

GLOBELICS
WORKING PAPER SERIES
THE GLOBAL NETWORK FOR ECONOMICS OF LEARNING,
INNOVATION, AND COMPETENCE BUILDING SYSTEM

SDG-6 in India: Challenges and
innovation for sustainable sanitation

Manjari Manisha

Working Paper

No. 2018-05

ISBN: 978-87-92923-31-8



SDG-6 in India: challenges and innovation for sustainable sanitation

Manjari Manisha

Academy of Scientific and Innovative
Research (AcSIR), CSIR – National
Institute of Science, Technology and
Development Studies, New Delhi, India

SDG -6 IN INDIA: CHALLENGES AND INNOVATION FOR SUSTAINABLE SANITATION

Manjari Manisha, Academy of Scientific and Innovative Research (AcSIR), CSIR – National Institute of Science, Technology and Development Studies, New Delhi, India

ABSTRACT

The Millennium Development Goal (MDG) stipulated cut-off date expired in December 2015 but inadequate sanitation remains a big challenge in India. Inadequate sanitation has a multidimensional negative impact on children’s health, education for girls, the environment, social dignity and national as well as individual economic growth. For children inadequate sanitation gives rise to infectious diseases like diarrhea, typhoid and regular illness resulting in chronic malnutrition, stunting, physical and cognitive disorder. Sustainability is one of the key features to win universal access of sanitation that has social, technical, financial and institutional challenges at every step of the way. A present pathway to improve sanitation is limited to constructing the toilets with little consideration of collecting excreta, transportation and its treatment. The innovation systems framework gives us an effective way to view the systemic linkages and processes, to understand the global challenges in sustainable sanitation. Sanitation is not merely about technological innovation, i.e. inducing new technology, but about social innovation, i.e. “adopting” and “using” the technology with stronger emphasis on sustainability. Social innovation will lead behavioral change and combat structural rigidities that are present in the society such as caste, social class, gender disparities, power, prestige, beliefs, superstitions etc. These can be combated by consistent and continuous advocacy to sensitize the masses/communities, particularly on the deleterious effects of lack of sanitation on children’s health, women’s dignity, pride and privacy, etc. to bring the mass transformation of mindset. Sustainable sanitation requires the integration of social, environmental, technical, financial and institutional sustainability and innovation. Unfolding the background of sustainability with allusion to the Sustainable Development Goals (SDGs) by studying and analyzing the current situations in India, this paper systematically explores the multidimensional impact of inadequate sanitation, the structural and functional challenges that may hamper the expected outcomes of Sustainable Development Goal-6 and attempts to propose a theoretical framework to represent pathways of sustainability and answer the challenges of sustainable sanitation with the lens of the

innovation system, and put forward recommendations with practically achievable solutions useful for government, policy making agencies and private sector practitioners. Increased sanitation coverage will have significant positive spillovers on many of the other SDGs and targets.

Keywords: Sanitation, Sustainable, Health, Innovation, Social Innovation

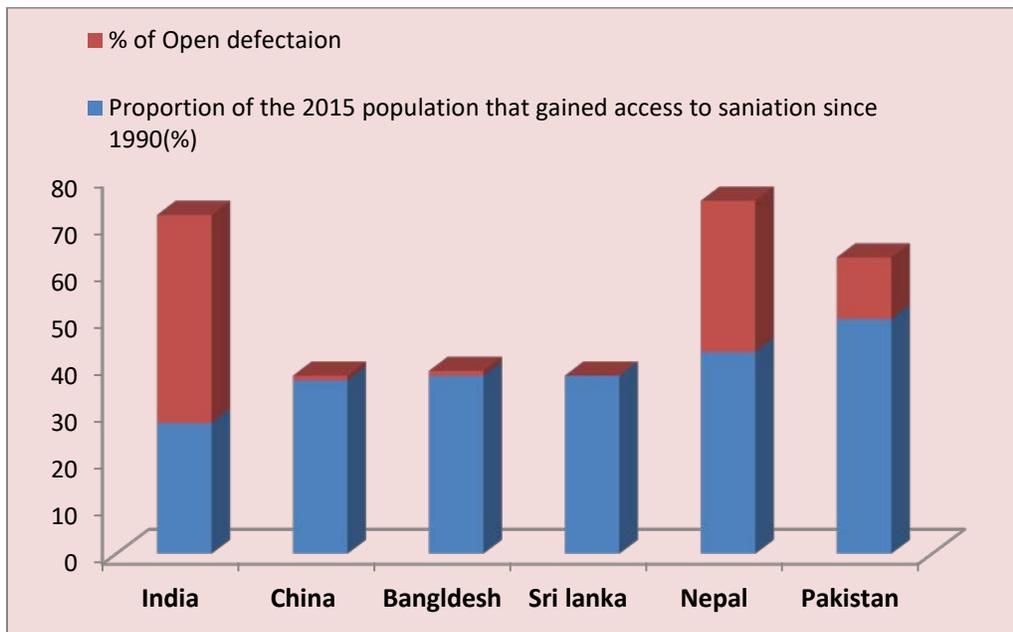
INTRODUCTION

Despite the fact that access to water and sanitation are known as integrated elements of National development, the most valuable public health intervention and fundamental need of human being remain a major concern in India and in many others developing countries. In 2000, India signed United Nations Millennium Development Goals (MDG) that includes 8 goals, 21 targets and 60 indicators and reached its deadline in December 2015. The MDG-7 target was to halve the proportion of the population without access to safe drinking water and basic sanitation that may play a significant role to achieve the target of MDG-4 i.e.; reduce child mortality rate. But India has made "moderate progress" and failed to achieve it as compared to its neighbor countries like China, Bangladesh, Pakistan, Sri Lanka that have made good progress (UNICEF & WHO,2015). Figure 1 shows that between 1990 to 2015 more than 35 percent of the population of India's neighbor countries gained access to adequate sanitation and the open defecation rate drastically came down. In contrast only 28 percent of the population of India gained access to adequate sanitation and the open defecation rate is still a concern, compared to other countries. During the MDG periods though the open defecation rate had declined in all regions, access to improved sanitation among urban, urban slums and rural regions are considerably different. In India, access to improved sanitation is greater in urban areas than rural and urban slum areas. Worldwide 96 and 82 percent of the world's urban population has access to safe clean water and improved sanitation facilities and 82 and 51 percent of the rural population, while in India according to 2015 data 44 percent of the population still defecates in the open in which 10 percent belongs to urban areas, 61 and 67 percent belongs to rural and urban slum areas respectively (UNICEF & WHO, 2015). Rapid urbanization due to increased migration of people from rural areas to cities for employment over the last century (from 25 million in 1901 to 1326 million in 2016 constituting around 32.4 percent of the total population in the country) led to overcrowding of

cities especially that of urban slums in India. At present, 17.7 percent of the urban population lives in slums¹ (Census, 2011) http://www.censusindia.gov.in/vital_statistics/SRS_Reports).

Urban areas have failed to meet the demands of this increasing population pressure resulting in large gaps in provisioning of basic amenities like water and sanitation facilities. The access to basic sanitation, drinking water and health of the urban slum is significantly worse than the rest of the urban population and is often compared to the health conditions in rural areas (Islam et al, 2006; Montgomery & Hewett, 2005). Despite the fact that several national and international programs were launched over time to increase the coverage of sanitation, rural and urban slum India shows sluggish and uneven progress and still has a long way to go.

Figure 1. Proportion of the 2015 population that gained access to sanitation since 1990(%) and open defecation: percentage of population in 2016.



Source: Compiled from UNICEF and WHO Report 2015, Progress on sanitation and drinking water, update and MDG assessment and World data Atlas data base.

¹

Slums are characterized by crowded living ambiance, unhygienic environment and lack of basic amenities such as garbage disposal facilities, drainage system, water and sanitation. (MHUPA, 2010)

India needs to bridge the gaps in access to sanitation among urban, rural, urban slum, rich and poor. MDG did not focus much on sustainable development, sustainability challenges, and innovation system. A new set of transformative "Sustainable development goal (SDGs)" as well as "Swachh Bharat Mission" adopted by India intends to make a "clean India". Sustainable Development Summit held on 25 September 2015 carried forward to make MDG sustainable with a slogan of achieving sustainable development goals. UN member States signed the 2030 agenda for Sustainable Development, which consists of 17 goals. The SDGs-6 renews efforts to ensure availability and sustainable management of water and sanitation for all by 2030. Any national or international program cannot achieve its target until understanding the sustainability challenges and focusing on innovation system framework to address the challenges. There is clearly a need to call policymaker and professionals to better anticipate inadequate sanitation risks and the consequences of increasing the national financial burden, poor children's health and hammering social dignity.

This paper presents an exploratory analysis of the impact of inadequate sanitation in consequence with different dimensions and identifies and addresses the challenges which are a hindrance towards the pathway to achieve sustainable development Goal-6 using the innovation system framework.

Objective:

1. To study the impact of inadequate sanitation and its consequences for national development.
2. To identify the structural and functional challenges that hamper the expected outcomes of Sustainable Development Goal-6.
3. To design a theoretical framework/pathways to sustainable sanitation using the innovation system to address the challenges.

SANITATION: A PROBLEM

Inadequate sanitation has a multidimensional negative impact on children's health, education for girls, the environment, social dignity and national as well as individual economic growth. All

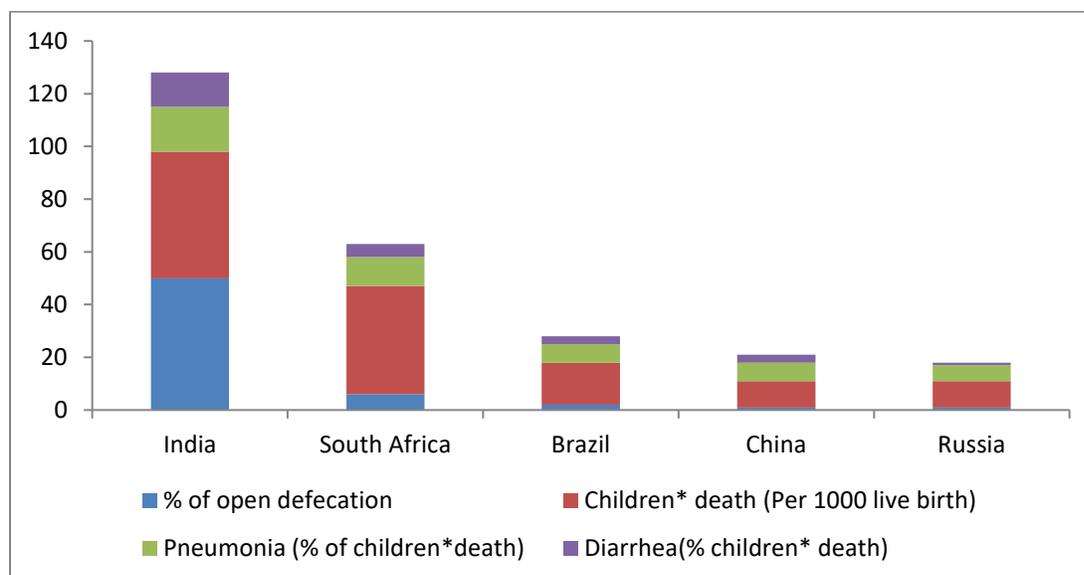
over the world, people at the bottom of the pyramid are deprived of sanitation and technological solutions. Unhygienic living conditions trigger a propensity to fall sick more often and increased recovery time and costs. The lack of sanitation gives rise to infectious diseases like diarrhea, cholera, typhoid, intestinal nematode infections, poliomyelitis, waterborne viral hepatitis, trachoma, etc., are mainly caused by enteric pathogens including viruses, bacteria, and parasites that primarily or exclusively transmit by the faeco–oral route leading to higher public cost for treatment and productivity loss. In India, infectious diseases share 31.9% of the total burden of diseases in which 10% are transmitted by fecal-oral route (NCMH, 2005). In India, diarrhea, the second leading contributor to the global disease burden, caused the deaths of more than 2 million children younger than five years per year, accounting directly for 12.6 percent of child deaths (Liu et al 2012). The World Health Organization (WHO) estimates that in 2011 around 240 million children in India needed preventive chemotherapy treatment for soil transmitted helminth² and in 2013³ more than 1 million children suffered from typhoid associated with inadequate sanitation. Also lack of clean air and environment in poor ventilated living condition would lead to respiratory disease such as pneumonia, tuberculosis, asthma, chronic respiratory disease, etc. In India, every year there are more than 4 million episodes of severe pneumonia and 0.32 million of all causes of pneumonia deaths occur in children younger than 5 years (biggest killer).

Figure 2 shows a correlation between the percentage of open defecation and under-five children deaths and death caused by diarrhea and pneumonia among BRICS countries. In India, high rates (50%) of open defecation may be one determinant for the high rates of sanitation-related diseases. In other countries such as South Africa, Brazil, China and Russia the open defecation rate is much lower and consequently the number of children’s deaths and occurrences of diarrhea and pneumonia are also lower than in India.

² http://www.who.int/neglected_diseases/preventive_chemotherapy/sth/en/

³ <http://cbhidghs.nic.in/writereaddata/mainlinkFile/Health%20Finance%20Indicators-2013.pdf>

Figure 2. Percentage of open defecation, Children’s deaths, and deaths caused by pneumonia and diarrhea among BRICS countries (2015). (*Children under 5 years).



Source: Compiled from World Bank Data. Available at: <http://data.worldbank.org/indicator/SH.DYN.MORT>

In India inadequate environmental sanitation, hygiene and quality and quantity of water is also responsible for the highest contribution of malnutrition and stunting prevalence in the world that damages cognitive functions, physical development, and immune systems and contributes to poverty by impeding people's ability to lead productive lives (Schmidt,2014; Dobe, 2015). An expected 50% underweight or malnutrition is associated with repeated diarrhea or intestinal nematode due to insufficient sanitation and absence of safe drinking water (Prüss et al. 2008, UNICEF, 2011). Table 1 shows the global and Indian figures of underweight, stunted growth wasted and severely wasted children. A child in the urban slum and poorest household are more than twice as likely to be malnourished as a child in the richest household.

Table 1. Global and Indian number of malnourished children and worldwide Indian contribution in percentage (2015).

Children under five years	Global (in millions)	India (in millions)	India (in percentage)	Total worldwide contribution of India (in percentage)
Underweight	99	56	48	56.5
Stunting growth	161	62	51	38.5
Wasting	51	16	13	31.37
Severe wasting	17	4.5	4	26.4

Source: http://www.worldhunger.org/articles/Learn/child_hunger_facts.htm

Various studies reveal that sanitation, hygiene, and improved water supply helped reduce the morbidity and mortality due to infectious diseases to a great extent. (Prüss et al ,2002; Nath, 2003; Mara et al., 2010). In India, Mizoram declared as an open defecation free state reported a 13 percentage-point decline in stunting and five percentage-point decline in underweight children. Jharkhand, Bihar, Uttar Pradesh were reported as the highest open defecation states accounting for 58, 72 and 73 percent respectively, and this also contributed to the highest malnourishment accounted for with 42, 37 and 32 percent as well as stunting 47, 49 and 50 percent prevalence respectively.⁴

IMPACT OF INADEQUATE SANITATION ON EDUCATION

Worldwide, one in five children between the ages of 10 and 15 are out of school (UNESCO, 2010) just due to inadequate and unavailable sanitation facilities. Girls in developing countries drop out of school, particularly around puberty, due to the absence of sanitation facilities in many schools worldwide. The absence of sanitation facilities in schools not only cause girls to miss school on their menstrual days but may also be responsible for verbal and physical harassment. Parents do not want to allow their girls to go to school at the pubescent age if

⁴ <http://www.indiaspend.com/cover-story/mizoram-shows-how-good-sanitation-can-reduce-child-malnutrition-78057>

sanitation facilities are not available (Kirk & Sommer, 2006; World toilet day advocacy report, 2014). Girls need privacy and safety at any place but the unavailability of sanitation facilities in schools excludes them from completing their education and creates gender disparity in education. A study undertaken in Bangladesh revealed an 11% increase in girls' enrolment mainly due to the provision of sanitary toilets (Technical paper series/IRC⁵).

In rural and urban slum areas illness due to repeated episodes of diarrhea and worm infection may be also a significant reason to miss classes. The interrelation between sanitation and education has not been understood in depth with respect to child education improvement. In most of the literature, inadequate access or unavailability of sanitation facilities in school has not been listed as a reason for rising drop-out rates for rural/urban slums girls. School sanitation has traditionally been neglected, but now the "Swachh Bharat Mission" initiative also focuses on providing sex-specific latrines in all government schools.

ECONOMIC AND SOCIAL IMPACT OF SANITATION

Inadequate sanitation causes increased national financial burden associated with the direct costs of treating sanitation-related illnesses, lost income through reduced or lost productivity, incomplete education of girls, access time as additional time needed for accessing shared toilets and open-defecation sites compared to using a private toilet within the household, and tourism impacts include potential loss of tourism revenues and the economic impacts of gastrointestinal illnesses among foreign tourists. A World Bank study reveals that inadequate sanitation in India amounted to a loss of 2.4 trillion (\$53.8 billion) in 2006, in which health share the wider loss accounted to 1.75 trillion (\$38.5 billion), which was 72 percent of the total impact and access time and tourism contributed 20 and 0.5 percent. In purchasing power parity (PPP) terms, the adverse economic impact of inadequate sanitation in India was \$161 billion, or \$144 per person. These economic impacts were the equivalent of about 6.4 percent of India's gross domestic product (GDP) in 2006 (World Bank, 2011).

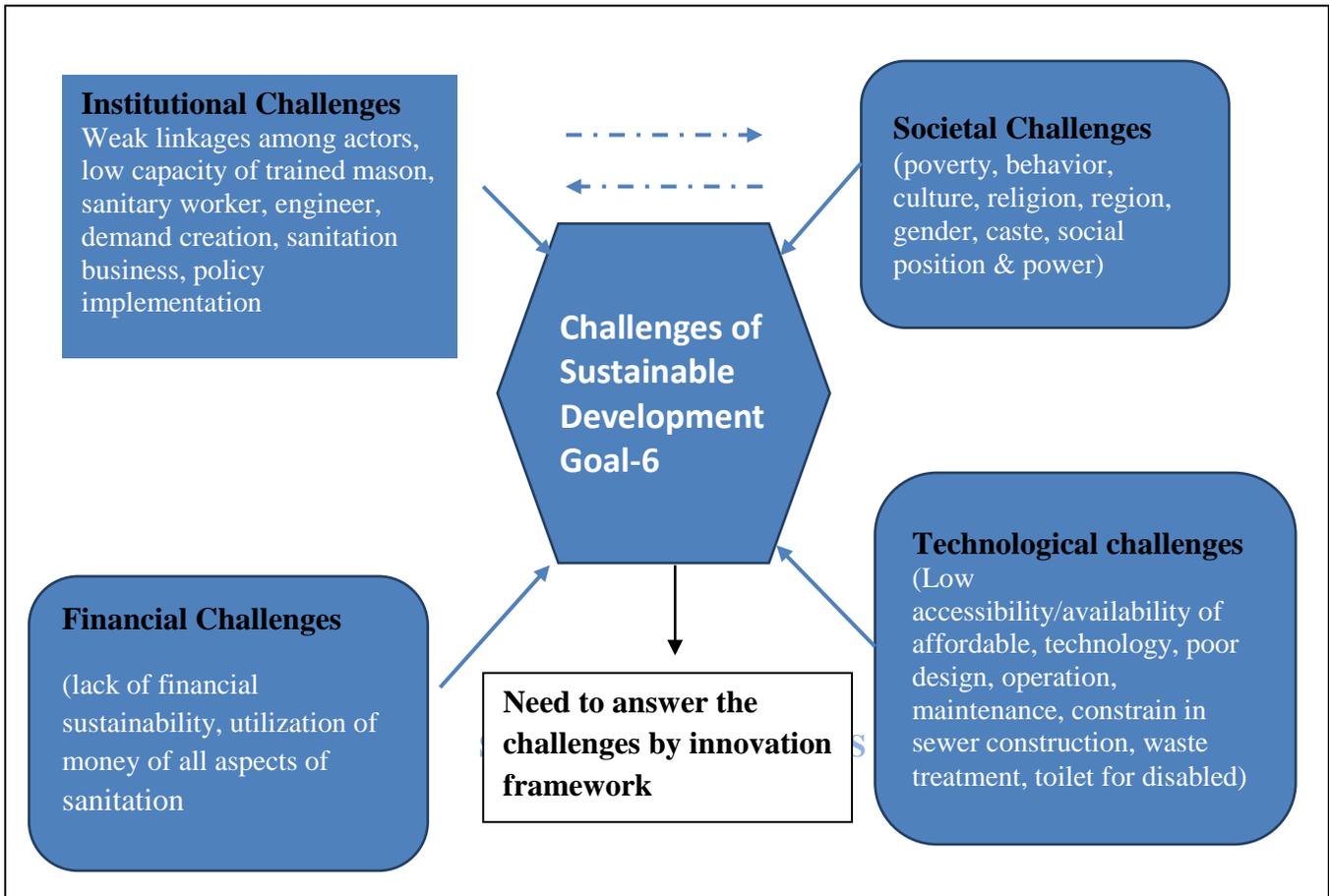
⁵ <https://sanitationupdates.wordpress.com/2015/01/20/yes-hygiene-and-school-enrolment-are-directly-proportional/>.”

Inadequate sanitation facilities also directly correlated with the increased risk of social issues such as rape and sexual harassments of women. There are several cases reported by the media on women assaulted and raped when they go outside to defecate in the early morning or late evening. In Bihar, more than 870 assault instances are reported just due to an absence of sanitation facilities in 2012 (Tewary A, 2013). In Uttar Pradesh two young women were stuck and murdered, when they were looking for a private spot to defecate (Soutik B, 2014). Whereas this story stood out as truly newsworthy, the truth of the matter is that many women face provocation, attack, and assault when looking for some measure of privacy. The open defecation pattern not only exposes women to dangers of sexual assault, but also to snakes, insects, scorpion bites, as well as mosquito borne diseases.

CHALLENGES IN SDG-6

Sanitation is a multidimensional problem including social, technical, financial and institutional challenges. Present pathway to improve sanitation is only limited to constructing the toilets with less focus on sustainability scale and without considering collecting excreta, transportation, and its treatment. There is also low attention given to the sewer construction and water availability, advancement, and improvement in waste management. Low political interference in service delivery, maintenance, human resource development, behavioral change, new knowledge creation, and the unstructured national programs are key challenges of sustainability. This section systematically deals with challenges that may hamper the pathway to sustainable sanitation.

Figure 3. Challenges in Sustainable Development Goal-6: A Conceptual framework



Access and adoption of a sanitation facilities is the main problem of poor populations, who live in urban slum and rural areas. India accounted for the largest number of population living below the international poverty line in 2013, with 30 percent of its population living below the poverty line on \$1.90-a per day (World Bank, 2012) and to worsen the situation 0.15 percent population amounting to 1.77 million are homeless (Cencus, 2011). Homeless people live on the street pavements, inside the hume-pipes, under fly-overs and staircases, or in the open places of worship, mandaps, railway platforms, etc. For poor and homeless people, who survive and cope by begging or on low wage jobs, the primary concern is food rather than the use and building of toilets or even spending a single penny for using the toilet. The effects of the poor socio-economic situation may seem obvious through the unsanitary living condition. This raises a number of interesting questions about the SBM program or any other program with mandate to construct infrastructure; *How do these programs create belief to use toilets with homeless or*

poor people, who suffer every day for food and water even, and who do not have permanent shelter? What are the different pathways to a SDGs-6 and Swachh India?

Socio-economic inequities in society are caused by the unequal distribution of power, income, goods, and services, nationally and locally that determine people's lives, homes, sanitary condition, their access to health care, schools, education and their conditions of work. Unsanitary conditions cause social as well as biological disease, a psychological degradation that lead desperate people to invest their hope in alcohol or worse (Hamlin, 1998). In India the most marginalized communities engage in manual scavenging. It is estimated that around 1.3 million marginalized castes in India, mostly women, make their living through manual scavenging. The manual scavenging term is used to describe the job of removing human excrements from dry toilets and sewers using basic tools such as thin boards, buckets, and baskets. Manual scavengers are treated as untouchables and there is complete social exclusion. This practice is like a black spot in our society that was mainly invented by society itself. Manual scavengers face social, political and economic discrimination. Persons who refuse to do such type of work may face intense social pressure by higher caste groups and are forced to do such work. They are exposed to health problems such as infectious disease, cardiovascular degeneration, and musculoskeletal disorders like osteoarthritis changes, etc. (Rashtriya Garima Abhiyan, 2013). Despite the government act to prohibit manual scavenging, it goes on and the funds allocated for rehabilitation are underutilized. The societal attitude towards the manual scavengers remains a challenge to improve sanitation and public health situation.

CULTURAL AND BEHAVIORAL CHALLENGES

Sanitation is primarily a behavioral issue. Despite having a toilet at home rural Indians choose to defecate in the open, and parents even forcefully send their children to defecate in the open. Water crisis may not allow people to use toilets built at home. People do not want to waste water for toilet use, which they collected it from long distances or spent huge amounts of time collecting it. Some people do not use the toilet because they feel suffocated inside an enclosed room and prefer to go outside to defecate because it provides them with an opportunity to take a morning walk, see their fields and take in the fresh air. Some people do not construct latrines at home because they tend to view latrines as ritually impure and are extremely concerned about emptying pits. Some of the new toilets are being used as storerooms and animal shelter by people

who consider toilets at home unhygienic (Kumar, 2010). Gender disparities also play an important role in open defecation, where men tend to think latrine use do not suit their daily life routine and open defecation are not shameful or a loss of dignity for them. Latrines are meant for females only as they need privacy and security. If females go outside to defecate, they stand up even in the middle of the act, when someone passes but males do not stand up, because they think privacy is not required for them. Females also like to go for open defecation in the evening as they go in groups or in pairs into the fields to chat with their friends/relatives about their daily lives and to feel free from household chores. Females use this time as opportunities to chat with others and disconnect from household chores, relax, socialize, release their stress from family problems and for venting out (Routray et.al, 2015). In a village despite toilets constructed at home old men continued to go outside because they thought: “*How can we go to the toilet that is also being used by our daughters-in-law?*”⁶ If there are more members in a family, toilets are used by just 30 percent of the members, mainly by females, just due to fear about filling the tank, getting dirty and utilization of much water. In some cases females do not want toilets constructed at home either because they fear the additional work load of keeping the toilet clean and as a woman already spends much time on other house hold responsibilities.

In India, open defecation is not only a behavioral problem but also a cultural issue. In the Indian society, the mentality of people do not allow the use of personal toilets by domestic workers, who sweep, mop, clean the floor, washroom and wash the dishes because they are considered “unclean” or “low caste”. Domestic workers have to wait to answer nature’s call until they go home to use the toilet, or relieve themselves in the parks behind the plants⁷. In India access to toilets for domestic workers remains a huge issue that is created by the caste-system embedded in the society. Transgender people also have a social stigma and are often dissociated from the mainstream society and earn their bread and butter through blessings activities at the time of marriage and child birth. In India almost 5 lakh transgender people are still facing everyday toilet challenges as there are few toilets available for these people. Akkai Padmashali, a well-known trans-rights activist and one of the foundingmembers of Ondede, an organization that aims to create awareness about sexuality, sexual diversity and the third gender, stated her

⁶ <http://indianexpress.com/article/india/india-news-india/open-defecation-swachh-bharat-mission-toilets-survey-swachh-bharat-2894143/>

⁷ <https://www.youthkiawaaz.com/2016/12/domestic-workers-no-toilet-access/>

story regarding the use of ladies toilets at Vidhana Soudha in Karnataka on “youth ki awaz”, an open platform.

*“As I entered the ladies’ toilet, a woman screamed in horror and told me, ‘You are not supposed to enter here! This is not a place for you,’ referring to my gender. And she shut the toilet door in anger. I was embarrassed and disturbed”*⁸

Behavioral change of people’s habits of a lifetime is difficult, takes time and requires resources and skill with regards to adopting sanitation and hygiene practices such as the use of toilets, hand wash with soap, and cooking practices. It is now understood that knowledge about germs is insufficient to change behavior due to financial costs, few technology choice as well as social attitudes to open defecation.

TECHNOLOGICAL CHALLENGES

Technology refers not only to a product including infrastructure but also to the knowledge, techniques, and skills that surround its diffusion and use. The success of product technology innovation is dependent on its diffusion and adoption by the society that may improve the way of livelihood (Tsinda et al, 2013; UN-Water, 2015). Sustainability in sanitation certainly cannot be guaranteed only by inducing technology and engineering. The importance of the technical feasibility, affordability and social acceptability are always much greater than that availability of technology in the market. In the case of sanitation technology, a "one size fits all" model cannot fit and be replicated all over so approaches need to be designed according to the need and concern of communities, specific locations, taking into account social aspects, traditions, geographical context, natural environment, institutional and financing arrangements. In rural and urban slum areas mostly toilets with a septic tank have been constructed, and once the tanks are full, creates concerns about emptying it. There is no clear strategy for emptying of latrines, so full latrines develop the risk of overflowing, contaminating the environment with large quantities of excreta containing harmful pathogens and causing offensive smells and diseases (Connell, 2014, Coffey, 2014). Pit/septic toilets generally due to poor construction can collapse, create bad smell after a period of use and can have serious health and environment consequences. Due to poor technology /engineering even newly built toilets get chocked after few uses, which again

⁸ https://www.youthkiawaaz.com/2016/11/no-public-toilets-for-transgender-people/?utm_source=yka&utm_medium=related&utm_campaign=views

forces people to adopt open defecation practices. In some villages where toilets were constructed under the national program, there is no proper running water supply, and excreta deposable systems so people get frustrated with the idea (Coffey, 2014). In India, there are only a few toilets at few places available and accessible for disabled men and women. Toilets constructed for disabled people were often found to be locked down or served as storehouses. No national program has shown much concern about the sanitation needs of persons with disabilities. India lacks sanitation technology considering disabled people. India cannot achieve Swachh Bharat Mission, until it addresses the loophole of the flushing system of the Indian Railways, in which excreta fall straight on to the tracks that are open for humans to cross and come into contact with harmful bacteria responsible for spreading disease⁹. Under the Swachh Rail-Swachh Bharat (Clean Rail-Clean India) programme, railways have planned to install bio-toilets, a technology developed by Defence Research and Development Organisation (DRDO), in every train. 17,000 bio-toilets are installed in trains and there are plans to increase this to 30,000 by 2019. Indian Railways has also installed vacuum toilets in a few trains, at an estimated cost of Rs. 3 lakh. But it is still a long way to go for sustainability as Indian Railways generate more than 6000 tons of solid waste from trains and passengers every day.

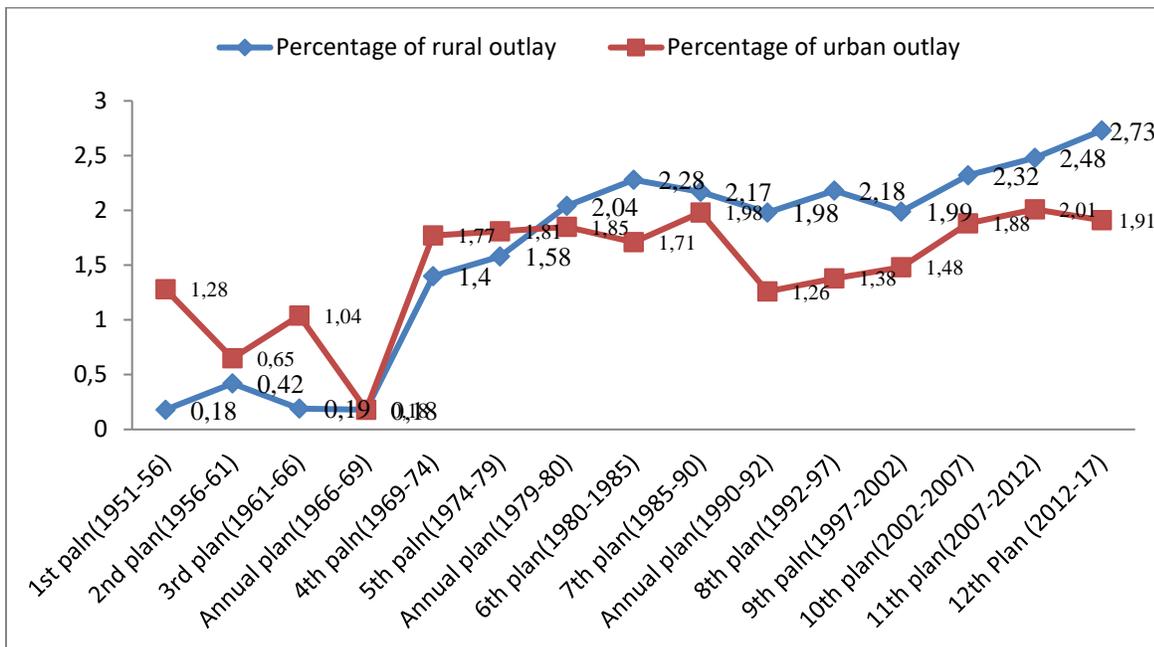
Sanitation is not just a rural problem in India. Even in big cities only 30 percent of sewage is treated and disposed of. According to the Centre for Science and Environment (CSE) 1.2 billion people in India generate 1.75 million tons of excreta per day in which only 22 percent of sewage is treated, while 78 percent is disposed of in open fields, rivers and lakes. Technology design in sanitation is very important for non-contamination as in many cases it can discharge of chemical and microbial contaminants from pit/septic latrines to ground water which may negatively affect human health (Graham & Polizzott, 2013). Toilet infrastructure and sewer construction engineers must look at important elements such as climate, water table, soil characteristics, and distance from drinking water sources etc.. In India very few studies have focused on the above mentioned elements prior to constructing the toilet infrastructure. Sanitation technology must focus on universal constant tap water supply, networks of high velocity sewers, safe disposal/treatment of sewage, and recycling of solid wastes with technically proven engineering methods.

⁹ <http://www.livemint.com/Opinion/fjIFQfc69zbgdmSNPP9BoL/Cleaning-up-Indias-economic-lifeline.html>

FINANCIAL CHALLENGES

Since long, low levels of government investment in sanitation and low political priority have been identified as the biggest barriers to achieve adequate sanitation in India. Until recently, urban sanitation has not been the main focus in most developing countries since the majority of the population lived in rural areas. However, the rapid growth of cities together with the growth of the urban poor and inequities created within cities made urban slum sanitation status worse than rural (Gupta, Arnold & Lhungdim, and NFHS-3, 2005-2006). Though poor sanitation and hygiene were identified as major sources of diseases and epidemics as long back as 1856 during British India, allotment of funds for the water supply and sanitation improvement was negligible; less than 1.5% even after India became independent in its first to fifth five-year Plans. Only in the sixth five-year Plan (1980–1985) amid the international decade for water supply and sanitation, the allocation was expanded to more than 4%. Urban water sanitation supplies (UWSS) were moderately higher in the rural area until the fifth five year Plan (1974-1979). However, since the Annual Plan of 1979-80 the rural water sanitation supply (RWSS) segment became the priority area for government expenditure (Figure 4), yet sanitation has not improved much in rural areas.

Figure 4. Percentage of investment in Rural Water-Sanitation supply and Urban Water-Sanitation supply (as percentage of total plan outlay).

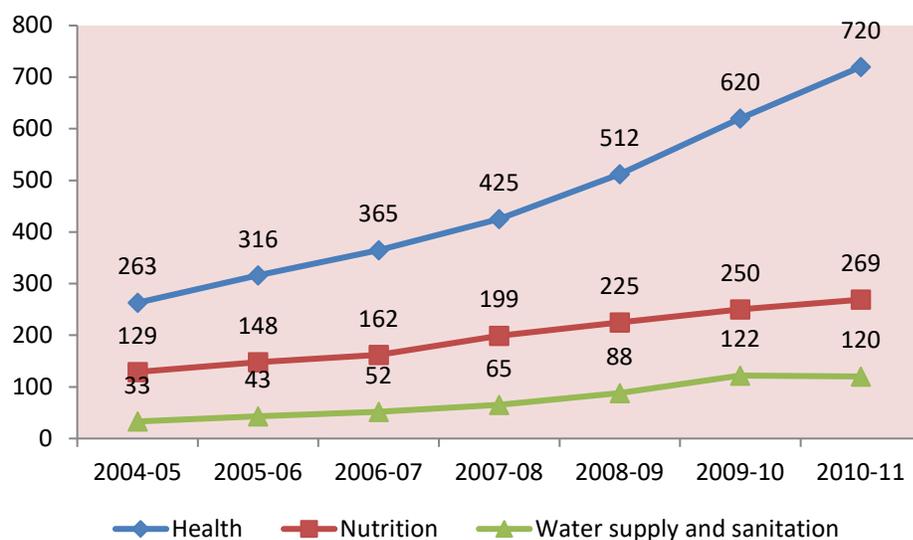


Source: Planning commission's yearly report

*Note: Outlays show central plus state investment at current prices (2005-06).

Figure 5 indicates that the water and sanitation sector expenditure of public funds which can have salubrious impact on both short as well as long term health issues is lower as compared to the expenditure on nutrition and health care sector in India.

Figure 5. Public expenditure on Health (curative), Nutrition and Water supply and sanitation at per capita current price, Rs (2010-2011).



Source: Economic survey (<http://www.indiabudget.nic.in/es2012-13/estat1.pdf>)

According a report by Centre for Policy Research (CPR), the Government’s allocation for SBM-Gramin /rural increased three-and-half times, from 2,850 crore rupees in 2014-15 to ₹10,500 crore rupees in 2016-17. The budgeted allocation for 2017-18 is 13,948 crore, a 33 percent jump over the previous year (Kapur & Aggarwal, CPR, 2017) but its outcome indicators have also been disappointing. According to the SBM-G website, some 3.8 crore household toilets were built, which is about 63 percent of the mission target but the continuing open defecation and a high proportion of non- acceptability and poor maintenance, and dysfunctional toilets, remain challenges for the sustainability of sanitation and SDG-6 goals¹⁰. It is important to make sure that funds allocated under the National program are spend in appropriate ways to avoid fund crunch.

¹⁰ <http://www.thehindubusinessline.com/economy/swachh-bharat-liberal-spending-but-limited-results/article9642357.ece>

INSTITUTIONAL CHALLENGES

There is lack of linkages and clarity on roles of different actors like government's organizations, Community-based organizations (CBOs), Non-Governmental Organisations (NGOs), municipalities, WHO and other external or internal agencies considering management of water and sanitation services. Within the state government and municipalities, sanitation has no 'institutional home', meaning that no single department or agency is accountable for it. As sanitation has multidimensional aspects such as infrastructure construction, selection of appropriate technology according to climate, soil, and community need, operation, and maintenance of toilets, ensuring water availability, electricity, sewer construction and wastewater treatment plants, the responsibilities assigned to different agencies are not clear and coordination between them is not always good. For example, toilets may be constructed under the national program but the availability of water is ensured by the water department, electricity by others and the sewer construction by the municipality. A state agency may have developed a sewage treatment plant even when there are no sewers in the town, then handed it over to a municipality that does not have the technical capacity or financial resources to operate and maintain it (Adil, 2013). Lack of community or end users involvement has led to the failure of program outcome. Such systemic weakness is a barrier to the achievement of successful outcome such as "Clean India".

Lack of capacity is a major bottleneck that hinders progress in achieving access to sanitation. Capacity building is often referred to in terms of staff training or human resources development. There is a huge shortage of trained engineers, sanitary inspectors, and sanitary workers in India. Municipality departments are supposed to have one sanitary inspector to cover the population of 5,000 people. Since the positions were not filled for the past few years, now each sanitation inspector needs to cover at least 20,000 people. The increased workload has reduced efficiency of the sanitary inspector and put the population at risk of infectious and vector borne diseases. Social stigma in being a mason and sanitation worker creates a shortage of skilled masons that badly hits the infrastructure development and unskilled masons will not be able to deliver sustainable toilets and sewers. The gap between demand and supply has also increased the labor rate. For sustainable access to the technology trained and scaled engineers are required that integrates efforts to make new technologies affordable and available where they are needed and

facilitates adoption of the technologies within the systems (Galli, 2014; Niemeier et al, 2014). A number of factors affect human resource development such as weak institution (rule/regulation), lack of financial support, and lack of familiarity with effective approaches to the sector (Rush & Marshall, 2015).

INNOVATION SYSTEM FRAMEWORK FOR SUSTAINABLE SANITATION

The 'innovation system' concept is an open, evolving and complex system encompassing relationships within and between individuals, institutions, socio-economic structures and organizations such as firms, consumers, public laboratories, universities, financial institutions and civic associations (Lundvall et.al, 2009). The innovation systems approach gives us an effective lens to view the systemic linkages and processes, to understand the global challenges in healthcare, water, energy, food and other social problems. The success of any national and international program towards addressing societal challenges depends on creation, diffusion, adoption, and regulation of innovations (Edquist, 1997). Any commodity or asset is an innovation for a potential user who currently does not have access to one; the SBM and SDGs-6 can be viewed as a state programme to diffuse 'toilets' as an innovation (Ramani and SadreGhazi, 2014). If adoption and/or use of the innovation improve the quality of life of poor beneficiaries significantly, then it is a pro-poor innovation. Sanitation is a typical example of a pro-poor innovation (Ramani et.al, 2016). In the sanitation area innovation can come in all shapes and sizes. For the poor segments it is about the construction of affordable infrastructure and most important behavioral change towards the adoption of infrastructure; sometimes it is about designing new products, other times it is about creating a new business model. Sustainable sanitation cannot come only from technological innovation by just building toilets and bringing the technology. It is more about the social innovation in using a toilet. Technology innovation will not be successful without strong social innovation. Without a stronger emphasis on social innovation, a lot of the investments made in the development of technological innovations may be waste of time and resources. A Total sanitation campaign was launched in 1999 with an aim to make India open defecation free but failed to translate into practice and outcomes were remarkably poor because social innovation could not be emphasized. "Availability" and "acceptability" are two main drivers of technological innovation diffusion (Reddy 1991; Tilley et al, 2006). In India, 88 percent of household have a mobile phone while 54 percent have a toilet in their home. Mobile phones beat toilets at all levels because of the wide range of availability

with respect to cost and design, an instant outcome such as communication, entertainment etc., and awareness by high advertisement, and social mobilization. In the case of sanitation technological availability needs additional efforts i.e.; motivating the user to "accept it" and realize the need for toilets as desperately as their need for mobile phones by social innovation that comes by changing their behavior away from open defecation.

PATHWAYS TO SUSTAINABLE SANITATION

Sustainable sanitation requires the integration of social, environmental, technical, financial and institutional sustainability. This section attempts to design a theoretical framework to represent pathways of sustainability and answer the challenges of sustainable sanitation with the lens of innovation system.

Figure 6: Pathways to sustainable sanitation

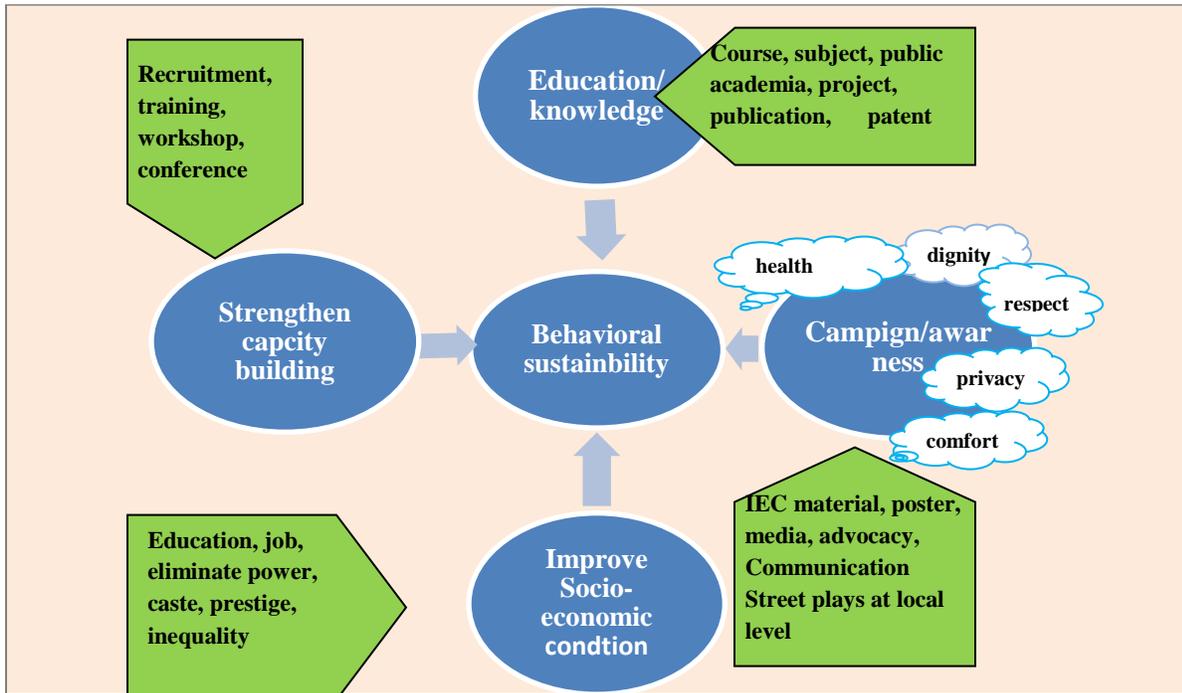


SOCIAL INNOVATION

Social innovation is a broader term but a precise and universally accepted definition is still missing (Franz, Hochgerner & Howaldt, 2012). Social innovation defines a "catch-all" category for all other forms of innovation, including improvement in the process or delivery of a technology as well as improved organizational and institutional arrangements (Hanlin, 2016). A social innovation is a new combination or new configuration of social practices in certain areas of action or social contexts driven by certain actors in a targeted manner with the goal of better satisfying needs and problems that is possible on the basis of established practices (Howaldt, Schwarz Kopp &, 2013). Social innovation is mainly a new idea (knowledge, model, process) that answered societal challenges and meet the societal need to improve quality of life of society (Anderson, Curtis & Wittig, 2014). In the case of sanitation, social innovation is more about creating the willingness to adopt sanitation at the household level. One of the main problems in adoption of sanitation is lack of communication as the discussion of toilets feels dirty and impure

and is associated with the negative stigma in society. Behavioral change through communication campaigns, information, education, and communication (IEC) methods, systematic advocacy and audio-visual aids, display of photographs/cartoons related to personal and community hygiene, street plays with the script composed in folk local language related to sanitation and hygiene practices may sensitize community at the regional, local and national level. Sanitation and hygiene promotion must be designed geographically, regionally and aimed to create awareness among diverse and specific mindset of people spread over the different socio-cultural system. Sanitation behavioral practices determinants are benefits, beliefs, and threats. Public beliefs must be gained through regular, transparent, and comprehensive communication with the local community that balance the risks and benefits of sanitation. Household adoption of sanitation practices is often associated with comfort, time saving, prestige, social dignity and safety as much as with health considerations. The inclusion of some incentive schemes and awards (family planning in India has cash prize incentives) may be important determinants for changing the socio-cultural system and adopting sanitation measures that gets integrated into the culture. Behavioral sustainability may be achieved by also improving socio-economic condition to reduce poverty, focused on marginalized and under deprived population, changing power, caste and class relationship within society as well as community and service providers, knowledge creation at the local and national level and strengthening capacity building at local and state level. Once the behavior change has been adopted by a critical mass of people, it becomes self-sustaining (Curtis, 2005). Behavior and cultural transformation is a cost-effective and bottom-up approach, which makes it highly scalable.

Figure 7. Behavioral Sustainability Framework

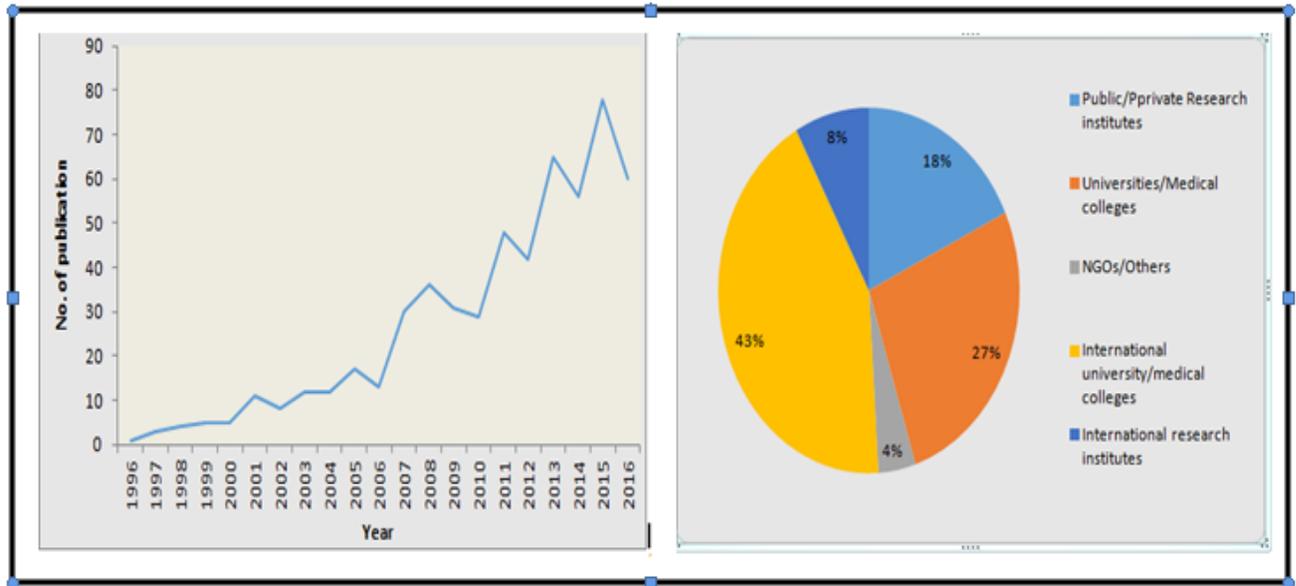


Source: Own elaboration

KNOWLEDGE CREATION AND DEVELOPMENT

In Innovation systems, knowledge creation relates to the competence building that is produced by formal/informal training, workshops, conferences and high education and knowledge flows by publications, documents, and reports. Measures of research activities are based on a fractionalized publication by different actors and national or international and public or private organizations. Publication activities on sanitation based research of two decades during the period 1996-2016 by Indian organizations consisting of public sector and private sector institutions bring out only 566 publications in science citation-index (SCI) journals and indicate a rising pattern. Significant work in the area of sanitation research has started after 2006 mainly by public sector institutes (figure 8). Figure 8 shows that the contribution of research institutes is less than medical colleges and academia while international organizations also have significant contributions with collaborating Indian organizations. All in all the volume of knowledge produced in terms of publication activities is not very significant and there is need for more publications by research institutes and other actors such as NGOs to facilitate the sustainable sanitation challenges by new ideas and policies.

Figure 8. Publication pattern in the area of sanitation in India and percentage of contributions by different organizations during the period 1996-2016.



Source: Web of Science data Base

TECHNOLOGICAL INNOVATION

Technological innovation is essential to solving many of the problems surrounding global poverty. Technological innovation can be made through capacity and capability building, education and institutional reform. In case of sanitation, the most important issues are affordability, low water consumption, sustainability, easy operation, less maintenance, easy installation, and availability of a wide number of technologies in order to solve the sanitation crisis. Technology needs to be innovated carefully, with proper reference to regional and local conditions, taking into consideration the availability of other resources such as water, space and the needs and preferences of service users.

Technology used in India:

- **E-toilet:** Eram Scientific Solutions Company developed a coin-operated e-toilet with an electronic system that automatically cleans itself after each use and the water gets recycled for flushing. In India 500 e-toilets are now in use which includes 150 in schools.

This type of toilet need technician's visits for periodic inspections to ensure sustainability of the toilet¹¹ .

- **GARV toilet:** Mayank Midha invented a comprehensive and sustainable stainless steel insulated GARV Toilet. GRAV toilets are vandal-proof, easy to clean and they don't rust. When users exit, technology can automatically activate floor washing and toilet pan washing systems¹².
- **Eco-friendly Two Pit, Pour-Flush Compost Toilet:** Owner of Sulabh toilet, Dr. Bhindeshwar Pathak's two pit model is very simple and installed in individual households. This toilet technology has also been recommended as a Best Global practice by the UN¹³.
- **RCC Affordable Toilet Technology:** Ramdas Mansing Mane invented an excellent quality of ready-made portable toilets by using scrape Expanded Polystyrene (EPS)/Thermocole sandwiched with concrete to reduce the weight and price of the toilet which can be installed within two hours and with half of the price¹⁴.
- **EcoSan Model:** The basic concept of the Ecological Sanitation model is to manage human excreta and urine by decomposing them before deposing, into useful organic resources, which can be handled safely and used in agriculture without harming the environment¹⁵.
- **Bio-gas linked toilet:** This toilet model convert waste material to Bio-gas, a non-conventional energy source. The fuel generated can be used as a local source of electricity, heat and light and the waste can be composted to Bio-manure which increases productivity and catalyses soil conservation. In 2012, UNICEF chose two districts in West Bengal to pilot this kind of design in India¹⁶.
- **Precast Textile Reinforced Concrete (TRC) based Toilet:** The Life Long Textile Reinforced Concrete (TRC) based Smart Toilet for Rural India is developed by state of

¹¹ <http://manavektamission.org/community-health/an-etoilet-innovation-is-leading-the-indian-revolution-in-public-sanitation/>

¹², ¹³ <http://swachhindia.ndtv.com/5-innovative-toilets-can-change-face-sanitation-india-4153/>

¹⁴ <http://indiacr.in/we-have-supplied-20000-readymade-toilets-on-no-profit-no-loss-basis-ramdas-mansing-mane-chairman-mane-group/>

¹⁵ <http://www.ecoideaz.com/expert-corner/ecosan-toilet-rural-india>

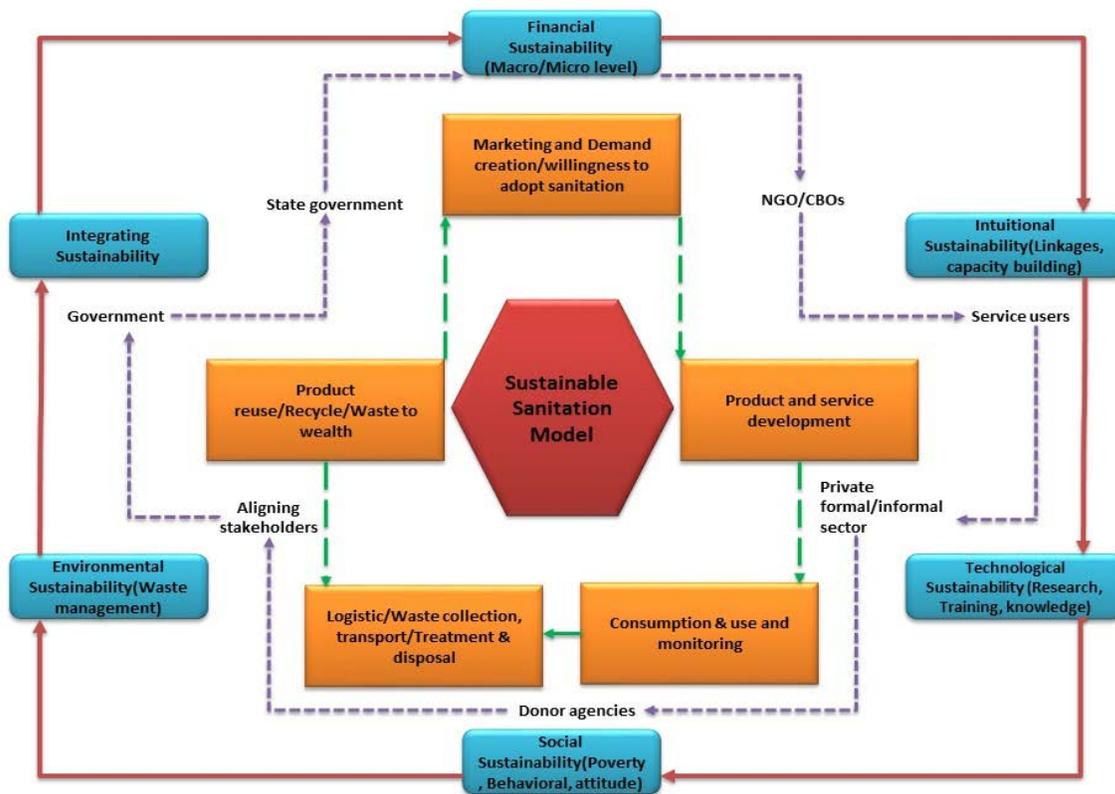
¹⁶ <http://www.thealternative.in/business/10-toilet-designs-for-rural-india/>

art technology. It comes with fire, corrosion and UV degradation resistancy and no maintenance for lifelong usage.

- **Bio-toilets:** In India bio-toilet are installed in railways: In this technology anaerobic bacteria is used for de-composition of fecal matter into gas and water.

In addition Sulabh has designed an open roof toilet to incentivize men who feel claustrophobic in the confines of a toilet, although it is not clear how this will work in cold winters or monsoons. Now these above mentioned innovative sanitation technology needs to be promoted, commercialised and utilized correctly to full-fill societal needs and bring sustainable sanitation.

Figure 9. Theoretical innovation framework for sustainable sanitation



FINANCIAL INCLUSION

Financial inclusion must provide funds for all the elements of a sanitation program. Apart from infrastructure development, public and private funds must be used to create awareness, capacity building, hygiene practices, and community hardware such as drainage, sewer constructions, waste transportation facility, waste treatment plants, monitoring system, policy development and

institutional strengthening. Human resources for behavior changes and trained masons and qualified engineers are equally important. A rough estimate shows about 6.4 lakh trained people will be needed from panchayat to state level to run “Swachh Bharat Mission”. The maximum strength of 600,000 is at the village level (one person per village) followed by about 33,000 at the block level, 3,265 at the district and 175 at the state level¹⁷.

Although government is paying attention to eliminate open defecation and improve waste management service to make “Clean India”, funds allocated are only about 30% of the envisaged requirement. Thus, there is a clear need to facilitate innovative financing mechanisms by an integrated financial model consisting of micro-financing, housing finance institutions, commercial bank loans, corporate social responsibility (CSR) and crowd funding aligned with local government financing. In India, Guardian and Grameen Koota are working as micro-financing institutions in the area of water and sanitation. Guardian works in four district in Tamil Nadu and accepted loans over 11 crore and Grameen Koota crossed a disbursement of Rs. 100 crore in Karnataka, Maharashtra and Tamil Nadu,. Crowd funding, a new financing mechanism at nascent stage in India, mobilises funds through internet platforms from a large number of people. Globally Indiegogo, Spacehive, Akvo and Kiva are working and in India only a few platforms such as Milaap and BitGiving mobilise loans for water and sanitation ¹⁸(Mehta & Mehta, 2014). Commercial banks and CSR funds may become the largest source of funding for sanitation in rural as well as urban areas. But there is also a need to facilitate, advertise, promote and create awareness of these innovative financing schemes to reach the most vulnerable and marginalized people. These financial schemes must be easily accessible and available so that people can get benefited. Several national programs such as Pradhan Mantri Gramin Yojana for constructing houses in rural areas and Janani Suraksha to improve institutional delivery for pregnant women could not benefit people due to complicated mechanism. There are some programs and international funding agencies actively supporting and ensuring consistency with the Government of India’s ‘Swachh Bharat’ (‘Clean India’) campaign, such as the Water Supply and Sanitation Collaborative Council (WSSCC), Bill & Melinda Gates Foundation, World Health Organization (WHO), UNICEF, United States Agency for International Development (USAID), Arghyam Foundation, Paul Hamlyn Foundation, The Coca-Cola India Foundation,

¹⁷ <http://www.thehindubusinessline.com/opinion/financing-swachh-bharat/article7089855.ece>

¹⁸ http://www.ideasforindia.in/article.aspx?article_id=370

Bharti Foundation, Hindustan Unilever, Tata motors, Dabur, Maruti Suzuki, etc. Apart from Government some public and private companies are also boosting clean drive of India by constructing infrastructure.

Table 2. List of top companies boosting “Clean India” drive.

Company/Corporation	No. of Toilets completed/proposed
Coal India	51,115
National Thermal Power Corporation Limited (NTPC)	24,626
Rural Electrification Corporation (REC)	12,379
Power Finance Corporation (PFC)	9,026
Vedanta Resources	9000
Oil and Natural Gas Corporation Limited (ONGC)	7,958
Tata Consultancy Services (TCS)	1,509
Mahindra	1,179
Airports Authority of India (AAI)	765
IFIG	150
Confederation of Indian Industry (CII)	138
GAIL (Proposed)	1021
Bharti Foundation (Proposed)	30,000
L&T (Proposed)	5,000

Source: <http://www.thehindubusinessline.com/news/over-one-crore-toilets-built-but-swachh-bharat-still-a-pipedream/article8472293.ece>

ORGANISATIONAL INNOVATION

Organisational innovation in the sanitation sector is not only about the coming together of private firms or private firms with public entities. There is also a wider set of inter-organizational innovation involving the water, health, and environmental sector that have been taking place and that are promoted to create more effective sustainable output. The engagement of all actors along with societal actors, mainly community, civil society and end users, in the research and innovation process is important to achieve the sustainable goal. Actors typically include

individuals and organizations operating at multiple scales such as central governments, local authorities, panchayat, wards, universities, private firms, nonprofit organizations, policymakers, entrepreneurs, and technology users. The grand societal challenges may be far better tackled if all societal actors are fully engaged in the construction of innovative solutions, products, and services (Owen et al, 2012). Decision making on sanitation policy must be conducted at a central government level, involving municipal departments, local government workers, and gram panchayats. Nongovernment organizations should be encouraged to participate in the sanitation drive with induction of public-private partnership (PPP) model. At present, policymakers and scholars recognize that social entrepreneurship has a crucial role to play as an innovation carrier in the area of sanitation because sanitation is a mainly social problem (Ramani et al, 2016). Social enterprises view "social problems" as "opportunities" and struggle to create social impact through creating awareness by developing an emotional connection with the targeted consumers via life-quality enhancing activities and project (Sridharan & Viswanathan, 2008). Social enterprises act as a catalyst for sustainable development mainly focused on the adoption of technology effectively in the community.

Community participation is very important to understand the existing traditions, cultures, divisions, and structures for a sustainable result. Involvement of women in sanitation campaigning may lead to better and faster adoption pace. For example, Bangladesh has developed a successful model to adopt a community-led total sanitation approach to stop open defecation (Ahmad, 2008) and woman's energetic involvement in the sanitation campaigns provide a sustainable solution as women are much more interested in the toilet than men (Hanchett, 2016). In India the "Midnapore model" has become one of the biggest success stories and cited all over the world for a sustainable alternative delivery system for sanitation. In India in the West Bengal's Midnapore was declared the 1st district in the country to have 100 percent access to sanitation toilets in 2001. The success of the Midnapore model is based on an excellent network system that connects program authorities to the community and end-users, and maintenance of low-cost sanitation hardware that made the system viable and affordable to the end user (Banerjee & Mandal, 2011). India needs to review all successful models and try to replicate the considering different socio-cultural regimes. The Public-private partnership (PPP) model also plays an important role in bringing sustainability in the water and sanitation area. In China sustainable sanitation and water is the best example of PPPs that emerged as one of the

most active markets in the world for PPPs in water and sanitation (Wu et al, 2016). In India involvement of the private sector is limited to technical and management support rather than investments in infrastructure. In India, Nagpur is the first city to adopt the PPP model for citywide water supply (NIUA, 2015). Garv Stainless Steel Public Toilet Infrastructure set up PPPs with municipal corporations for installation, operation and maintenance of toilets primarily in some cities. In recent years, non-profit organizations, namely Sulabh International, Finish Society, Shuddhi, SPARC, Arghyam, Niwas etc., actively participated in the sanitation drive in rural and urban areas that may help to accelerate the “Swachh Bharat Mission” and the Sustainable Development Goal-6.

Table 3. List of NGO/Trust/Social organization (non-Profit organization) undertaking CSR projects in the field of rural drinking water and sanitation under Ministry of drinking water and sanitation.

Name of Non-profit Organization	Specialization
Sulabh International Social Service Organization	Implementation of sanitation project/infrastructure
Plan India	Implementation of Water and sanitation project/Practices
BAIF Development Research	Watershed management/ Sustainability Structures
Himalayan institute hospital trust	Implementation of Drinking Water Supply
Bhoruka charitable trust	IEC and Capacity Building
Gram Vikas	Implementation of Water and Sanitation
BYPASS Sansthan	Implementation of Drinking Water
Gramin Vikas Trust	Implementation of Sanitation project
The Energy and Resources Institute	Capacity building/ M&E
Support for Implement and Research(SIR)	Water and sanitation project
Centre for environment education	Implementation of Sanitation Project
Arpan Sewa Snasthan	Training and capacity Building

Socio-economic unit foundation	Implementation of water treatment plant
Manthan Gramin evam Samaj Sewa Samiti	Implementation of solid waste water management
M.R.Moraka,Rural Research Foundation	Implementation of waste water management
Citizens Foundation	Community development, water harvesting
Tulsi Shiksha Samiti	IEC campaign and capacity building in water and sanitation
Staya Foundation	M & E implementation of water quality and community building
Aga Khan Rural Support Programme	Implementation of water and Sanitation Project
Ambuja Cement Foundations	Implementation of water and Sanitation Project
Developments Alternatives	Implementation of water Projects
Administrative staff college	Capacity building and project foundation
Humana people to people India	Eco-san toilet
Nirmal foundation	Implementation of rain water harvesting and water Projects
Self Development Institute	Capacity Building
International Academy of Environmental Sanitation and Public Health	Implementation of water and Sanitation Project
M.G.S.A resource centre	Awareness program in sanitation
Indian Grameen Services	Capacity Building
Keshari Chand Puran Chnad Sethi Charitable Trust	Implementation of water and Sanitation Project
ACII	Implementation of water and Sanitation Project
Ashwamwegh Gramin Panlot kshetra Vikas	Implementation of water and

	Sanitation Project
AFPRO	Capacity Building in water and sanitation

Source: Website of MDWS. Available at: <http://www.mdws.gov.in>

POLICY AND INSTITUTIONS

Several government initiatives in the form of schemes and programs have been launched from time to time to improve the sanitation situation in India. It started with the launching of a central rural sanitation program in 1986 with an objective to accelerate sanitation coverage in rural areas. This included the Total Sanitation Campaign (1999) to improve sanitation coverage by motivating communities and Panchayati Raj Institutions; Nirmal Bharat Abhiyan (2007) to make India clean and healthy; and the latest Swachh Bharat Mission (2014) to eliminate open defecation by 2019. Effective translation of national program into sustainable development is facing many challenges due to various uncertainties associated with weak institutions and management. Institutions include the set of formal and informal rules, norms, decision-making procedures, beliefs, incentives, and expectations that guide the relations and performance of actors in an innovation system (March 2006; Johnson, 2010). Institutions govern complex adaptive system involving different actors and organizations operating simultaneously from local to global scales to deal with challenges and facilitate sustainable development (Lundvall, 2010). As per the Constitution of India, water and sanitation is the responsibility of the State Governments assisted by the central government. The States have generally delegated powers to the local bodies for the provision of these services to people at the local level. The intergovernmental transfer of fund or multistage governing body between central to state and then state to local bodies and weak network and linkages among these actors may affect and delay the outputs of the program (Bharat & Sarkar, 2016). Government funding towards improving sanitation should be distributed at the different stages carefully to evaluate the strong driver, need and gap at different elements of sanitation. For example lack of adequate capacity, especially at the municipal levels, inadequate local knowledge, low community involvement, and poor monitoring adversely affected the implementation of the program in many ways. There is need to create and strengthen appropriate network and linkages and knowledge at the local level that are responsible, efficient, and accountable and capable of providing quality services. There

is also need to focus on the components of sanitation systems such as the use of toilets, safe excreta collection followed by transport, treatment and disposal at the local level.

CONCLUSION AND DISCUSSION

Sustainable development goal-6 to "ensure availability and sustainable management of water and sanitation for all" can be achieved by following suitable pathways and integrating sustainability through social, technological, financial and institutional innovation. Sanitation is primarily a social problem and cannot be solved just by building toilets. It is about adopting and using the technology with a stronger emphasis on sustainability. Sustainability in technological innovation can be shaped by providing focus on some important factors such as availability of a wide range, affordability, easy operation, low maintenance, eco-friendliness and implementation of technology with proper reference to regional and local condition taking into account the socio-economic, cultural and traditional context and the availability of other resources such as water, hand wash facilities, space and the needs and preferences of service users. Strengthening capacity building at the local level by training of masons, engineers, and sanitary workers, increased numbers of sanitary inspectors and inclusion of women and the local community in sanitation campaigning can boost sustainable pathways. Technological innovations in reuse/or recycling of human waste and financial support as an incentive for solid waste management at local levels ensures sustainability. Such institutional mechanisms stimulate sustainable economic development by offering incentives for business development and employment creation. Further, it requires the creation and strengthening of the appropriate network, linkages, and knowledge at the local level that are responsible, efficient, accountable and capable of providing quality services. There is also a need to focus on components of the sanitation system such as the use of toilets, safe excreta collection followed by transport, treatment, and disposal at the local level. Financial inclusion should be carefully distributed to every element of sanitation such as capacity building, waste management and monitoring to ensure the benefit to the most vulnerable and marginalized people and communities. Human waste can be turned into high-quality products, such as nutrients, biogas, and organic fertilizers.

Social innovation to bring behavioral changes and attitudes of communities is possible through continuous advocacy, knowledge creation, motivation, mobilization, and sensitization and awareness activities to implement sustainable sanitation in the society. Structural rigidities that

are present in the society such as caste, social class, gender disparities, power, prestige, beliefs, superstitions etc., can be combated by consistent and continuous advocacy to sensitize the masses/communities particularly on the deleterious effects of lack of sanitation on their children health, women dignity, pride, and privacy etc. to bring the mass transformation of mindset slowly and consistently. Successful models such as Sikkim and Manipur can be adopted in other states as well. More involvement of NGOs and the launching of more social campaigns by state government like the 'no toilet, no bride' resolution taken by the Haryana government and facilitated by the panchayat may bring sustainable solutions.

Innovation in sanitation requires a bottom-up approach and both macro and micromanagement of systematic planning and strategy involvement of all stakeholders by building strong cross-sectoral linkages and networks among national and international actors and organizations. Enterprises can play a more proactive role in the maintenance of infrastructure as through their commitment to social responsibility. NGOs and corporate companies can play a facilitator role in the clean India drive through their active participation in promotional activities such as demand creation, mass mobilization/sensitization, capacity building and maintenance of technology rather than only the building of the infrastructure.

REFERENCES

- Adil UF (2013). Low Cost Technology Options for Sanitation in India as per the Demand of the Local Surrounding. *CCS Working Paper No.307*.
- Anderson T, Curtis A, Wittig C (2014). Definition and Theory in Social Innovation. Master of Arts in Social Innovation, Danube University.
- Bharat GK and Sarkar SK (2016), Swachh Bharat Mission (Urban) Towards Cleaning India: A Policy Perspective. TERI, India.
- Coffey D, Gupta A, Hathi P, Khurana N, Spears D, Srivastav N, and Vyas S (2014) Revealed preference for open defecation: Evidence from a new survey in rural north India. *SQUAT Working Paper*.
- Connell O (2014) What Influences Open Defecation and Latrine Ownership in Rural Households? Findings from a Global Review.
- Curtis V (2005)// “Hygiene Promotion – WELL Fact Sheet” Available: www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/hp.htm.
- Dobe, M.(2015). Viewpoint: The role of sanitation in malnutrition – A Science and Policy Controversy in India. *J Public Health Policy* 36(1) 7-14.
- Graham JP and Polizzotto ML (2013) Pit Latrines and Their Impacts on Groundwater Quality: A Systematic Review, *Environ Health Perspect* .121(5).
- Edquist, C. (Ed.) (1997). *Systems of Innovation: Technologies, Institutions and Organizations*. London: Pinter Publishers/Cassell Academic, 432 pp.
- Franz HW, Hochgerner J, Howaldt J (2012). In *Challenge Social Innovation* .Berlin: Springer-Verlag (1-16).
- Giacomo Galli (2014.)Towards Systemic Change in Urban Sanitation. *IRC working paper*.
- Hanlin R (2016) Health System Strengthening Rethinking the role of Innovaton. Globelics book.
- Howaldt J, Kopp R and Schwarz M (2013). Social Innovations as Drivers of Social Change – Tarde’s Disregarded Contribution to Social innovation Theory Building .Technische Universität Dortmund, Germany.

Rush H and Marshall (2015) *Case Study: Innovation in Water, Sanitation and Hygiene*. Available: http://r4d.dfid.gov.uk/pdf/outputs/Hum_Response/Innovations-in-Water-Sanitation-and-Hygiene_Case-study-MIHIS-project-FINAL.pdf

Gupta & Kumar P (2007) Social evils, Poverty & Health. *Indian J Med Res*, 126(4)279-288.

Hamlin C and Sheard S (1998). Revolutions in public health: 1848, and 1998? *BMJ*, 317(7158): 587–591.

Hanchett S (2016) Sanitation in Bangladesh: Revolution, Evolution, and New Challenges. *CLTS knowledge hub learning paper*.

Islam *et al.* (2006). Urban Health and Care Seeking Behaviour: A Case Study of Slums in India and the Philippines. Bethesda, MD: The Partners for Health Reform Project, Abt Associates Inc.

Kirk J and M. Sommer (2006). Menstruation and Body Awareness: Linking Girls' Health with Girls' education." Royal Tropical Institute (KIT).

Kumar SG and Kar SS (2010). Sustainable behavioral change related to environmental sanitation in India: Issues and challenges. *Indian J Occup Environ Med*. 14(3): 107–108.

Lundvall B-Å (2010). National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning. Anthem Press; London.

Mara D, Lane J, Scott B and Trouba D (2010). Sanitation and Health, *PLoS Med* 7(11).

Montgomery MR and Hewett PC (2005). Urban Poverty and Health in Developing Countries: Household and Neighborhood effects, *Demography*, 42 (3).

National Commission on Macroeconomics & Health (NCMH) Background Papers (2005)—*Burden of Disease in India (New Delhi, India)* Ministry of Health & Family Welfare, India.

Owen R. Macnaghten P, Stilgoe PJ (2012) Responsible research and innovation: From science in society to science for society, with society. *Science*.39 (6), 751-760.

Kapur A & Aggarwal A (2017), Swachh Bharat Mission - Gramin (SBM-G Budget Briefs GOI, 2017-18, 9(1).

Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, Rudan I, Campbell H, Cibulskis R, Li M, Mathers C and Black RE (2012). Global, Regional, and National Causes of Child

Mortality: An Updated Systematic Analysis for 2010 with Time Trends since 2000. *The Lancet*, 379: 2151-61

Prüss -Üstün, A. Bos, R. Gore, F. and Bartram, J. (2008). *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health*. World Health Organisation, Geneva.

Prüss A, Kay D, Fewtrell L and Bartram J (2002) .Estimating the Burden of Disease from Water, Sanitation, and Hygiene at a Global Level, *Environ Health Perspect* 110 (5) 537-542.

Rashtriya Garima Abhiyan (2013). Manual Scavengers and Their Health .Available at:<http://www.mfcindia.org/main/bgpapers/bgpapers2013/am/bgpap2013h.pdf>.

Ramani SV, Sadreghazi S, Duysters G (2012). On the Diffusion of Toilets as Bottom of the Pyramid Innovation: Lessons from Sanitation Entrepreneurs. *Technol. Forecast. Soc.Chang.* 79,676–687

Ramani SV, Sadreghazi S, Gupta S (2016). Catalysing Innovation for Social Impact: The role of Social Enterprises in the Indian sanitation sector. *Technol. Forecast. Soc.Chang.*

Reddy NM., Aram JD, Lynn LH (1991). The Institutional Domain of Technology Diffusion. *J. Prod. Innov. Manag.* 8, 295–304.

Routray P, Schmidt WT, Boisson S, Clasen T and Marion W (2015). Socio-cultural and behavioural factors constraining latrine adoption in rural coastal Odisha: an exploratory qualitative study. *BMC Public Health* (2015) 15:880.

Schmidt CW (2014) Beyond Malnutrition: The Role of Sanitation in Stunted Growth, *Environ Health Perspect*, 122(11).

Sridharan S, Viswanathan M (2008). Marketing in Subsistence Marketplaces: Consumption and Entrepreneurship in a South Indian context. *J. Consum. Mark.* 25, 455–462

Soutik B (2014). Why India's sanitation crisis kills women. *BBC News*, India. Available: <http://www.bbc.com/news/world-asia-india-27635363>.

Tewary A (2013). India, Bihar: Rapes 'Caused by Lack of Toilets. *BBC News*, India. Available: <https://sanitationupdates.wordpress.com/tag/sexual-violence>.

Tsinda A, Abbott P, Pedley S, Charles K, Adogo J, Okurut K, and Chenoweth J (2013). Challenges to Achieving Sustainable Sanitation in Informal Settlements of Kigali, Rwanda *Int J Environ Res Public Health*. 10(12).

UNESCO (2010). *Out-of-school adolescents.* Available at: <http://uis.unesco.org/sites/default/files/documents/out-of-school-adolescents-2010-en.pdf>.

UNICEF (2011) *The Situation of children in India A Profile, New Delhi, India*. Available: http://unicef.in/Uploads/Publications/Resources/pub_doc36.pdf.

UNICEF and WHO Report (2015) *Progress on sanitation and drinking water, update and MDG assessment*. Available at: <http://www.unicef.org/media/files/JMPreport2015.pdf>.

UN-WATER (2015) *Water and Sustainable Development, Technology Challenges and tools for the implementation of the water- related sustainable development goals and targets*. Available: http://www.un.org/waterforlifedecade/waterandsustainabledevelopment2015/pdf/Water_technology_tool_paper_final.pdf.

World Bank (2011). *Economic impacts of inadequate sanitation in India*. Water and Sanitation Program. Washington, DC: World Bank.

World Bank Report (2012) *Perspective on Poverty in India*.

World toilet day advocacy report (2014). *We can't wait*, A Report on Sanitation and Hygiene for Women and Girls. Available: <http://worldtoilet.org/documents/WecantWait.pdf>.

Wu X, Schuyler R, Peri R (2016) Public-private partnerships (PPPs) in water and sanitation in India: lessons from China, *Water Policy*. 18 (S1).