and fecal matter at source and resource recovery methods would be studied through literature. At village cluster level, potential to implement FSM would be studied. Currently, one of the major issues related with recycled products is their social acceptance. Hence through Primary survey community's willingness to use recycled products, to work in FSM and willingness to use community toilet will be understood.

7.3.5 Circular economic framework

It is found that in addition to creating demand for consumers to buy a toilet, the downstream part of system (Transport, collection and treatment) is challenging. To work out downstream sanitation chain efficiently, village land use map will be prepared indicating basic land uses mainly residential area, public area, existing community toilets, institutional area, school and agricultural area. This map would help in locating collection points for waste based on certain selection parameters including distance from access point to village and well connectedness to waste generating points. In later part of research, re-engineering of waste collection and separation, Logistics from Local collection point to central processing unit, selection of the recycling units and establishing industrial linkage would be carried out.

7.4 Analysis of Stakeholders

Stakeholders are people, groups, or institutions which are likely to be affected by a proposed intervention (either negatively or positively), or those which can affect the outcome of the intervention (Rietbergen-McCracke & Narayan). The first step of a stakeholder analysis is to identify the key stakeholders, i.e. those who are affected by the outcome, negatively or positively, or those who can affect the outcomes of a proposed intervention (Rietbergen-McCracke & Narayan). The identification criteria of stakeholders for Sustainable Sanitation will have to answer the questions for instance,

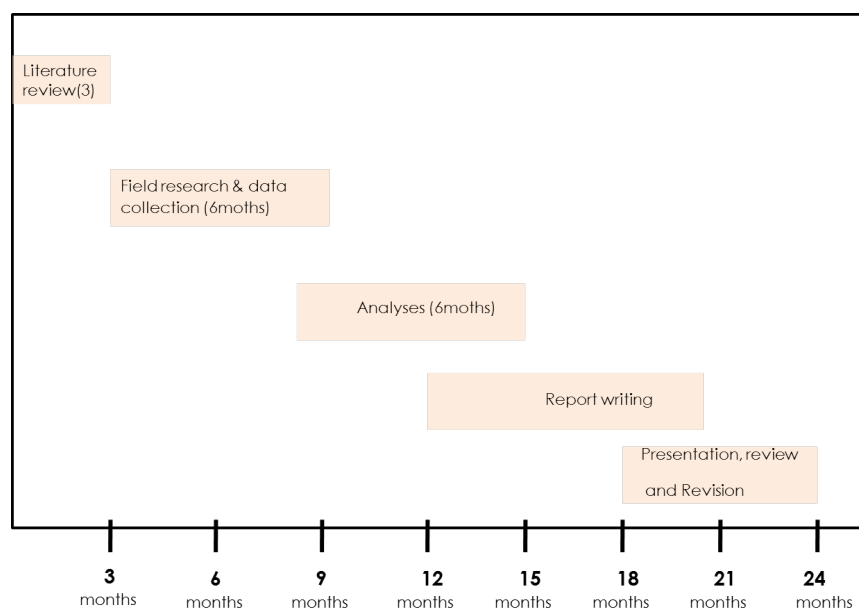
Who are the people/groups/institutions that are interested in the intended initiative?

What is their role (polluter, regulator, direct consumer, indirect consumer, etc.)?
 Who are the potential beneficiaries? Who might be adversely impacted?
 Who has constraints about the initiative?
 Who may impact the initiative?
 Who has the power to influence?

8 Possible Research outcome

The present research attempts to deliver both tangible and intangible benefits to rural community. The outcome of this research will be a framework to build circular economy model in rural sanitation. This framework can be used by . Demand for resources being derived from toilet will create self-sustaining sanitation business which will encourage investment in sanitation. As a result, more economic gains will be ensured to rural society along with environmental and social gains. Community driven approach will not only ensure toilet construction but also its usage by rural people. This will transform villages to open defecation free (ODF) with minimal funding requirement.

9 Research timeline



10. Details of collaborative organizations

Present research will attempt to collaborate with organizations which are primarily working on nutrient recovery, Community driven sanitation approaches and closed loop sanitation techniques. Such organizations include Gramalaya, SCOPE (Trichy), Aga Khan Development Network, AIILSG, Riddhi foundation.

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