Improving Delivery of Sustainable Rural Sanitation by Applying Design Thinking

Research plan

Submitted by

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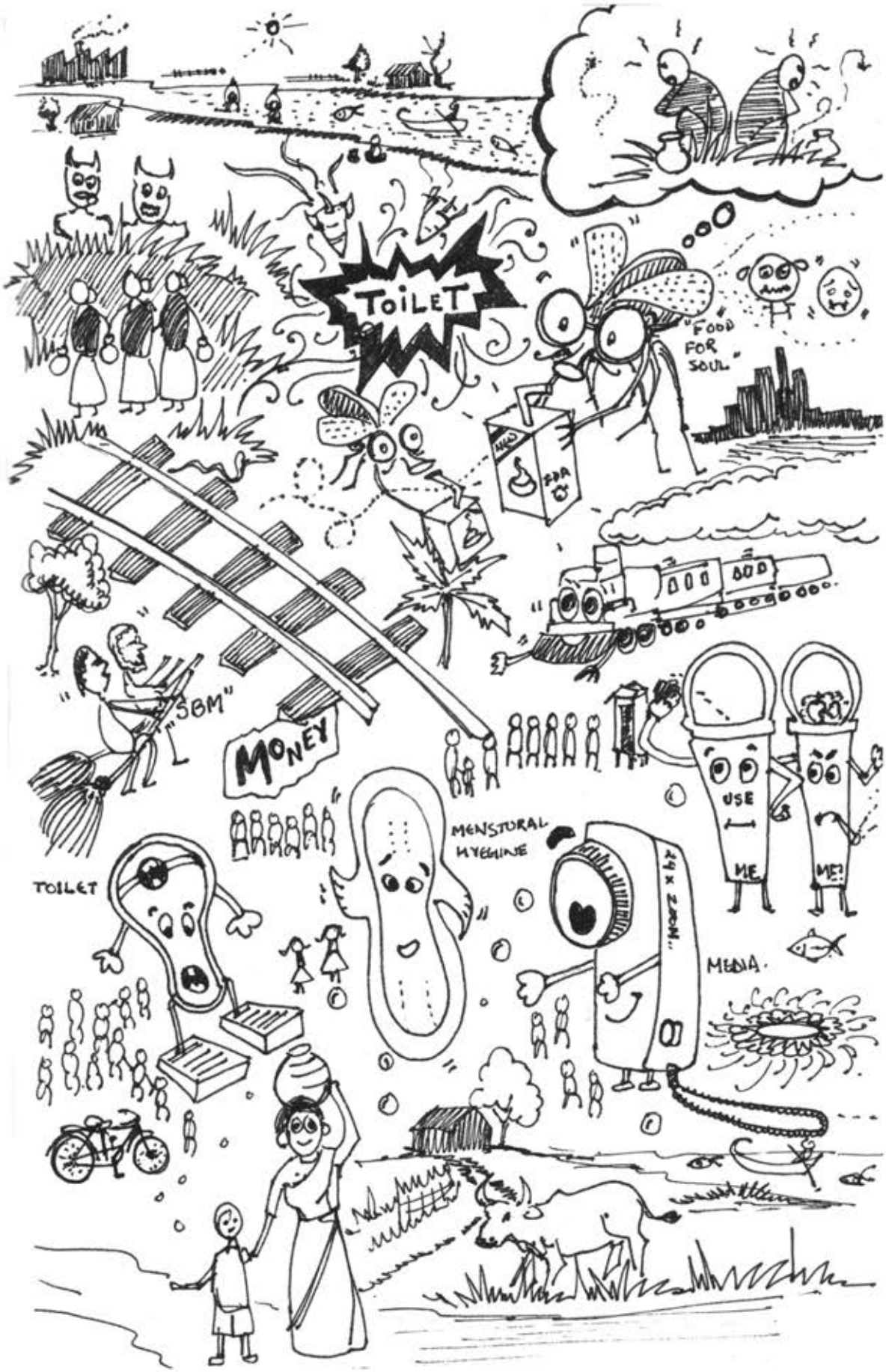
TOILET
"FOOD FOR SOUL"
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1. Background

The declaration on Sustainable Development Goals (Osborn et al, 2015) states that it is imperative that, "*by 2030, ensure availability and sustainable management of water and sanitation for all,*" many countries are striving towards that direction. A survey in 2016 by WHO/UNICEF Joint Monitoring Programme indicated that worldwide, an estimated 2.4 billion people do not have access to improved sanitation (UNICEF, 2016). In the same lines WHO GLAAS Report 2017 has stated that nearly 70% of countries are working on reaching poor populations in their WASH policies and plans but the implementation is still in question. Sanitation Data for India for the year 2015 indicates that improved sanitation facilities was accessed by 63% of Urban population and 28% of Rural population with a National average of 40% (UN Glass 2017 Report). These figures indicate that we have many challenges to overcome if we are to achieve the Sustainable Development Goals.

Statistics from the most recent Swachhta Status Report of the National Sample Survey Office (NSSO), 2016 indicates that Percentage of households having sanitary toilet in Rural in about 45.3% compared to 88.8% in the urban areas. The report also indicated that around 52.1% of rural population in country still defecates in open. The survey which was carried out in 3788 villages showed that 13.1% villages in India were found to have community toilets and about 1.7% villages were found to be having the community toilets but not using them (National Sample Survey Office, 2016).

With the promise of Eliminating Open Defecation by 2nd October, 2019 the movement of Swachh Bharat Abhiyan was launched by Prime Minister Narendra Modi and about 52 million household toilets were built between October 2014 and November 2017 (Water Aid, 2017).The budget allocation for Swachh Bharat Abhiyan (Rural) has increased over threefold from Rs 2,850 crore in FY 2014-15 to Rs 9,000 crore in FY 2016-17 (Bansal, 2016). However, there are independent studies such as Out of Order, 2016 which are somewhat critical of the supply driven and infrastructure focused approach to achieving saturation of sanitation figures.

Many decades ago, the visionary that Mahatma Gandhi was had realized that as a society, we could declare ourselves to be truly free only if we gave a life of dignity to sanitation workers (Gandhi, 1909, Hind Swaraj). This is an issue where much transformation needs to take place in India. Therefore, it is apt to state that, the issue of sanitation in India is an

example of a multi-dimensional issue which transcends social, cultural and ecological realms. Many researchers and social scientists who think deeply about issues from a civilizational perspective have been articulating a view that only a minuscule proportion of the sanitation issue would be addressed by creating sanitation infrastructure (Joshi, 2016 – Jal, Thal aur Mal, Gandhi Peace Foundation).

2. Literature Review

Scientists, Entrepreneurs, Activists, Designers around the world are working on various toilet technologies and contributing to the pool of technologies which can be customised to meet unique requirements. Many innovative approaches are taken by different companies which give a lot of insights on technologies to choose from.

2.1 Innovations in Sanitation

Industries and Universities are working on making the Toilets very Innovative and Design Centric. To bring about significant change in the sanitation ecosystem both established industries and startup companies have been working with great zeal. These innovative approaches taken by different organisations will help uplift the sanitation scenario throughout the world.

Eawag/EOOS have introduced grid-free dry diversion toilet, which provides water for flushing, hand washing and personal hygiene (for washers and for menstrual hygiene). The toilet also features a business model, linking the family scale toilet to a community scale Resource Recovery Plant (RRP) where resources from urine and faeces are recovered. The business encompasses the entire sanitation value chain, and constitutes a profitable business opportunity which creates jobs for the local community (Lüthi, 2014).

Eram Scientific Solutions' e-Toilet makes effective use of ICT for solving major issues of public sanitation, such as lack of cleanliness and lack of adequate manpower support to manage the conventional toilets. Even though a lot of Hi Tech features are applied to the toilet the maintenance in a place like India is really difficult and hence the Design can be looked into from the point of view of Design for Indian context. (www.eramscientific.com, 2018).

Zero Discharge Toilet System developed by IIT Kanpur (Misra, 2013) is a toilet system where the solid and liquid matters are separated underneath the toilet seat by using a solid-liquid separator. Ecolet is an eco-friendly composting toilet company. The company have been working on effective aerobic decomposition of the waste (Ecolet, 2017).

An IIT Delhi incubated startup – Ekam Eco Solutions, has taken to market several sanitation innovations including waterless urinals, solid-liquid separation systems and green innovations for Faecal Sludge Management. (www.ekameco.com,Accessed on 10/02/2018).

Another very unique, effective and affordable sanitation solution for both rural and semi-urban settings is the Tiger Toilet. The core innovation of the Tiger Toilet is the worm-based digester which involves a filtration system for safe and effective on-site waste treatment. The highlight of the Toilet is it uses locally available species of earthworms (tiger worms) to digest faecal solids. The Tiger Toilet, unlike any other solution currently available, addresses the most critical yet unmet needs of users (C. Furlong, 2014).

Namma Toilet an initiative by the Municipal Administration of Tamil Nadu is looking at the Design and Development of a Toilet which has Universal Accessibility. Their work is collaborative, user-centric and have taken a practical approach to find the best ideas and solutions (Gireesan, 2015).

The Loowatt Toilet is working in a very interesting dimension of deployment in BOP (Bottom of Pyramid) Urban Market; disaster relief toilets; hospital toilets; and festival and events toilets. The Toilet uses the technology of sealing human waste in a biodegradable film for easy transfer to a locally sited anaerobic digester which is later used to produce energy and fertilizer using several steps including thermophilic aerobic composting, and vermicomposting (Loowatt, 2015).

Sanergy is another company working in the space of sanitation. They have been manufacturing in area of low-cost yet, high-quality sanitation facilities. The mode of operation has been through a network of Fresh Life Operators who are actually local residents who purchase and operate the hygienic sanitation facilities. The operators become franchise partners: Sanergy provide them with Toilets, training, access to financing, ongoing operational and marketing support, and a daily waste collection service. The operators generate local demand and ensures that the toilets are kept clean. They have three

distribution models for the Fresh Life Toilets in the communities namely Commercial, Residential and Community Institution i.e. Toilets in schools etc (Sanergy, 2015).

Another Social Service Organisation by the name Sulabh International is synonymous with the toilet scenario in India. This organisation is working on various aspects of breaking the stigma related to Sanitation as well as providing Public Toilet Facilities covering pan India. Their coverage is quite a lot and they have been introducing the Twin Pit system in many parts of Rural India (Sulabh, 2018).

Aerosan Toilets have worked on odour reduction techniques for the toilet which not only allow decrease in odour but also additional reduction in volume and weight of the sludge (Andrew, 2017). The reduction of volume in very much needed as this can be easily transported and processed. If waterless technology is used then it is an added advantage. Beijing Sunny Breeze has worked on a similar direction and has developed a waterless toilet with a complete Mini Waste Processor that dries and sterilizes human waste in an automatic system (BMGF, 2014).

Asian Institute of Technology has worked on more efficient septic tanks which use the thermophilic anaerobic conditions to provide more efficient sludge digestion (Prashant, 2014). For more community centric solutions Biofilcom has developed a digester, which completely decompose the faeces on-site, without any chemical agents. The digester can be installed onto an existing in-home sanitation setup, or can be part of a new community sanitation solution (Tuffor, 2014).

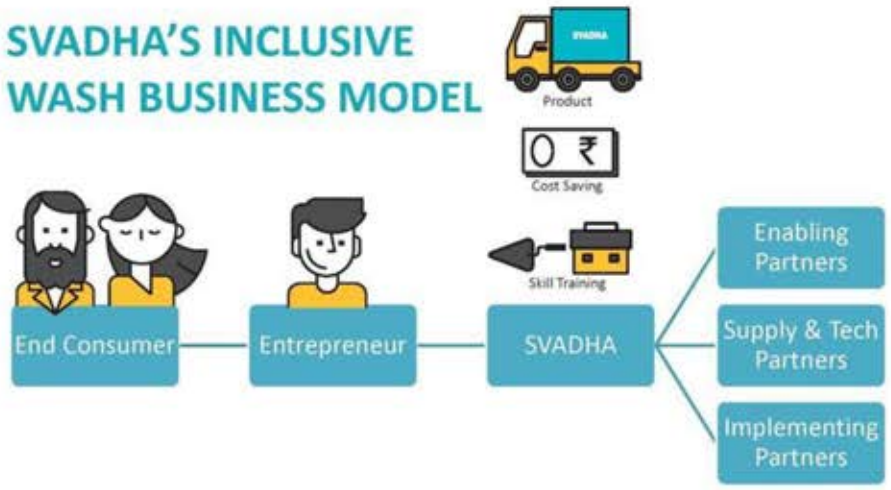
A combination of proper technologies used for toilet with an equally efficient faecal sludge management system can work wonders in the sanitation ecosystem. If these two aspects can be coupled with a robust and efficient service the loop of sanitation can be closed.

Table I (pl see Annexure I) is an exhaustive compilation of various technological innovations with detailed specifications.

2.2 A 360 degree Approach to Sanitation

2.2.1 Entrepreneurship

Many a times the Water And Sanitation Hygiene (WASH) solutions for Base of the Pyramid (BoP) markets in today's Global Scenario have been inefficient, ineffective, and lacking the mechanism to reach universal access. This is where Svadha have been trying to bridge the gap and is using the approach of creating an organized WASH market by connecting last-mile entrepreneurs with first-mile product and service providers. Solutions are tailored for BoP customers through design research and negotiating directly with suppliers to deliver quality products at fair prices for households. By leveraging ICT and with the help of village entrepreneurs, Svadha is able to deliver complete WASH solutions at the doorsteps of BoP customers. A very interesting angle to Sanitation that Svadha have worked on is providing Toilet Insurance to areas where there can be damage to the toilets due to natural calamities etc.



Svadha Business Model

SVADHA creates unique user experiences to the clients by providing solutions which are adapted to meet different needs and aspirations such as comfort, privacy, social status, and good health. SVADHA also provides complete one stop WASH solutions to the clients as well as the entrepreneurs which are quite affordable and easily accessible (Ideo, 2016).

2.2.2 Sanitation from a Livelihoods Perspective

Creating livelihoods using sanitation and training masons to create sanitation infrastructure is an important aspect focused by several NGOs and Civil Society organisations across the world. One such NGO in India which has done sustained work with communities is

Gramalaya. Gramalaya (Gramalaya, Website, Accessed on ddmmyy) has been working with bottom of the pyramid communities in Tamilnadu since the late 1980s. Through their work, they have impacted over 5,00,000 people in rural and urban Tamil Nadu with the help of government, donors, and community support. One of the innovative aspects of Gramalaya's work is its approach at using microfinance for sanitation. Through this approach, they have reached over 60 thousand families through loan for toilets and water solutions. They have been working extensively with the community to increase household awareness and motivation to invest in sanitation. Gramalaya sees toilets from the perspective of Hardware (the toilets and water) and Software (cleanliness, demand for toilets, maintenance) and only when these two are in sync the Toilet works. Gramalaya engages the entire community, particularly Women Self Help Groups (SHGs) in rural areas and urban slums to include health and hygiene education, construction of low-cost and environmentally sustainable toilets and safe water supply.

3. Research Gap

Based on an exhaustive review of the literature, it is apparent that sanitation interventions in India have focused on infrastructure creation and hardware to the exclusion of understanding individual and community motivations and aspiration. Implementation has been often dominated by a one-size fits all approach. This has led to reluctant and dissatisfied users and lack of sustainability with respect to new behaviour.

This research study will therefore focus on the hitherto neglected aspect of understanding individual aspirations, studying community behaviour and using principles of user-centred design and behaviour change approaches to ensure that rural communities play a leadership role in co-creating sustainable sanitation infrastructure and systems.

4. Research Objectives

The Objectives of the present Research are as follows :

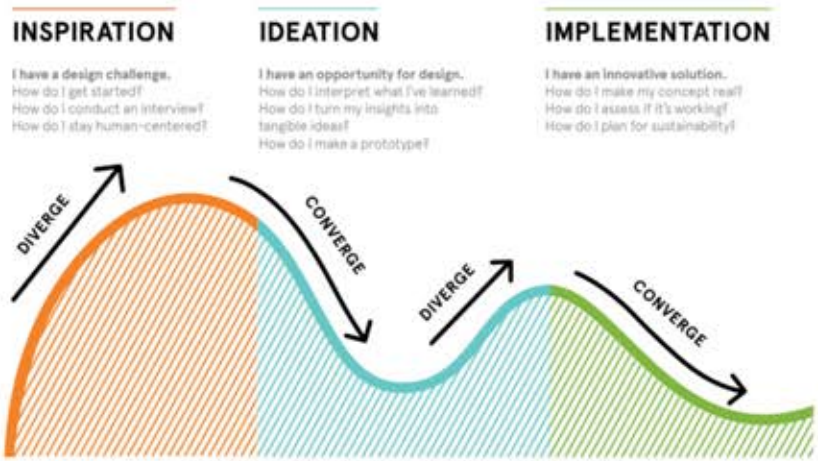
a. Understanding Rural Sanitation from the perspective of multiple stakeholders, viz, users, local government, NGOs and policy makers
b. Assessing the role of Design Thinking and Human Behaviour in achieving Sustainable Sanitation
c. Developing an Actionable Design Framework which multiple stakeholders could use to implement Design Thinking based Rural Sanitation

5. Research Methodology

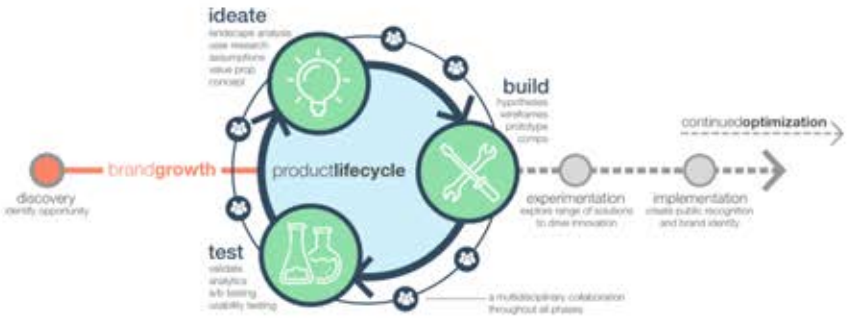
Traditionally Designers have focussed mainly on enhancing the functionality and aesthetics of products. However the current picture has changed. Recently Designers are using design tools to tackle more complex problems.

5.1 Design Thinking

Design Thinking addresses the needs of the users who will use the product or service and the infrastructure that enables it. Design Thinking may not use the conventional problem solving techniques but it taps into the capabilities that everyone has but are normally overlooked. Design Thinking seems more optimistic, constructive and experiential in its approach. This was of thinking not only focuses on creating products and services that are human centered but making the process itself deeply human. The design thinking process can be seen as a system of overlapping spaces rather than a sequence of orderly steps. There are three spaces are inspiration, ideation, and implementation. Inspiration as the problem or opportunity that motivates the search for solutions; ideation as the process of generating, developing, and testing ideas; and implementation as the path that leads from the project stage into people's lives. These are referred to as spaces, rather than steps, is that they are not always undertaken sequentially. Projects may loop back through inspiration, ideation, and implementation more than once refining ideas and exploring new directions. (IDEO 2010)



Source: IDEO – Mosaic Learning Partners Blog

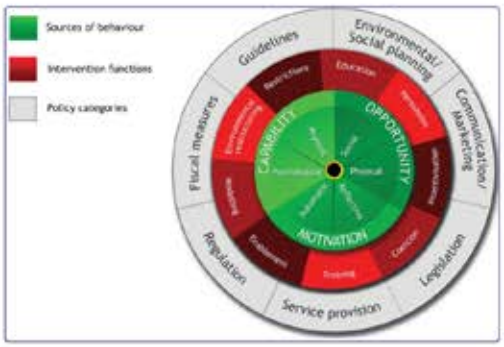


Source: http://www.christopherswantz.com/process/

5.2 Behaviour Change and Design

There are many ways to influence behaviour for better. One such tool that can be used to influence is "Design with Intent Method". It can be used as a tool for influencing user behaviour. The whole Swachh Bharat Abhiyan if it can be termed as a product, service or a system where users' behaviour is very important for its operation. Or can this be designed in such a strategic manner that it can alter the current behaviour of (current sanitation practices) towards a particular target behaviour. The method can also be a suggestion tool, inspiring design solutions by taking suggestions from these particular target behaviour. (Michie et al. 2011) had proposed new framework is a 'behaviour system' involving three essential conditions: Capability, Opportunity, and Motivation. This forms the hub of a 'Behaviour Change Wheel' around which are positioned the nine intervention functions aimed at addressing deficits in one or more of these conditions; around this are placed seven categories of policy that could enable those interventions to occur.

The COM-B system - a framework for understanding behaviour.



The Behaviour Change Wheel.

(Thaler, 2009) have used yet another very interesting Theory that has been used by many corporates and organisations. This Theory namely Nudge Theory is being used by many Behavioural Economics experts to find out about decision making patterns taken by many people in making choices for their day to day lives. Countries like the UK and US have set up Nudge Units which help governments design incentives so that individual behaviour is nudged in a particular direction. These techniques are already used to a great extent in the field of online marketing and other such consumer driven models. But given a chance this theory can indeed help the government deal with such challenges that are rooted in human behaviour or social realities (Livemint, 2016).

5.3 User Centered Design

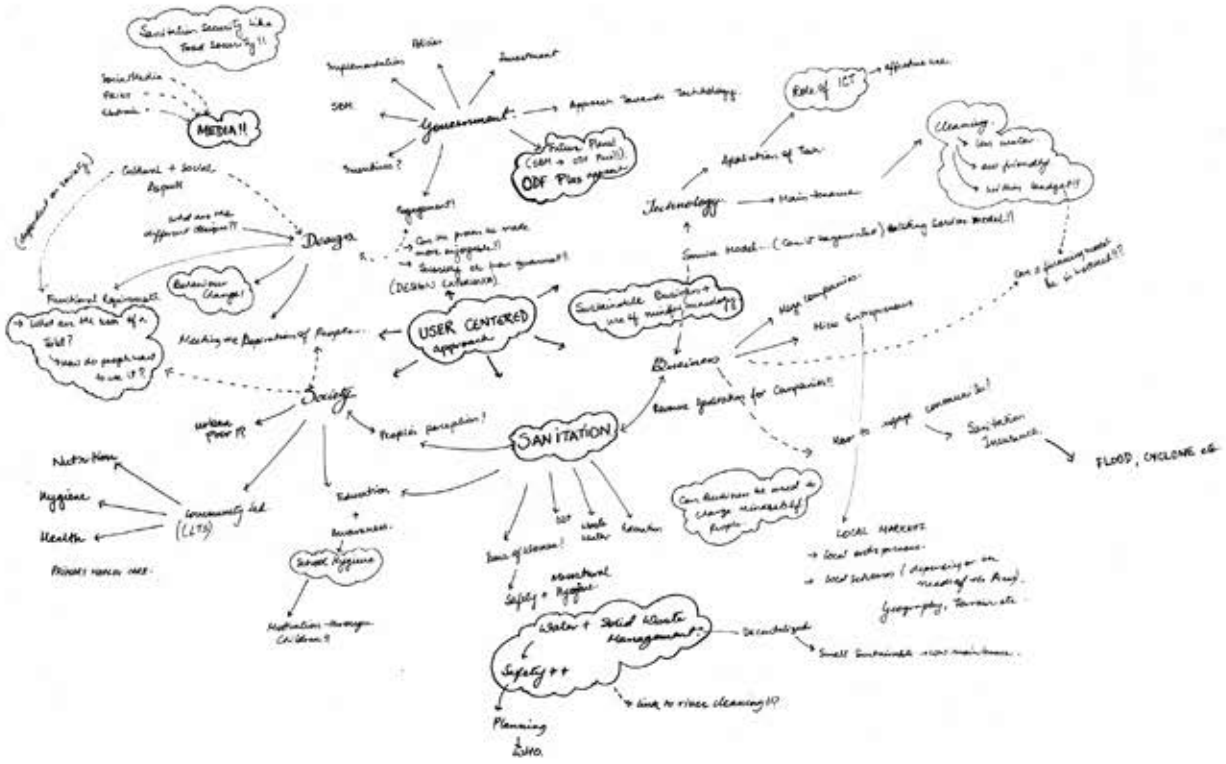
Normally the term User Centered Design is used in relation to Human Computer Interaction but here if it can be used in the context of sanitation numerous out of the box ideas could be thought about. Considering the toilet as an Interactive Product it could be and felt that various layers of interaction take place between the user and the product.

And using the term user here itself has a lot of thought to ponder upon. (Abras et al 2009) have considered it necessary to think carefully about who the user is and how to involve the users in the design process. Many consider users as the people who use the product to accomplish a task or goal but there are different categories of users as well. Eason (1987) considered three types of users: primary, secondary, and tertiary. Primary users are the ones who use the product; secondary users are those who might occasionally use the product and tertiary users are the persons who either make decisions about the purchase of the product or might be affected by the use of the product. For the successful design in the context of sanitation these wide range of stakeholders should be taken into account. Once the stakeholders have been identified the needs can be analysed and alternative solutions can be

design which can be further evaluated by the users. This feedback loop amplifies designers understanding of the intended purpose(s) of the product, artifact or the service that is being designed.

5.2 Research Work Initiated

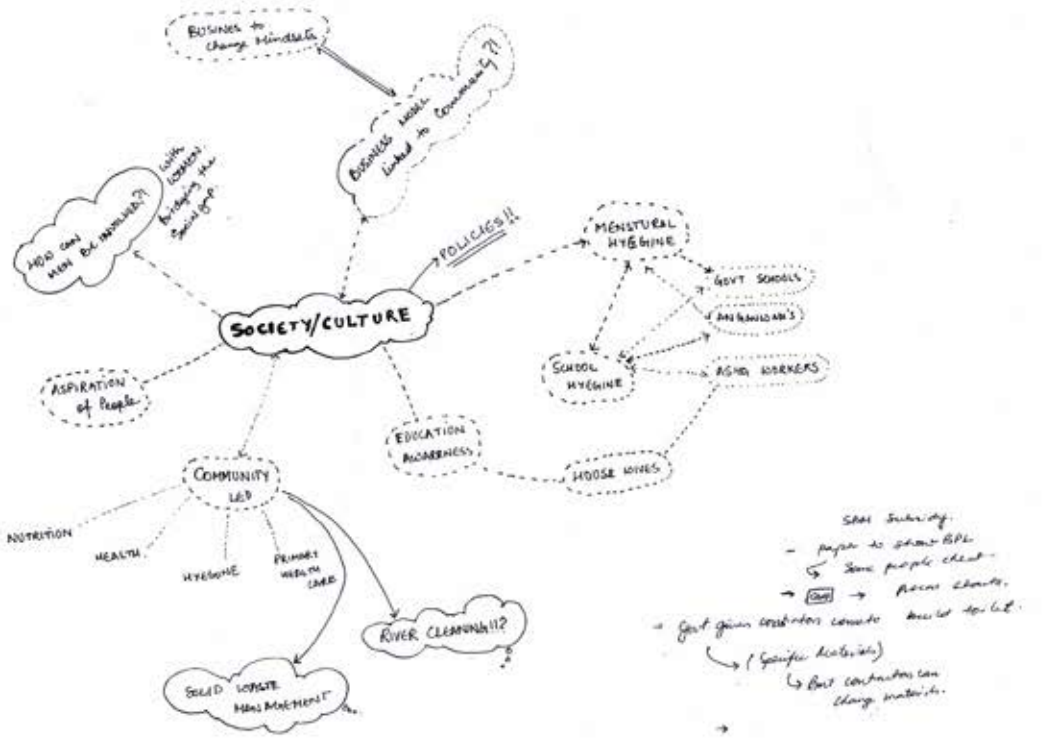
The background study was carried out to understand sanitation and the different areas which are connected to this field. The following Mind Map gives an overview about the probable linkages that need to be understood to ensure that interventions are both meaningful and sustainable.



5.3 Understanding individuals and community

In order to understand patterns of Individual behaviour of various stakeholders different set of qualitative and quantitative interviews needs to be conducted.

To conduct these interviews a pilot survey needs to be done which helps in getting an overview of the in depth survey has to be conducted. This initial survey will not only help in rapport building amongst the community and the individuals but also help in further design of the surveys in such a way so that accurate data can be easily collected.



5.4 Understanding an Individual and the dynamics of thinking

Proper design cannot be done if the users of the particular policy, product, service cannot be understood. In order to have an in depth knowledge and understanding about the user a human centered approach or a design thinking approach is very much required.

The interview need not be closed questions rather these can be open ended questions or even better conversations where one can express his/her feelings in free flow.

Once the interview is done there has to be Observations that is to be noted down, the problem area that is required to be identified, the Opportunities that can be harnessed and the Needs that can be catered to.

Once the interviews are done the data collected is to be converted to map out personas of different stakeholders. The Personas will represent a particular segment of users which will include motivations, aspirations, drives/blocks of the users that needs to be analysed.

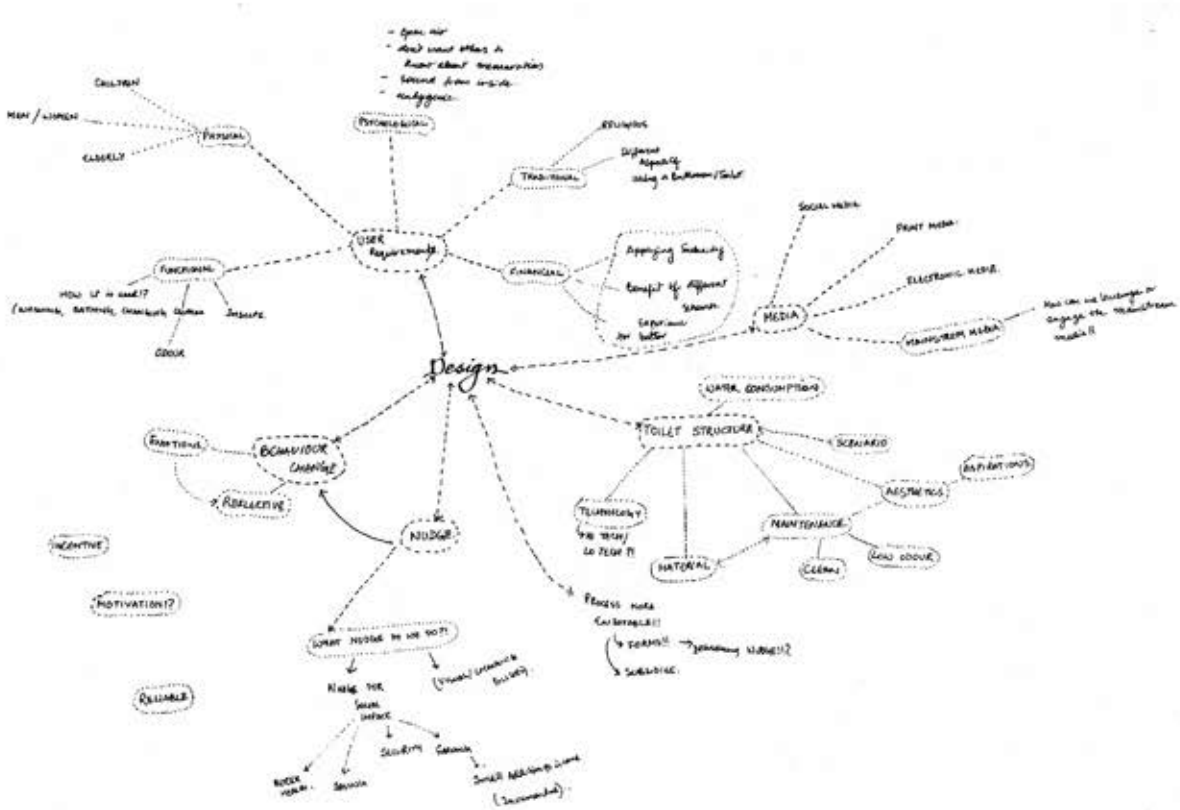
5.5 Behaviour Change and Applying Nudge Principles

User personas would be developed which would be the foundation for design of sanitation interventions. The personas will represent the overall stakeholder in area that the product will cater to. These personas will give us an idea of the existing patterns of behaviour and where there may be changes that is necessary. The more rigorous the previous exercise is the better we will be able to pinpoint the patterns and pain points. With the patterns and pain points appropriate Nudge Principles need to be identified and applied. The nudge applications can be done for better adoption of technology, behaviour change in community level as well. Various other behaviour change tactics that can be applied are use of media, engaging children and women for bringing change. Use of Media, Films, Folk Culture,

Stories, Cartoon etc can be some of the examples where conscious attempts can be taken for change in behaviour.

5.6 Determine appropriate technology for design of toilets

Once individual behaviour, community behaviour and cultural aspects of sanitation are understood, it would be appropriate to choose a combination of sanitation technologies and sanitation design which would be acceptable to the community and address their aspirations.



6. Outcome of Thesis and Impact

The outcome of this research would be an Actionable Design Framework which multiple stakeholders could use to implement Design Thinking based Rural Sanitation. The Actionable Design Framework for Sanitation could be used by (a) policy makers to formulate coherent and holistic policies (b) NGOs to catalyse community involvement and

create behaviour change by (c) local government to effectively implement innovative sanitation infrastructure

The thesis will also come up with insights which could be useful for social scientists studying knotty social transformation issues in communities which have great diversity and where there are deeply embedded attitudes and value systems.

The research study will also take up in depth study of sanitation interventions from a social, cultural and technological perspective and come up with a menu of design interventions that could be adopted in a mode that promotes entrepreneurship, livelihoods and ecosystem management.

7. Timeline

Annexure I

COMPARATIVE STUDY OF VARIOUS TOILETS

TYPES	COUNTRY/ AREA USED	MATERIAL USED	PREFAB	ODOUR CONTROL	TECH USED/PROCESSING	COMPOSTING FERTILIZER/ ENERGY RECOVERY	WASTE PROCESSED OFF SITE	CONSUMABLE	ENERGY USED	WATER USAGE/RECOVERED	LIFE/USERS PER DAY	COST/BUSINESS MODEL
AEROSAN	USA/HAITI	Vinyl Billboard Fabric		Yes	Passive ventilation dries and reduces volume, odour released at a higher elevation (4.3m) above ground.	Can be done.	Yes.	No	Wind & solar driven/No	No /No.	4 - 8 yrs/10 - 20 users per day	Direct Sales
ASIAN INSTITUTE OF TECH	Lab testing		No		Solar septic tank and applying high temp for anaerobic digestion and Hydrocyclone toilet. Separated liquid treated by electrochemical technology.	Fertilizer from hydrocyclone toilet/Bio gas can be done.	No	No	Solar	Yes for flushing/ Yes recovered	10+ yrs/4-10 per day	User fees.
BEIJING SUNNY BREEZE	China	Screw ball assembly	No	Yes	Dry faecal sludge and heat sludge and kill pathogens. (Blowing hot air rapidly)	Yes dried faecal sludge can be used.	No	No	Solar / electricity in non solar area	No	10 yrs/ 5-6 users	
BIOFILCOM	Ghana		Digester can be installed to existing system	Yes	Aerobic decomposition by natural microorganisms used (earthworms, beetles, snails, black soldier fly)	Composting can be done where the waste is dumped.	Yes	No	No	Water filtered and returned to land.	10-20 yrs/10-20 per day	Direct sales and user fees also.
CALTECH	Showcased in Delhi	Steel	Can be Fitted to ERAM		Electrochemical reactor to oxidize organic waste and bacteria.	Phosphates , nitrates	10% waste processed off site.	Salts needed for electrolysis	Electrical energy	Yes	20yrs/ 5 -50	
Climate Foundation, Cornell University	Kenya			Yes / carbon filter	Conversion of human waste into biochar using pyrolysis at community scale facility	Biochar, approx. 10 g/user	Community processing	No	Electricity generated by pyrolysis used.	Yes	10 yrs/ 2000-4000 per day	Service charge waste processing
Cranfield University	Lab test	Polymer bags to contain waste.	No	Yes	Rotating mechanism transport. Biodegradable polymer for solids coating, Mechanical screw for solids transport, Low glass transition membrane for dewatering	1gm / user	Water to be processed off site./ ash waste to be disposed.	Yes / polymer bags	Bicycle generator or hand crank	No	7 - 14 yrs/ 10 users	Individual sales
DRDO Biotoilet	Parts of India	No	No	Yes , P trap used	Biotank where raw sewage digested and the effluent water from the tank treated using reed bed, a natural filtration bed.	No	No	No	No	Yes needed to flush/ 80% recovered	30 yrs	Community based
Delft			No	Yes	Plasma gasification, electrochemical fuel oxidation, biological layer filtration.	10 tons ash fertilizer/yr	Recycled	Sand, absorbents for gas	Self generated.	2000L per day	7.5 - 10 yrs/ 400u/d centre 50000u/d	$400000
Duke University	With Eram	Eram	No	Yes	Anaerobic digester, heat sterilization powered by biogas.	Biogas 20L/u/d	No	No	Self generated	Developed	20+ yrs/ 10-30	$1000 system $1500 whole
Duke and Missouri	Testing at Duke		No	Yes	Thermo chemical oxidation at high temp and pressure.	No	No	No	Self generated	95% water recovered	20yrs/1200u/d	$300 - $ 500

Eawag Design by EOOS	Tested at Kampala Uganda		No	Portable	Electrolysis to remove the urine's colour and prevent pathogen regrowth. processing with biologically activated membrane reactor.	Yes, urine and faeces are processed at the Recovery Plant	No	No	solar panel on-site system, providing electricity	60 Litres of water and afterwards less than 1 Litre/day	Toilet 7-10 yrs/ 10-12u/d RRP 20yrs /800-1000u/d	
ERAM	Trivandrum , India	Steel	No	Yes	Seat sterilization system, Power flushing system. The exhibit also requires civil base construction before installation.	Not generated	No	No	Electricity	Water for flushing, seat cleansing, floor washing	10 - 15 yrs/50-120u/d	User fees and advertisement revenue.
The Earth Auger: Urine Diverting Dry Toilet	Ecuador		Maybe	Little odour	foot actuated compost mixing and movement, optional dry flush and sawdust addition operations. Excreta handling is not needed; the whole process is pedal-operated until harvest, when material is automatically stored in attached bag. Typical decomposition via compost bacteria.	120g compost, 0.25Lurine/user/day	Yes, some storage is required to achieve pathogen destruction.	Yes, sawdust, other organic material or ash is mixed with faecal solids	No	No	5+ years./5users	Direct sales is the anticipated business model
IIT KANPUR BINOD TARE	Testing and demonstration			Yes, Deodourizing agents, Polymer, Enzyme, Microbes	Solid and liquid separated underneath the toilet seat using a solid-liquid separator which allows formation of a thin water film that adheres to the surface of the separator and flows outwardly while most of the solids gravitate. Solids disintegrate to form slurry, then fed to the bio-composter. Liquid clarified adopting flocculent settling using enzymes and polymers. Liquid is recycled for flushing the toilets.	Conversion of faecal matter to quality organic manure Nitrogen, Phosphorus and Potassium recovery from flush water. > 90 % of nutrients and > 40 % organic matter	No	Yes, polymer,	No	Water reused.	25-30 Years/	$6,500 [set of 4 toilets excludes processing plant] $0.05/user/day [per use]
LOOWATT	Proven through product launch madagascar	Biofilms, plastic	Can be fitted to existing	Yes	Simple sealing apparatus and emptying in the local digester; in the digester they relate to heating, mixing and other internal functions.	Anaerobic digestion, aerobic thermophillic and vermicomposting in the posttreatment of digestate (the liquid output from AD). 0.5 kg/user/day	Can be done if needed.	Biodegradable films	No	No	5+ years/Up to 100 uses per toilet between service calls.	$95 USD (toilet) $1000 USD (digester)
NUS	Lab testing going on		No	Yes,	Pyrolysis/combustion is used for processing. For evaporation of urine and condensation of vapor; solar drying of faeces using Fresnel lens; solar pumps for water transfer; Solar LED for lighting and disinfection; forward osmosis process for diluting fertilizer.	Fertilizer: 0.1L/user/day	No	Charcoal/wood chips are used to initiate pyrolysis/ combustion, and sawdust is used for odour control	All energy available in the faeces and urine will be recovered and used by the system.	Recovered 1L/user/day.	10-12 years/ 40-50 users	US$0.01 – $0.02 per user

RTI International	Lab experiment			Water sill	Solid liquid separation and solid waste drying via convection, electrochemical disinfection of the liquid waste, combustion of the solid waste, and thermoelectric energy harvesting.	No	No	No	Energy generated (100% neutrality)	Water supply may be added for hand washing and anal cleansing	10+ years	$0.01 – 0.06/user/day (max of 50 users per day)
Sanergy Fresh Life Toilet	Nairobi slums			Modular	Collects the faecal sludge from its network of 310+ Fresh Life Toilets in Nairobi, Kenya. Sanergy aggregates the faecal sludge – 5+ tons per day – and converts into a variety of useful by-products. The predominant by-product is organic fertilizer.	Biochar Animal Feed Struvite Blue Diversion Toilet Biogas Ammonia Disinfection					5–6 years/80-120 users/day $0.04-$0.08/user/day	$100-300 User fees for Fresh Life Operators By product Sales for Sanergy
Santec	Lab experiment				The content will go through an initial gravity filtration to separate the liquid and solid content. The solid content will be retained in a suspended basket post-filtration, while the liquid content will flow under a partition wall and be stored in a second chamber. When the unit processing chamber and the secondary unit liquid holding container has reached the 30-person process capacity, the unit will initiate a process cycle.	Dewatered solids can either be safely used as fertilizer or used in a subsequent bio-energy generation process.	No	System will require minor routine maintenance of component parts.	Provided by solar	75L of water for initialization; afterward recovered.	Low: 10 Years High: 15 Years/ Users Low 10-15 High: 45-60	$0.035/user/day
Stone India Limited KOLKATA	India			Bio deodourizer	Mechanical process used for gradual holding and Bio treatment of the waste for complete digestion. Aerobic bio digestion process using multi strain Aerobic Bacteria for the complete digestion of the waste is used.	Waste that enters the Bio digester is fully converted into fertilizer	No	Bio Media, Bio Cleaner, Disinfectant	Pumping water.	Flushing	20-25 Years/30 people a day	$650 - $1950 $0.003/user/day
SULABH	Pan India	Various			Two Pit Pour Flush Toilet Pan with a steep slope of 25 to 28° and a specially designed trap with 20 mm water seal, requiring only 1 to 1.5 litres of water for flushing. Pits are used alternately.	The digested sludge is good manure & soil conditioner.	Agricultural fields	No	No	Water required for flushing.	Two Pit Pour Flush Toilet: Each pit 3 yrs	US$ 20 –US$1000 per household unit.
University of Colorado Boulder		Demo phase		Yes exhaust fan	Solar powered pyrolysis is used to convert faeces into char and other by products.	Up to 80 g char/person/day and 1 L treated urine/user/day	No	No	Solar energy	Washing	20 years 4 users/day	$0.03 – 0.23/user/day
Ecolet	Australia	ABS Plastic and stainless steel.	Can be done.	Fan used	Composting involves the biological decomposition of organic matter using natural occurring organisms such as bacteria, fungi and other small organisms into compost which is a humus like product.	Yes	No	No	For heater and fan	Less		
TIGER TOILET (SOLDIER FLY)	India	Field	Prefab		Worm based digester. With different layers for filtration.	Yes, vermicompost	No	No	None	Yes	8 to 10 yrs	Similar to twin pit.

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