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Julia Krauss 12/1/2017

Cost Analysis of a Combined, Household-level Piped Water Supply and Sanitation Program in Rural Odisha, India

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Cornell University

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An abstract of

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University

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Abstract

Cost Analysis of a Combined, Household-level Piped Water Supply and Sanitation Program in Rural Odisha, India

By Julia C. Krauss

Background: A lack of safe water, sanitation and hygiene (WASH) is particularly a problem in India, which is responsible for the majority of world's open defecation. The Government of India's response to the country's WASH challenges, which includes campaigns focused on improving sanitation coverage, has been inadequate. To fill the gaps of the government-led sanitation campaigns, Gram Vikas, a nonprofit organization in Odisha, India developed the Movement and Action Network for Transformation of Rural Areas (MANTRA) program. MANTRA facilitates the establishment of a community-wide water distribution system that provides household-level piped water that is contingent on full village-level toilet coverage.

Methods: This cost analysis used a prospective costing approach to enumerate intervention inputs, estimate base year costs from a broad societal perspective, and extrapolate intervention costs over a 10-year time period, with 2015 as the base year. Costs were incurred or constructed, in the costing model, on three levels – the program implementer (i.e., Gram Vikas), village and household. The fixed capital and recurring costs for each of the three levels were summed together per year and discounted to 2015 using a 3% discount rate. The discounted, per annum costs were totaled to determine the total cost of MANTRA over the 10-year period and allocated per household based on the number of households projected to participate in the intervention during the 10-year analytical period. Data were collected from village and household level surveys, which were supplemented with inputs from Gram Vikas collected through an enumeration exercise, interviews and by examining Gram Vikas' financial records.

Findings: The total cost of the MANTRA program over the 10-year analytical period was approximately $1,240 per household. The fixed capital cost of the village water system ($327 per household) and the household sanitary unit ($747 per household) accounted for the majority (85%) of the total cost. Approximately 30% of the household sanitary unit fixed capital cost was attributed to unpaid labor contributed by the household members. The Government of India played a major role in reimbursing the cost of the village water system and providing households with an incentive ($180) for their sanitary unit.

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Background

Global water & sanitation challenge

As of 2015, 2.3 billion people lacked access to basic sanitation services. Only 39% of the global population use a safely managed sanitation service whereby the excreta is safely disposed of off-site or treated in situ (WHO/UNICEF, 2017). Basic sanitation services are defined as the use of improved facilities that are not shared with other households. In addition, approximately 892 million people around the word continue to practice open defecation (WHO/UNICEF, 2017). In regards to access to safe water, approximately 71% of the global population use a safely managed drinking water service. A safely managed drinking water service involves a water source that is located on the premises, available when needed and one that is free from contamination (WHO/UNICEF, 2017). Yet, about 844 million people still do not have access to basic drinking water services and 159 million people collect drinking water directly from surface water sources. Further, only 27% of the population in the least developed countries have access to basic handwashing facilities, which include soap and water. 26% of this population have facilities that lack soap or water, leaving approximately 47% of the population without any handwashing facility (WHO/UNICEF, 2017).

The lack of proper water and sanitation is a global issue as inadequate clean water and improper sanitation management can lead to a myriad of poor health outcomes and hinder development. Inadequate water, sanitation and hygiene (WASH) is associated with various infectious diseases such as, diarrhea, soil-transmitted helminth infection, trachoma and schistosomiasis (Prüss-Ustün *et al.*, 2008). Such diseases are caused by an array of bacteria, viruses, protozoa and parasites. Diarrhea, in particular, is a major burden of disease caused by inadequate WASH. According to Prüss-Ustün, *et al.*, 88% of global diarrhea cases are linked to unsafe water, inadequate sanitation or insufficient hygiene (2008). In 2012, there were 1.5 million deaths due to diarrhea. 502,000 of these diarrheal deaths were caused by inadequate drinking water and 280,000 were the result of poor sanitation (Prüss-Ustün, *et al*., 2014). Open defecation is particularly a problem as it causes fecal waste and pathogens to re-enter directly into the environment, leading to the contamination of water and food supplies. Research has demonstrated that open defecation is a major cause of diarrhea and parasite infections in children under 5-years old (Mara *et al*., 2010). Diarrhea poses a greater risk to children under the age of five. According to the WHO, in low-income countries, diarrhea is responsible for approximately 19% of all deaths in children under 5-years old (World Health Statistics, 2006). Poor WASH conditions have also been shown to be associated with a heightened risk of respiratory infection, which is the leading cause globally of mortality for children under 5-years old (UN Inter-agency Group for Child Mortality Estimation, 2015; Budge *et al*., 2014; Aiello *et al*., 2008). There is also growing evidence that improper WASH, particularly open defecation, can have negative effects on malnutrition (Dangour *et al*., 2013), cause stunting (Spears, 2013) and impair cognitive development (Sclar *et al*., 2017).

In addition to diarrhea and other enteric diseases, inadequate WASH can have negative consequences on individual's social, physical and mental well-being. Women and girls in particular are disproportionately burdened by the lack of access to adequate sanitation and safe water. In many developing countries, women and girls are responsible for the majority of the household chores, including fetching water when piped water is not available on the premises. Obtaining water from a communal water source can put women and girls at a higher risk for waterborne disease (Schmidlin *et al*., 2013). This activity can be very time consuming, limiting the amount of time women have for pursuing economic activities (Sorenson *et al*., 2012). In general, a lack of access to safe WASH hinders economic opportunities due to the amount of time spent on WASH-related activities, such as fetching water and going to the field to defecate, as well as the time and funding required to treat WASH-related diseases. Research has shown that it is economically beneficial to invest in water and sanitation infrastructure, as the cost of doing so is recouped in better health outcomes and time savings (Hutton, 2013). Insufficient WASH can have negative effects on girls' ability to attend school and their academic achievements. Schools' access to safe water and sanitation has been closely linked with issues related to menstrual health management. Research has documented that when girls reach puberty and do not have access to safe sanitation at school, they forgo class to avoid the potential embarrassment of not being able to manage their menses at school and being teased by their classmates (Mahon and Fernandes, 2010; Montgomery *et al*., 2012). Even when sanitary facilities are available, they are often not designed or cleaned in a way that allows girls to properly maintain their hygiene, leaving girls more susceptible to urogenital infections (Das *et al*., 2015). Outside of a school setting, inadequate or missing sanitary infrastructure can cause women and girls stress due to perceived environmental and social barriers to access hygienic sanitary infrastructure and resources that provide women and girls with privacy (Sahoo *et al*., 2015). In particular, research has demonstrated that open defecation can cause women stress due to fear of a lack of privacy and for their safety, as physical and sexual violence against women openly defecating has been documented (Jadhav, *et al*., 2016).

Impact of WASH interventions

Studies have indicated mixed results regarding the impact of WASH interventions on human health. A 2015 systematic review found that there is insufficient evidence to conclude if source-based water improvements including protected wells, communal tap stands, or chlorination/filtration of community sources result in reduced diarrhea (Clasen *et al*., 2015).

Based on the same systematic review, point-of-use water quality interventions had a greater effect on diarrhea. According to the review, point-of-use filtration systems cut the risk of diarrhea in half (RR 0.48, 95% CI 0.38 to 0.59, 18 trials, 15582 participants) (Clasen *et al*., 2015). There are currently no studies to evaluate the effect of piped-in water at the household level on health impacts. In regards to sanitation, a systematic review found that sanitation was associated with 12% lower odds of diarrhea (Freeman, *et al*., 2017). The impact of sanitation on diarrhea was greater in areas with higher levels of access to improved water supply (Freeman *et al*., 2017). This same review found that sanitation was associated with lower odds of infection from STH worm species including *A. lumbricoides*, hookworm and *S. stercarolis,* as well as lower odds of active trachoma and schistosomiasis (Freeman *et al*, 2017). The effect of sanitation on nutritional status is not as clearly defined. Research found a borderline association between interventions to improve sanitation and stunting, yet these sanitation interventions were not associated with being underweight or wasting (Freeman *et al*., 2017). However, the strength of these findings is limited. For instance, the protective association between sanitation, and soil-transmitted helminth (STH) infections and schistosomiasis outcomes were not found throughout intervention studies. Further, statistical heterogeneity of the meta-analyses was high throughout the review and the risk of bias based on average Lot Quality Assurance Test (LQAT) scores ranged from moderate to high, limiting the results of this systematic review (Freeman *et al*., 2017).

The effect of proper sanitation on health outcomes may be hindered by a lack of 100% coverage and/or lack of use. Studies have found that sanitation interventions can increase the amount of the target population covered by improved sanitation (Arnold *et al*., 2010; Clasen *et al*., 2014). However, research has proven that due to multiple transmission pathways, an impact on human health may only be seen if high levels of community coverage are achieved (Hunter and Prüss-Ustün, 2016). In addition, improved sanitation coverage does not equate to the same gains in latrine use, which may further hinder sanitation interventions' impact on health outcomes (Garn *et al*., 2017). Therefore, while it has been recognized that inadequate WASH can affect the burden of disease, the extent to which WASH-related interventions can reduce this burden varies.

Call for action

Overall, the global community has recognized that water and sanitation are core to improving people's health and to sustainable development. In 2015, following the conclusion of the Millennium Development Goals (MDGs), the UN General Assembly established the 17 Sustainable Development Goals (SDGs). Goal 6 of the SDGs acknowledges the importance of WASH, as it states that the goal is to "Ensure availability and sustainable management of water and sanitation for all" (UN General Assembly, 2015). In particular, provision 6.2 calls for equitable sanitation and hygiene for all, which includes eliminating open defecation and focusing specifically on the needs of women and girls by 2030 (UN General Assembly, 2015). By specifically focusing on the elimination of open defecation and meeting the sanitary needs of women and girls, the SDGs intend to outline specific targets national governments, nonprofits and other key stakeholders can achieve in the overall goal of improving global safe WASH. Between 2000 and 2015, the number of people practicing open defecation declined by approximately 22 million per year. However, this rate is not sufficient to meet the SDG's goal of abolishing open defecation by 2030 (WHO/UNICEF, 2017).

India's water & sanitation challenge

India has 16% of the global population and only 4% of the world's fresh water supply (WaterAid, 2007). It is expected that by 2020, India will be a water stressed nation. A nation is considered water stressed when the per capita availability of water drops below 1700 cu. m/person/year (WaterAid, 2007). There are often competing demands for water in India. Approximately 90% of ground and surface water is used in the agricultural sector, 2-5% is used for industry, leaving about 3-9% of surface and ground water for the domestic sector (WaterAid, 2007). Thus, access to a sufficient supply of water continues to be a growing issue in India. In addition to water quantity, access to safe drinking water quality is often a challenge. According to the World Bank, 94% of India's population has access to an improved water source. In particular, 93% of the rural population of India has access to an improved water source, a great improvement from the 64% of the rural population that had access to an improved water source in 1990 (World Bank, 2017). An improved drinking water source is defined as a source that due to the nature of its construction, it adequately protects the water from outside contamination. For instance, examples of improved water sources include, a household connection, public standpipe, borehole, protected dug well, protected spring and/or rainwater collection (WHO, 2017). However, only 49% of the rural population of India has access to a *safely managed* drinking water source, meaning that the improved water source is accessible on the premises, water is available when needed and the water supplied is free from contamination (World Bank, 2015; WHO, 2017). According to the 2011 Census, 30.8% of rural households in the country have access to tap water, with only 7.5% of rural households in Odisha having access to a piped water supply (Press Information Bureau, 2013). Based on this 2011 Census, 43.6% of the rural population rely on a handpump for drinking water, 13.3% of the rural population use wells, and 8.3% use tubewells as their main source of drinking water (IPE Global, 2013). Through its

Strategic Plan, the Ministry of Drinking Water & Sanitation attempts to address the lack of access to safely managed piped water and aims to improve the coverage of piped water to rural households. In particular, the Strategic Plan sets the goals of ensuring at least 90% of rural households are provided with piped water supply, at least 80% of rural households have piped water supply with a household connection; less than 10% use public taps and less than 10% use other safe and adequate private water sources (Press Information Bureau, 2013).

A lack of adequate safe sanitation has particularly been an issue in India where less than 50% of the population is covered with basic sanitation services (WHO/UNICEF, 2017). This equates to around 2.5 billion people who do not have access to improved sanitation (WHO/UNICEF, 2013). As of 2016, approximately 67% of the population of India live in rural areas (World Bank, 2017). Rural areas often share a disproportionate amount of the burden of inadequate WASH. In 2015, only 31% of the rural population of Indian had access to piped water compared to 69% of urban areas (WHO/UNICEF, 2017). Further, the issue of open defecation is greater in rural vs. urban areas. According to the JMP 2017 report, 40% of India's population continues to openly defecate; this includes 56% of the population in rural areas and 7% of the population in urban areas (WHO/UNICEF, 2017). India is the largest contributor to the problem of open defecation across the world. Roughly two-thirds of the global population who practice open defecation reside in India (WHO/UNICEF, 2012). This equates to approximately 53% of households or 624 million people in India who continue to openly defecate.

Recent research has found that even with an increase in access to household-level improved sanitation, use of these toilets is low. The mismatch between sanitation coverage and usage may be due to behavioral preferences for open defecation. Open defecation is a historical practice in

India. Individuals in rural northern Indian stated that open defecation is preferred even in places with latrine access because of the perceived convenience, comfort and pleasure of openly defecating, in addition to a lack of recognition of the health benefits (Coffey *et al*., 2014). A study that included focus groups with women also noted that going to the fields to openly defecate in a group was an important daily ritual that provided the women with a means of social capital (Routray *et al*., 2015). In addition, research has demonstrated that low levels of household sanitation facilities may be due to the technology used for the toilets, as well as the toilets' reliance on scarce resources. Toilets that rely on water are not always the most appropriate given the limited availability of water. While most villages, even in more remote areas in India, have access to a water source, the availability of water may not be sufficient for flushing purposes (WHO/UNICEF, 2017; Ecrumen *et al*., 2015). Access to a reliable household level water supply may be integral to encouraging consistent usage of household latrines and in improving overall WASH by eliminating potential contamination sources and pathways (Routray *et al*., 2015).

India's WASH-related burden of disease

Due to its lack of safe WASH, India shares a large burden of WASH-related diseases. Diarrhea is the third leading cause of childhood mortality in India, accounting for approximately 13% of all deaths in children less than 5 years old (Bassani *et al*., 2010). According to the 2005-2006 National Family Health Survey-3, 9% of all children under 5-years old were reported to have suffered from diarrhea in the last two weeks. As previously noted, there is growing evidence that establishes a relationship between child growth and household WASH practices (Ngure *et al*., 2014). A lack of WASH can contribute to stunting as children ingest high quantities of exposed fecal bacteria (human or animal sources) through soiled fingers and contaminated household items. This can lead to intestinal infections, which can impair a child's appetite and his/her ability to absorb nutrients (Dewey *et al*., 2011). According to the National Family Health Survey of India, 48% of Indian children under 5-years old, or about 61 million children, are stunted (IIPS, 2007). This figure accounts for approximately one-third of stunted children in the developing world (IIPS, 2007). As in other developing countries, women are disproportionately affected by poor WASH in India. Women in India have indicated that menstruation and the responsibility of securing water can cause stress, as well as a lack of privacy, often a condition of poorly constructed latrines and open defecation (Hulland *et al*., 2015; Routray *et al*., 2015). The risk of safety and violence against women who practice open defecation was highlighted recently when two girls were raped and killed on their way to the fields to openly defecate, a story that circulated widely among news outlets (McCarthy, 2014).

Indian sanitation campaigns

In 1999, recognizing the issue of improper sanitation, the Indian Ministry of Rural Development established the Total Sanitation Campaign (TSC). The goal of the TSC was to increase access to sanitation infrastructure, particularly in rural regions of India. As a part of the initial TSC, the government provided subsides, Rs. 500 (about $7.50 in 2015 dollars) for household latrine construction to households who fell below the poverty line (BPL) (WaterAid India, 2008).

The TSC campaign has been modified a few times since its inception in 1999. For instance, in 2004, the TSC revised its guidelines to focus on broader sanitary arrangements as well as latrine construction by strengthening the School Sanitation and Hygiene Education component, and by expanding the provision of toilets to Anganwadi Centers and to all schools (WSP, 2010). In 2005, to encourage local government buy-in to improving their village’s sanitation, the Government of India developed the Nirmal Gram Puraskar program that rewards Gram Panchayats that achieve open defecation free (ODF) status (Ministry of Drinking Water and

Sanitation, 2015). The amount of the incentive is based on the population size of the district (WSP, 2010). In 2007, the TSC guidelines were further expanded to include a focus on developing community-led and ecologically safe systems to manage sanitation solid and liquid waste. Due to rising costs of inputs, the subsidy provided to BPL households was increased from Rs. 1,200 ($18 in 2015 dollars) to Rs. 2,200 ($33 in 2015 dollars) (WaterAid India, 2008). As of 2010, the TSC was implemented in 606 districts of 30 states in India (WSP, 2010).

In 2012, the TSC was renamed *Nirmal Bharat Abhiyan*. The mission of Nirmal Bharat Abhiyan was similar to that of the TSC with the main goal being to expand sanitation coverage in rural areas in order to improve the quality of life. Nirmal Bharat Abhiyan emphasized the promotion of sanitation facilities through awareness creation and health education to generate a demand driven approach to improving sanitation (General Knowledge Today, 2013). Nirmal Bharat Abhiyan sought to secure 100% coverage in communities by focusing administration at the Gram Panchayat level, expanding to include above the poverty line (APL) households and schools, and by increasing the subsidy to Rs. 4,600 ($69 in 2015 dollars) to provide for greater variation in latrine type (WSP, 2010; Press Information Bureau, 2013). This shift was largely due to the success of the Nirmal Gram Puraskar fiscal incentive in promoting 100% latrine coverage in rural areas (Barnard *et al.*, 2013).

Most recently, the Prime Minister of India launched the *Swachh Bharat Mission* on October 2nd, 2014. Swachh Bharat Mission (SBM) is a country-wide initiative to achieve a clean and hygienic India by October 2, 2019, the 150th anniversary of Mahatma Gandhi's birthday (Ministry of Housing and Urban Affairs, Government of India, 2017). Implemented by the Ministry of Drinking Water and Sanitation in rural areas and the Ministry of Urban Development in urban areas, SBM plans to improve the efforts to increase sanitation coverage, as well as target other aspects of WASH, such as menstrual health management, water/sanitation systems and sustainability. For rural areas, this includes putting a greater emphasis on eliminating open defecation and developing sustainable solid and liquid waste management systems (Ministry of Drinking Water and Sanitation, Government of India, 2017).

SBM attempts to increase the number of villages that achieve ODF status by continuing the Nirmal Gram Puraskar fiscal incentive program. The Nirmal Gram Puraskar awards carry a tremendous amount of prestige as they are presented by the Honorable President of India to district-level and block-level winners who achieved ODF status and by high ranking state dignitaries to village-level winners (WSP, 2010). The financial subsidy provided to both BPL households and specified APL households under Swachh Bharat Mission –Gramin (sanitation program in rural areas) is up to Rs. 12,000 ($180 in 2015 dollars) for the construction of one individual household latrine (Rural Development and Panchayati Raj Department, 2015).

The evolution of India's sanitation campaigns is summarized in table 1.

Table 1: Evolution of India’s Total Sanitation Campaign

Year	Initiative	Goal	Capital incentives
1999-2004	Total Sanitation Campaign	A community-led approach with a focus on collective achievement of total sanitation	Rs. 500 ($7.50)* subsidy for household latrines, only Below Poverty Line (BPL) households
2005-2007	Total Sanitation Campaign	Reoriented campaign to focus on achieving the outcome of an open defecation free (ODF) environment, targeting households, as well as communities, villages and Panchayat governments	Rs. 1,200 ($18)* subsidy for household latrines, only Below Poverty Line (BPL) households
2003 -	Nirmal Gram Puraskar	Program that offers fiscal incentives (cash prizes) to local governments that achieve 100% sanitation, 100% ODF	Amount of incentive is based on the population
2007 – 2012	Total Sanitation Campaign	Guidelines modified to include an emphasis on solid and liquid waste management	Rs. 2,200 ($33)* – Rs. 3,200 ($48)* subsidy for household latrines, only Below Poverty Line (BPL) households
2012 – 2014	Nirmal Bharat Abhiyan	Aims to accelerate the usage of proper sanitation led by gram Panchayats, utilizing CLTs schemes	Rs. 4,600 ($69)* for household latrines Inclusion of specified Above Poverty Line (APL) households
2014 -	Swachh Bharat Mission	Focus on improving general cleanliness of India, particularly through solid and liquid waste management activities and by making villages open defecation free by October 2019, the 150th Birth Anniversary of Mahatma Gandhi	Rs. 12,000 ($180)* incentive for household latrines Inclusion of specified Above Poverty Line (APL) households

*Based on 2015 dollars

Successes and challenges of India’s sanitation campaigns

SBM has seen some success in mobilizing the Indian population toward the goal of improved cleanliness and sanitation coverage. SBM has garnered tremendous political support and has raised approximately $25 billion from the Indian Government, private sector and civil society to reach the goal of eliminating open defecation. Based on SBM data, the coverage of latrines in rural India has increased from 42% in October 2014 to 65% in June 2017. According to this database, such latrine coverage has led to a decline in the number of people who openly defecate from 550 million to 330 million in June of 2017 (Ministry of Drinking Water and Sanitation, 2017).

However, there has been much discussion that questions the success of the TSC and SBM. A study to assess the effectiveness of the TSC to prevent diarrhea, soil-transmitted helminth infection and child malnutrition found no evidence that demonstrated the TSC was protective against diarrhea in children or that the intervention reduced the prevalence of egg counts of soil-transmitted helminth infections (Clasen, *et al*., 2014). This same study did not find a significant difference in faecal contamination of wells and of water stored in households when comparing households that participated in the intervention (TSC) and those that did not (Clasen, *et al*., 2014). An additional study based in Madhya Pradesh found the TSC had a modest increase in the number of household latrines and an even smaller effect on child health outcomes associated with poor sanitation including, diarrhea, highly credible gastrointestinal illness (HCGI), parasite infections, anemia and growth (Patil *et al*., 2014). The effect of the TSC and SBM on WASH-related health outcomes may be hindered by its focus on sanitation coverage, as opposed to on the usage of the latrines. For instance, the Nirmal Gram Puraskar awards are only given once and are not based on continual coverage and usage of the latrines (WSP, 2010). A lack of usage may be attributed to the poor quality of many of the latrines supported by government-led sanitation programs. For instance, a study of 321 government-sponsored latrines found that only 47% of the latrines met the criteria for functionality, including minimal wall height and a door or other closure to ensure privacy (Barnard *et al*., 2013). Further, based on a report from the Water and Sanitation Program (WSP), the technology used to build the toilets is mostly based on cost, as opposed to including input and resources from the community (2010). Recently, SBM has recognized the importance of measuring usage and has generated a National Annual Sanitation Survey that will collect data on usage of the sanitation facilities in order to adequately measure progress toward eliminating open defecation.

Gram Vikas

To supplement the efforts of the Indian government, several local and international nonprofits have developed programs to improve access to, and utilization of, safe WASH in India, particularly in rural settings. Gram Vikas (Village Development) is a local non-governmental organization located in Odisha, India that established a WASH program, Movement and Action Network for Transformation of Rural Areas (MANTRA), in response to gaps in the government led efforts (http://www.gramvikas.org). In particular, Gram Vikas sought to improve the issues regarding inadequate water quality and quantity at the household level and the low usage associated with government-led sanitation programs. Therefore, Gram Vikas developed MANTRA, a sanitation program that provides household-level piped water connections that are contingent on full community-level toilet coverage (Reese *et. al*, 2017).

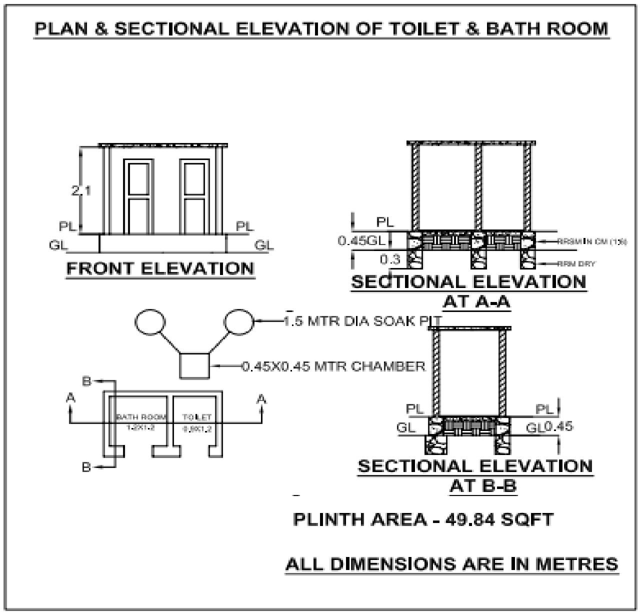
Prior to the establishment of its MANTRA program, Gram Vikas' programming had always been focused on improving the lives of people in rural areas of India. The founders of Gram Vikas came together in the early 1970s to assist victims of a devastating cyclone in Orissa. They created Gram Vikas and officially registered as a nonprofit organization in January 1979. Gram Vikas' activities originally focused on improving the living conditions of the tribal communities of India through education and awareness, and by assisting the tribal people in securing stable sources of income and in recovering their land. Other Gram Vikas activities included providing financial and technical support for individuals building disaster-resistant houses and encouraging the development of the National Biogas Development Program across India in 1983 in order to bring biogas technology to rural communities as a means of providing energy while protecting the forests (gramvikas.org).

Overtime, Gram Vikas realized that the prevailing problem afflicting the rural communities of India was poor health, which was directly impacted by a lack of proper sanitation and hygiene practices. Therefore, Gram Vikas began building toilets, along with strengthening community support and acceptance of the toilets to ensure their uptake and consistent use. In 2004, Gram Vikas formally launched the MANTRA program, which reinforces Gram Vikas' mission of "promoting processes which are sustainable, socially inclusive and gender equitable to enable critical masses of poor and marginalized rural people or communities to achieve a dignified quality of life" (gramvikas.org). Gram Vikas conducts programs in 7 Indian states – Odisha, Jharkhand, Mdhya Pradesh, Andhra Pradesh, Chattisgarh, West Bengal and Nagaland. The greatest concentration of their work is in Odisha, where they host programs in 25 districts of the state (gramvikas.org). Currently, the MANTRA program encompasses approximately 80% of Gram Vikas' work. Gram Vikas has been a fairly effective organization. The nonprofit was recognized in 2016, as it was listed in the Top 25 of the Top 500 NGOs world-wide by NGO Advisor, an independent media organization.

MANTRA program

The Movement and Action Network for Transformation of Rural Areas (MANTRA) program aims to demonstrate the relationship between health risks and poor sanitation, and empowers and trains communities to construct, manage and maintain their own sanitation facilities. Gram Vikas mandates that all households in a village participating in MANTRA construct a sanitary unit, which is comprised of a latrine and an adjacent washroom (See Figure 1 and Figure 2). Once all households have built a sanitary unit, Gram Vikas ensures that each household has access to piped safe water. The stipulation that 100% of households in a village establish a sanitary unit is vital to eliminating potential sources of water contamination and in reducing village-level inequalities based on caste and gender. With MANTRA, Gram Vikas intends to further address social and gender inequalities by leading income-generating workshops and by requiring that female heads of households are involved in the decision-making process (gramvikas.org). Overall, the MANTRA program promotes a village's ability to independently sustain their own sanitation network by incorporating financial training, construction skill-building and hygiene education workshops into its programming. Gram Vikas also stipulates that to participate in the MANTRA program, each village must establish a Corpus Fund, an accumulation of monetary contributions from each household. The funds are used to assist households who move into the village after the completion of the MANTRA program build their own sanitary units and to maintain the village water system. Overall, the MANTRA program works with villages to develop sustainable WASH systems and to promote activities to improve the health and livelihoods of all people in the village.

Figure 1: Plans for household sanitary unit (latrine & washroom)



Credit: Gram Vikas

Figure 2: Photographs of the construction of the household sanitary unit

Photo credit: Gram Vikas (via Sojan Thomas)

The MANTRA program includes three phases – Motivational, Implementation, and Completion – and takes a village approximately three years to complete the entire intervention. The first phase, the Motivational Phase lasts approximately 6 months. During this phase, representatives from Gram Vikas visit the identified village several times to assess its interest in participating in the MANTRA program and to establish the criteria required of a participating village. These requirements include the inclusion and participation of all households in the village, the establishment of a village corpus fund based on monetary contributions from each household, and the creation of guidelines regarding the maintenance and use of each household's sanitary facility.

Once a village has completed the Motivational Phase and it is committed to meeting the goals of Gram Vika's MANTRA program, the village enters into stage 2, the Implementation Phase. During the Implementation Phase each household constructs its own pour-flush toilet with two-soak pits and an attached bathing room. Households are responsible for the construction of their own latrines and bathing rooms, which includes hiring and/or providing the necessary skilled and unskilled labor, as well as sourcing local materials required for the structure. Gram Vikas assists in supplying external materials, such as the PVC pipes and porcelain pans (Personal correspondence, Maryann Delea).

At the same time as the household construction, Gram Vikas works with village members to construct a village level water system including a water tank/tower and a piped water distribution system leading to a water connection in each household's sanitary unit and kitchen. This phase is the longest phase of the MANTRA program and typically requires villages 16-18 months to complete (Personal correspondence, Maryann Delea). The final stage of the MANTRA program is the Completion Phase. The village enters into the Completion Phase when all households have finished construction on their sanitary units and the village water system has been completed and so, the water system can now be switched on.

See Table 2 for a general list of activities involved in each phase of the MANTRA program.

Table 2: Activities per MANTRA phase	
Phase	*Activities*
Motivation	• Village meetings • Exposure visits • Leadership development trainings • Establish village Corpus Fund
Implementation	• Households clear land and build sanitary unit • Trainings on: o Income generation activities o School sanitation and hygiene o Pump operation (for pump operators) o Health camps • Construct village water tank/tower and distribution network
Completion	• Activate water distribution system • Monitor water quality and use of household sanitary units

Cost of water & sanitation

Meeting the SDG targets regarding water and sanitation will require an influx of financial capital and resources. According to the GLAAS 2017 Report, to achieve SDG targets 6.1 and 6.2, capital investments in WASH will need to be tripled, reaching $114 billion per year in addition to operation and maintenance costs (GLAAS, 2017). However, in order to appropriately raise and allocate funds for WASH, it is important to understand the costs required to establish, operate and maintain adequate and safe water and sanitation systems. However, there is limited research on the costs of water and sanitation, as the costs vary geographically and there are many stakeholders – governments, NGOs, private firms – that contribute to building and maintaining these systems thus, tracking and aggregating all costs is a complicated process. Additional attributes of cost analyses that add to their complexity include cross-subsidies, as well as flexible implementation and local investments. Cross-subsidies occur when sanitation-related programs share resources and activities with other programs, thus making it difficult to determine and allocate costs appropriately to either program(s). Flexible program implementation in which a WASH program is not completed at one time causes difficulties in determining the total costs due to incongruences in program completion. Often local investments include time and resources that are not assigned a monetary value at the time of the program, further complicating the cost analysis of a WASH program (Crocker *et al*., 2017). Therefore, many of the completed cost analyses are unable to reliably account for the total upfront costs, as well as the operation and maintenance costs of a WASH program.

Water cost

The cost of safe water depends on the geography and the technology used to supply and treat the water. Overall, there has been an increase in the percentage of the global population with access to an improved water supply. In particular, the number of people with access to a piped water supply has increased from approximately 3.5 billion people in 2000 to 4.7 billion people in 2015 (WHO/UNICEF, 2017) However, the types of improved water supplies, particularly in rural areas, continue to vary as indicated by the fact that while 86% of the rural population has access to an improved water source, only 55% of the rural population has access to a safely managed water source (an improved water source that is available when needed on the premises) (WHO/UNICEF, 2017). Other types of improved water supplies include shared water sources such as protected wells, communal tap stands and the chlorination/filtration of community sources. Typically, these source-based water quality interventions are more expensive in comparison to point-of-use water treatment methods. A systematic review that evaluated the cost-effectiveness of different water improvement interventions found source-based interventions cost US$1.26 for a borehole, $1.63 for a dug well and $4.95 for a communal standpost per person per year in Southeast Asia (Clasen *et al*., 2007). In comparison, the annual cost of point-of-use water improvement interventions equate to approximately US$0.63 for solar disinfection, $0.66 for chlorination, $4.95 for flocculation/disinfection and $3.03 for ceramic filtration (Clasen *et al*., 2007). A WHO report compiled investment cost per person across three major world regions (Africa, Latin America and the Caribbean, and Asia) for a household water connection. This report found that the initial investment cost per capita (based on 2005 dollars) for a household water connection (treated) was approximately $164 in Africa, $148 in Asia/Oceania and $232 in Latin American and the Caribbean (LAC). The annual recurrent costs for household connections (treated) were approximately $13.4 in Africa, $9.60 in Asia and $14.60 in Latin American and the Caribbean (Hutton and Bartram, 2008). The cost of improved water via a household connection (treated) was the greatest in comparison to other methods of water improvement, across all geographies. Table 3 details how the cost of household water connections compares to other water improvement methods.

Table 3: Per capita costs (in 2005 dollars) of water improvements, excluding program costs

	Initial investment cost			Annual recurrent cost		
Water improvement	Africa	Asia	LAC	Africa	Asia	LAC
Household connection (treated)	164	148	232	13.4	9.6	14.6
Standpost	50	103	66	0.5	1.0	0.7
Borehole	37	27	89	0.2	0.2	0.6
Dug well	34	35	77	0.2	0.2	0.5
Rainwater	79	55	72	0.4	0.5	0.5

Sanitation cost

A handful of studies have reported a range of cost estimates for sanitation programs on a household level. For instance, a cost study on WaterAid-supported sanitation software and hardware programs in Bangladesh, Nepal and Nigeria found that cost of the sanitation program to range from $6-$84 per household across these geographic areas. These costs included programmatic costs (training and support), overhead (local NGO and WaterAid national support), software (hygiene), and sanitary hardware. Contributions for this program stemmed from WaterAid, local governments, UNICEF, and household contributions (WaterAid, 2009).

A cost analysis of community led total sanitation (CLTS) programs located in Ghana and Ethiopia found the cost of the program to be between $30.34-$81.56 and $14.15-$19.21 per household in the two countries, respectively. CLTS programs attempt to improve sanitation by utilizing methods that mobilize a community to take their own actions to become open defecation free. The costs for this program included unit costs, such as staff salaries, vehicle purchases, training venue rental, accommodation and meals, per-diems, and district government contracts, as well as general parameters such as minimum wage which was multiplied by hours spent on CLTS to determine the appropriate labor cost. The data were gathered from the program's quarterly financial reports, discussions with staff, as well as from web resources and literature in order to gather accurate information for general items. Travel time was estimated and monetized based on Google Earth and the American Automobile Association (AAA) guidelines, using intervention and study site specific estimates (Crocker *et al*., 2017; AAA, 2015). An additional CLTS study reported that the government-facilitated sanitation program in Ethiopia cost $1 per household (Sah and Negussie, 2009). However, this study did not detail the means of the data collection or cost analysis methods.

Table 4 details the range of costs for various sanitation programs per household, aggregating the hardware and software costs when possible. These estimates are often hindered with issues regarding a lack of clarity and transparency around data collection, cost items and analysis methodology.

Table 4: Cost estimates for sanitation programs per household

Region	Per Household Costs	Implementer	Financing Mechanism	Reference
Combined hardware & software				
Ecuador	$401 ($355 hardware; $46 – software)	World Bank	Government, multilateral, households	Trémolet *et al.*, 2010
India	$223 ($208 – hardware; $15 – software)	Government, World Bank	Government, households	Trémolet *et al.*, 2010
Senegal	$712 ($568 – hardware; $144 – software)	Government, NGOs, World Bank	Government, multilateral	Trémolet *et al.*, 2010
Vietnam	$218 ($197 – hardware; $21 – software)	Local NGO, World Bank	External governments, multilateral	Trémolet *et al.*, 2010
Nepal	$58-$84	Local & international NGO	Donors, households	WaterAid, 2009
Nigeria	$30	Local & international NGO	Donors, government, households	WaterAid, 2009
Pakistan	$106	Local NGO	Donors	Robinson, 2005
India	$57	Local NGO	Donors & government	Robinson, 2005
Bangladesh	$12	International NGO	Donors	Robinson, 2005
Software				
Ghana	$30.34-$81.56	Local & international NGO	Donors, households	Crocker *et al.*, 2017
Ethiopia	$14.15-$19.21	International NGO	Donors, households	Crocker *et al.*, 2017
Ethiopia	$1	International NGO	Donors	Sah and Negussie, 2017
Bangladesh	$6-$7	Local & international NGO	Donors, government, households	WaterAid, 2009

WASH cost analysis implications

Despite increasing WASH budgets, many countries estimate that financing allocated to WASH improvements remains insufficient to meet national WASH needs. 80% of countries currently do not have sufficient financial resources to meet national targets for water and sanitation (GLAAS, 2017). In order to properly finance WASH, it is imperative to know the costs required to meet such targets for water and sanitation. Yet, according to the GLAAS 2017 report, many countries in the report indicated limited availability of data regarding external aid expenditures for WASH, and more than one-third of countries demonstrated limited availability of information on government expenditures for WASH (GLAAS, 2017). Therefore, this cost analysis contributes to the knowledge base of WASH expenditure in India and can be used to supplement the information tracked by the Government's Swachh Bharat Mission.

It has been widely documented that the costs of implementing WASH services are less than the costs incurred due to WASH-related diseases (Hutton, 2013). In fact, the WHO estimates that investment in WASH can lead to economic returns of $2 for every dollar spent on water and $5.50 for every dollar spent on sanitation (Hutton, 2013). The main contributor to the overall benefits of sanitation and water is time-savings which accounts for approximately 70% of total benefits in all regions based on a cost benefit analysis of drinking-water supply and sanitation interventions (Hutton, 2013). Therefore, it is important to understand the costs incurred to implement and maintain WASH programs and infrastructure to inform key stakeholders', such as governments, nonprofits and funders, decisions and budgets. This analysis provides a cost estimate of providing a household piped water and sanitation intervention over a period of 10-years. Therefore, the Government of India can utilize the results of this analysis to make improvements to the Swachh Bharat Mission program and to inform policies regulating water and sanitation.

Providing household-level safe piped water is considered one of the more costly means of providing safe water (Haller, *et al*., 2007). In general, hardware-based interventions are thought to be more expensive in comparison to software interventions, such as hygiene education, social marketing of good hygiene practices, regulation of drinking-water and monitoring of water quality (Varley *et al*., 1998). However, studies have also demonstrated that the provision sanitation hardware can have positive health impacts (Haller, *et al*., 2007). While there is no research to date regarding the health effects of providing household water connections (Clasen, 2015), research has demonstrated the impact of providing both improved water and sanitation on health outcomes can be greater than providing improved sanitation or improved water supply alone (Haller *et al*., 2007). Therefore, this cost analysis is key to demonstrate to stakeholders the per household level cost of an intervention that includes both an improved sanitary unit and an improved water supply at the household level, as the intervention's impact on health may be greater than that of a sanitation intervention alone. Further, the MANTRA program's mandate that all households in a village participate in the program is vital to reach sanitation coverage levels that have greatest improvement on health outcomes (Hunter and Prüss-Ustün, 2016).

The methods and results of this cost analysis contribute to research regarding the costs of WASH-related interventions and provide insights into the feasibility of an intervention that provides both sanitary units and safe water connections at the household level. In general, methods for cost analyses vary due to inconsistencies in cost analysis guidelines and the limitation of available data (Adam, *et al*., 2003). The strengths and limitations of this study can be used to evaluate the impact of applying certain guidelines and methodologies. The lessons learned from this assessment can inform future cost analyses in an attempt to standardize and improve the methodology used when conducting a cost analysis.

Study Aims and Objectives

The overall goal of this cost analysis was to determine the costs associated with Gram Vikas' MANTRA program, both the total cost of the program and the cost per household. A second objective of this study was to then identify the key financial stakeholders and to assess each stakeholder's proportion of the cost of the MANTRA program.

In particular, this study aimed to assess the financial role of the Indian government and to determine the required financial investments of each of the participating households to provide for an intervention that includes household piped water connections and household sanitary units (latrine and washroom). The study further compares the cost of the MANTRA program from a societal perspective, which includes valuing "free" resources such as labor, to the monetary cost incurred by the stakeholders.

The objective of this study was to identify the cost of implementing a similar intervention that involves household level piped water connections and sanitary units. In this way, the study seeks to lay the groundwork of aggregating all costs associated with the MANTRA program to be used for future studies that evaluate the cost-benefit and/or cost-effectiveness of the MANTRA program.

Methods

Costing approach and rationale

A prospective costing approach was used to enumerate intervention inputs, estimate base year costs, and extrapolate intervention costs over a 10-year time period. In an attempt to establish comparability with other cost analysis studies, whenever appropriate, the methods used to analyze the costs of Gram Vikas' MANTRA program adhered to the guidelines provided by the WHO for a cost-effectiveness analysis (WHO, 2003). For instance, as recommended by the WHO, this analysis took a societal perspective where costs from all activities, across all stakeholders, are considered to determine the entire cost of the MANTRA intervention (2003). A societal perspective was utilized, as this costing approach enables the results of this analysis to be used to answer more policy-related questions that address the full cost of implementing a similar intervention regardless of the source of funds or who actually incurs the costs, or whether the expenditure is in cash or in kind.

The costs were identified over a 10-year time period (i.e., the analytical period), and the costing model assumed that the intervention was fully implemented throughout the 10-year analytical period (WHO, 2003). The base year for this analysis was 2015, so a 10-year analytical period assessed the costs of the MANTRA program from 2015 to 2025. This analysis did not include the costs incurred by the villages that completed the MANTRA program prior to 2015, though presumably these villages and households would incur recurring costs throughout the study's 10-year analytical time period. The costing model assumed no villages or households have been intervened upon at base year, 2015.

Costs were incurred, and therefore accounted for in the costing model, on three levels – the program implementer (i.e., Gram Vikas), village and household – and were allocated per household based on the total number of households that were projected to participate in the intervention during the 2015-2025 timeframe, given the rate at which households have historically participated in Gram Vikas' MANTRA. An analysis of the total costs aggregated to the village level is also included. The costs for each of the three levels were summed together per year and discounted back to 2015 using the WHO recommended 3% discount rate (WHO, 2003). A sensitivity analysis that explores the effect of alternative discount rates is discussed. The discounted, per annum costs were totaled to determine the total cost of MANTRA over the 10-year period, and were divided by the total number of households that completed the MANTRA program in order to arrive at the per household cost of Gram Vikas' MANTRA program.

Sampling

The sampling frame for the cost analysis consisted of the 90 villages enrolled in the matched cohort study. The ten most recently intervened-upon study villages with at least 20 or more enrolled households and their matched controls were selected for the cost analysis. By 'most recently intervened-upon,' we mean the ten villages from amongst those enrolled in the matched cohort study that Gram Vikas most recently engaged in the 'Motivational Phase' of the MANTRA program in Ganjam or Gajapati Districts. Note all villages enrolled in the matched cohort study have reached the 'Completion Phase' of the MANTRA program. 20 households from each of the 20 villages were randomly selected via a random number generator to be included in the cost analysis. In the event that no household member who made decisions regarding the construction of the household latrine, wash room, or water connections was available (or those individuals refuse to provide consent for the household survey), the next enrolled household situated to the right of that household was selected for replacement until 20 households were included from each of the 20 cost analysis sub-study villages (i.e., the 10 intervention villages and their matched controls) (Delea, 2016).

Data collection

The data used to complete the cost analysis were collected as a part of a matched cohort study designed to assess the effectiveness of the MANTRA program (Reese et. al, 2017). The primary outcome of the matched cohort study was prevalence of diarrheal disease. Secondary outcomes included other health and nutritional outcomes such as child growth, stunting, STH infections, acute respiratory infections and environmental enteric dysfunction. Further, non-health outcomes such as the effect on sanitation and water coverage, access and use of sanitary facilities, environmental fecal contamination, women's empowerment, collective efficacy and intervention cost-related inputs were also measured (Reese et. al, 2017).

Data were collected on the larger MANTRA program matched cohort study from the Ganjam and Gajapati districts in eastern Odisha, India from July 2015 to October 2016. However, data regarding village-level and household-level inputs were collected during February to June 2016. Materials and labor inputs provided at the village and household levels for the implementation of the MANTRA intervention were obtained via village and household surveys. Field workers administered village surveys to a village leader who was engaged in the construction of the communal water distribution system, and household surveys to the household decision-maker to collect data regarding the utilization of the intervention and required inputs. Village and household level materials and labor input data were supplemented with data on inputs from Gram Vikas that were collected through an enumeration exercise, interviews and by examining Gram Vikas' financial records (Delea, 2016). The majority of inputs provided at the household and village level were obtained from the village-level and household-level surveys. Once all types of inputs were enumerated at these three levels (Gram Vikas, village and household), a prospective valuation approach was employed, using current (2015) costing estimates obtained from the implementing organization, local markets, and Government of India policies for programmatic and point of delivery costs, respectively. An economic definition of costs was used in cost valuation as opposed to a financial (i.e., accounting) definition (Delea, 2016). All costs were enumerated and cost calculations were calculated in Indian Rupees (Rs.), per 2015 value. These costs were then converted and reported in U.S. dollars using the average 2015 exchange rate, 66.78 Rs. per 1 U.S. dollar (IRS, 2017).

Data analysis

Subsequent to valuation, costs were broken down into the three levels, those incurred on the implementer, village and household levels. Within each level, costs were further categorized as fixed capital or recurring costs. Recurring costs were enumerated per year. See Table 5 for a breakdown of the fixed capital and recurring cost components, per level. See Appendix A for a chart detailing the calculation of all model cost assumptions.

Table 5: Cost levels and components		
Level		*Components*
Gram Vikas	Fixed Capital	Office equipment Vehicles/motorbikes
	Recurring	Building rent Transportation Trainings Staff salaries
Village	Fixed Capital (Motivational)	Trainings Supplies
	Fixed Capital (Implementation)	Land Water tank/tower Water distribution network Labor (skilled/unskilled)
	Recurring	Water treatment Pump operator salary Electricity Labor (skilled/unskilled) – repairs & improvements Hardware materials – repairs & improvements
Household	Fixed Capital (Motivational)	Corpus Fund
	Fixed Capital (Implementation)	Hardware materials Labor (skilled/unskilled)
	Recurring	Hardware materials – repairs & improvements Labor (skilled/unskilled) – repairs & improvements

MANTRA program timing and coverage

Overall, based on conversations with Gram Vikas it was determined that villages required approximately three years to complete the MANTRA program, six months in the Motivational phase, 16-18 months in the Implementation phase and six months in the Completion phase. Based on these time requirements, the costing model assumed that per village all Motivational phase-related costs were incurred in year one along with one-third of the Implementation phase-related costs; the remaining two-thirds of the Implementation phase-related costs were incurred in year two and that the Completion-phase related costs were incurred in year three.

According to Gram Vikas, approximately five villages per field office (15 field offices) enter into the Motivational phase per year and so, the costing model assumed 75 villages entered the Motivational phase per year. Given that villages take approximately three years to complete the MANTRA program, the cost model only accounts for new villages being enrolled in the program during years 0-8 of the 10 year analytical period. Based on conversations with Gram Vikas, the costing model assumed that 95% of the villages that entered the Motivational phase moved to the Implementation phase and 100% of the villages in the Implementation phase completed the intervention. Further, based on the average number of households per village recorded in the village cost surveys and from conversations with program enumerators, the costing model assumed there were approximately 158 households per village, and that this number remained constant over the 10-year analytical period.

Gram Vikas fixed capital costs

Gram Vikas fixed capital cost items were incurred once during the base year (2015) in order to provide for a conservative estimate. In 2015, the MANTRA program accounted for approximately 80% of the Gram Vikas program portfolio, and so, 80% of all shared Gram Vikas program costs were allocated to the MANTRA program. The model assumed that MANTRA would continue to comprise 80% of the Gram Vikas program portfolio over the 10-year analytical period. When possible, rental values for buildings and equipment were used in the analysis. Therefore, fixed capital costs mainly included items that were unable to be assigned a rental value, including generators, vehicles and office equipment.

Gram Vikas recurring costs

Gram Vikas recurring costs included staff salaries, building rental costs, and travel and training costs that are independent of the number of villages in the MANTRA program per year. Staff salaries were multiplied by the number of persons in each position per year. The costing model assumed that the number of personnel per MANTRA field office remained the same over the 10-year analytical period, and that Gram Vikas does not expand to include additional field offices, potentially increasing staffing needs and rental costs. The building costs were identified based on the most recently documented (per 2015) monthly rental value, and calculated annually. The trainings included as Gram Vikas recurring costs were annual trainings that were not contingent upon the number of villages in each phase of the intervention. For instance, according to Gram Vikas, Income Generation Activity trainings occur 4 times per year per field office, thus the unit for Income Generation Activity training included in the model was 60 (15 field offices times* four trainings). As per Gram Vikas program data, the costing model assumed the unit cost of each yearly training was inclusive of all cost drivers associated with the training (e.g., supplies, accommodation, food, stipend costs). Based on Gram Vikas data, the cost of transportation for all meetings and trainings was lumped together into one parameter estimate that was included in the model per year. Additional travel costs included local transportation costs for all MANTRA-related internal staff meetings, as well as the operation and maintenance costs associated with MANTRA vehicles.

Village level fixed capital costs

Costs were considered fixed capital on the village level if they were incurred once per village. Village level fixed capital costs were categorized based on the MANTRA phase during which these costs were incurred. The costs per phase were then multiplied by the number of villages entering into each phase and summed together to calculate the total village level fixed capital cost per year. Motivational phase village level costs included the costs of exposure visits, leadership development trainings and of the paperwork required for a village to demonstrate its commitment to 100% household participation in MANTRA. The majority of the village level fixed capital costs occurred during the Implementation phase, during which the village completes construction of the village water tank/tower and piped distribution network. Trainings based on the number of villages in the Implementation phase were included in the model at the village level and were multiplied by the number of villages in the Implementation phase to determine the total cost per year. The costs associated with the village water system included the price of labor and materials required to construct the village water system. There were three different types of village water systems that were characterized based on the primary water source (bore well, gravity flow and well) used. Based on the village surveys, the costing model assumed that a majority of the villages (70%) utilized a bore well as their primary source of water. The remaining 30% of villages were equally allocated to using a gravity flow system and a well as their main source of water for the village water system.

Based on these proportions for each water source, a weighted average of the village water system was calculated to determine the average water system cost per village in the costing model. The model assumed that the proportion of villages utilizing each type of water system remained the same over the 10-year analytical period. Given heterogeneity in village size across the MANTRA program, costing model parameter estimates for the village water system reflected an average village size of 158 households. The breakdown of the different water systems' costs were provided by Gram Vikas. These estimates included the cost of skilled labor, materials and equipment per required per water system. Based on the village and household surveys, the model assumed that all village/household member labor contributions were valued as unskilled labor. Therefore, the cost of unskilled labor for the village water system is based on the average number of village laborers required to construct the village water system, per village surveys multiplied by the minimum wage for unskilled labor in Odisha (Labour & E.S.I. Department, 2015). Further, the costing model included the cost of trainings that occurred during the Implementation phase at the village level. Gram Vikas' data provided the unit costs for each of these trainings, which was then multiplied by the number of villages per Implementation phase to determine the overall training cost per year.

Village level recurring costs

Village level costs were considered recurring if a village incurred the cost every year post completion of the MANTRA program. The village level recurring costs were determined by multiplying the yearly recurring costs by the total number of villages that had completed the MANTRA program from 2017 Village level recurring costs were mainly those associated with the operation and maintenance of the village water system. Village operation and maintenance costs included those covering the annual salary of the pump operator, the cost of electricity and a water treatment fee, as well as the cost of labor and materials required for major repairs and improvements to the system. The costs for the pump operator salary, pump electricity and water treatment were based on averages calculated from the village cost survey. Based on the village surveys, 8% of the villages would require repairs and/or improvements on their water tank/tower and distribution system per year. Therefore, the model calculated all recurring costs associated with village water system repairs and/or improvements by multiplying the costs by a standardized percentage (8.6%) to indicate that only 8.6% of the villages would incur these costs per year. Similarly, the cost of skilled labor for repairs and/or improvements was based on the proportion of villages that utilized skilled labor for repairs and/or improvements per year according to the village survey multiplied by the 2015 minimum wage for skilled labor in Odisha, India (Labour & E.S.I. Department, 2015). The annual village level operation and maintenance costs were net of the annual household level maintenance fees per village. Based on the household survey, the costing model assumed these fees would go toward covering the operation and maintenance costs of the village water system.

Household level fixed capital costs

Costs were categorized as household level fixed capital costs if the costs were incurred once per household. Similar to village level fixed capital costs, household level fixed capital costs were classified based on the MANTRA phase during which the cost was incurred. The costs per phase were then multiplied by the number of households in each phase and totaled to arrive at an annual household level fixed capital cost. In the Motivational phase, the only household level fixed capital cost was the Rs. 1000 ($15) that each household donates to the Corpus Fund established prior to the Implementation phase. All other household level fixed capital costs were enumerated during the Implementation phase and were incurred due to the construction of the household sanitary unit. These costs included the cost of labor and materials needed to build the sanitary unit and household-level water connections that pipe water from the main communal level distribution network to the three household water taps. The model assumed the amount of each material was based on the average consumption of materials indicated in the household surveys. The model valued the cost of each material at its 2015 market value. Based on the household surveys, certain materials such as tiles and pre-fabricated grill were not used by all households in the construction of their sanitary units. Therefore, the model disaggregated these additional material inputs from the general material inputs and took into consideration the proportion of households utilizing each of these additional materials when calculating their cost. Labor was designated as either skilled or unskilled. Based on the household survey, the costing model assumed the unit of labor (skilled and unskilled) was the average number of skilled/unskilled laborers required to construct the sanitary unit multiplied by the average number of full labor days. Both skilled and unskilled labor were valued based on the 2015 minimum wage in Odisha (Labour & E.S.I. Department, 2015).

Household level recurring costs

Similar to village level recurring costs, the model considered costs to be recurring at the household level if they were costs that households incurred per year after completing the MANTRA program. Household level recurring costs included those incurred for the operation and maintenance of each household's sanitary unit. The household level recurring costs were calculated by multiplying the annual recurring costs by the total number of households that had completed the MANTRA program from 2017. Based on the household surveys, the majority of the households paid an annual fee for the operation and maintenance of the village water system and so, the costing model assumed this fee was incurred per household per year. As previously mentioned this fee was subtracted from the village level recurring costs to avoid double counting the expenditure. In regards to maintenance, the household surveys indicated that approximately 1.4% of the households required repairs and/or improvements per year. Therefore, the costing model assumed that a standardized number (1.4%) of the total number of households that had completed the MANTRA program would incur the costs associated with repairs and/or improvements per year. Similar to the methods used to determine the units of labor for village level repairs and/or improvements, the cost of skilled/unskilled labor for repairs and/or improvements of the household sanitary units was based on the proportion of households who utilized skilled/unskilled labor for repairs and/or improvements per year according to the household surveys multiplied by the 2015 minimum wage for skilled/unskilled labor in Odisha, India (Labour & E.S.I. Department, 2015). Further, based on the household surveys, not all materials were used equally for repairs and/or improvements of the household sanitary units. Thus, the model assumed the units of materials for household level repairs and/or improvements was based on the proportion of each material used according to the household surveys, which was then multiplied by the 2015 market price of each material to arrive at the total material costs for household sanitary unit repairs and/or improvements. In addition, the costing model accounted for the costs associated with waste disposal of the household sanitary units. Using the information provided on pit emptying through the household surveys, we assessed the average amount of time that had passed since the pit required emptying. We then extrapolated this over the 10-year analytical period and standardized this number across the 10 years to determine that approximately 1.1% of households would require fecal sludge management (FSM) services per year over the 10-year analytical period. Thus, the costing model assumed that 1.1% of the total households that had completed the MANTRA program since 2015 would require FSM services and multiplied that number by the average cost of FSM based on the household surveys to determine the per year cost of waste disposal. It was assumed that operation and maintenance costs for both the village water system and household sanitary units remained the same over the 10-year analytical period.

Results

General

Population and implementation numbers of Gram Vikas MANTRA program over the course of the 10-year analytical period are detailed in Table 6. Taking a societal approach, the total cost of the MANTRA program over the 10-year analytical period was approximately $125,250,000, or about $1,240 per household ($1,013 incurred monetary costs; $227 unpaid, in-kind labor contributions). Aggregating the costs on a village level amounted to a per village cost of $195,370 for the initial implementation and recurring costs associated with the MANTRA program over the 10-year analytical period. The overall cost estimate included Gram Vikas' upfront fixed capital costs and their recurring cost per annum, as well as the fixed capital and recurring costs associated with the village water system and household sanitary units for 641 villages and 101,318 households over the course of the 10-year analytical time period. Table 7 shows the total cost of each component over the 10-year analytical period discounted to the base year, 2015, using a 3% discount rate (WHO, 2003). See Appendix B for detailed cost estimate calculations.

Table 6: MANTRA program statistics over 10-year time period

Variable	
Gram Vikas field offices	15
Total villages	641
Bore hole source for water system	449
Gravity flow source for water system	96
Well source for water system	96
Average households per village	158
Total households	101,318

Table 7*: Societal cost of the MANTRA program over a 10-year time period		
Cost component	*Total cost (in 2015 dollars)*	*Cost per household (in 2015 dollars)*
Gram Vikas fixed capital costs	$121,219	$1.20
Gram Vikas recurring costs	$9,230,929	$91.11
Village level fixed capital costs	$33,459,212	$330.24
Village level recurring costs	$954,244	$9.42
Household level fixed capital costs	$77,140,167	$761.37
Household level recurring costs	$4,342,939	$42.86
Total	$125,248,710	$1,236.20

*Includes the costs of all inputs associated with each level based on the time at which they occur and frequency of occurrence

Programmatic costs

Programmatic costs included the expenses required to support Gram Vikas' development and implementation of the MANTRA program. Table 8 illustrates the total programmatic costs incurred over the 10-year analytical period discounted to 2015. Expenses related to Gram Vikas upfront fixed capital costs and its recurring annual cost make up a minimal proportion, approximately 7% of the total cost of the MANTRA program over a 10-year period. The majority of Gram Vikas' costs are due to its recurring expenditures, such as those to cover building rental costs, staff, salaries, and costs associated with travel. Allocating Gram Vikas programmatic costs over the 10-year time period costs households approximately $8.96 per year.

Table 8*: Programmatic cost of MANTRA over a 10-year time period			
Cost component	*Total cost (in 2015 dollars)*	*Cost per household (in 2015 dollars)*	*Cost per household per annum (in 2015 dollars)*
Gram Vikas fixed capital cost (e.g. generator, vehicles, technology equipment)	$121,219	$1.20	$0.12
Gram Vikas recurring costs			
Staff salaries	$7,852,696	$77.51	$7.75
Building rentals	$513,511	$5.07	$0.51
Travel	$322,483	$3.18	$0.32
Other direct costs	$259,630	$2.56	$0.26
Total programmatic costs (fixed capital & recurring)	$9,069,539	$89.52	$8.96

*Includes the fixed capital and recurring costs per annum over a 10-year time period incurred by Gram Vikas independent of the number of villages and households in the MANTRA program (e.g. does not include training costs that are dependent on village participation)

Software costs

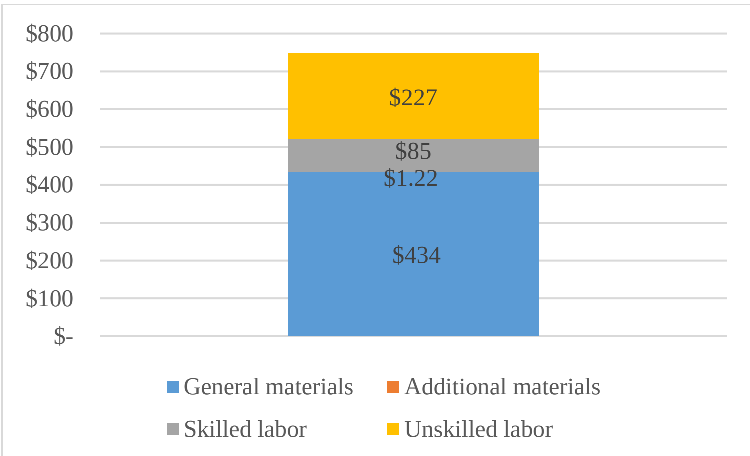
The model incorporated all trainings associated with the MANTRA program to increase villagers' knowledge of WASH, and to improve villagers' WASH behaviors and overall quality of life. The total cost of trainings over the 10-year analytical period discounted to the year 2015 was $566,319, equating to approximately $5.60 per household.

Hardware costs

The fixed capital cost for village level water system accounted for approximately 26% of the total cost of the MANTRA program over a 10-year period. The fixed capital cost of the household sanitary unit, including a latrine and washroom, comprised of approximately 60% of the total cost of the MANTRA program over a 10-year time period. Figure 3 and Figure 4 illustrate the breakdown of the fixed capital costs for the village water system and the household sanitary unit. The average cost of the village water system was $327 per household and the average cost of the household sanitary unit was $747 per household. Table 9 indicates the average cost components of the fixed capital cost for the village water system and household sanitary unit over the 10-year analytical period discounted to the base year, 2015.

A sensitivity analysis regarding the proportion of villages utilizing each type of water source (bore well, gravity flow and well) for their village water systems revealed that changes to the proportion of villages utilizing each system have a large effect on the average cost of the water system per household. Currently, the model assumed that 70% of the villages use bore wells, 15% use gravity flow and 15% use wells. Should the proportion of villages using each type of water source change to reflect a greater percentage of the villages (70%) using a gravity flow, the average cost of the water system per household would be $221, and should a greater percentage (70%) of the villages rely on a well, the average cost of the water system per household would be $374. The village water system cost per household was also highly sensitive to the number of households per village. An increase in the number of households per village by 25% leads to an average fixed capital cost of the village water system of $261 per household, and a 25% decrease in the number of households per village leads to an average fixed capital cost of the water system of $435 per household.

Figure 3: Fixed capital cost components of household sanitary unit per household



Note: General materials – those required for sanitary unit construction
Additional materials – inputs a proportion of households chose to include

Figure 4: Fixed capital cost components of village water system per household

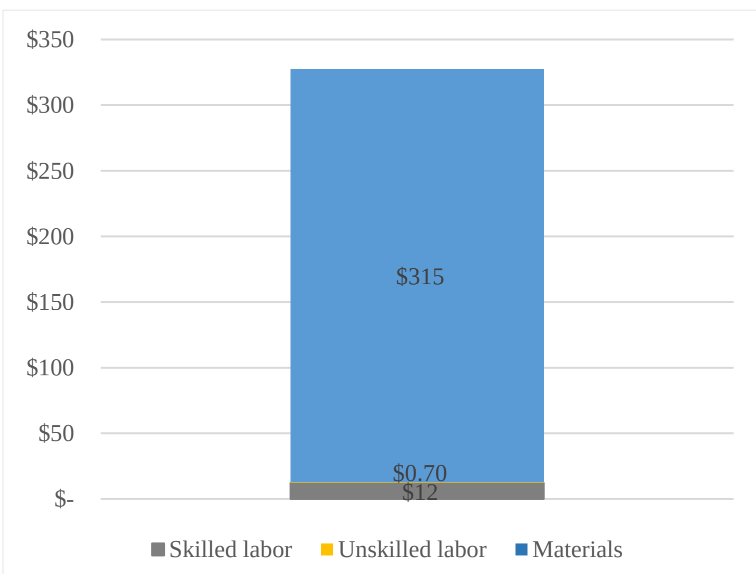


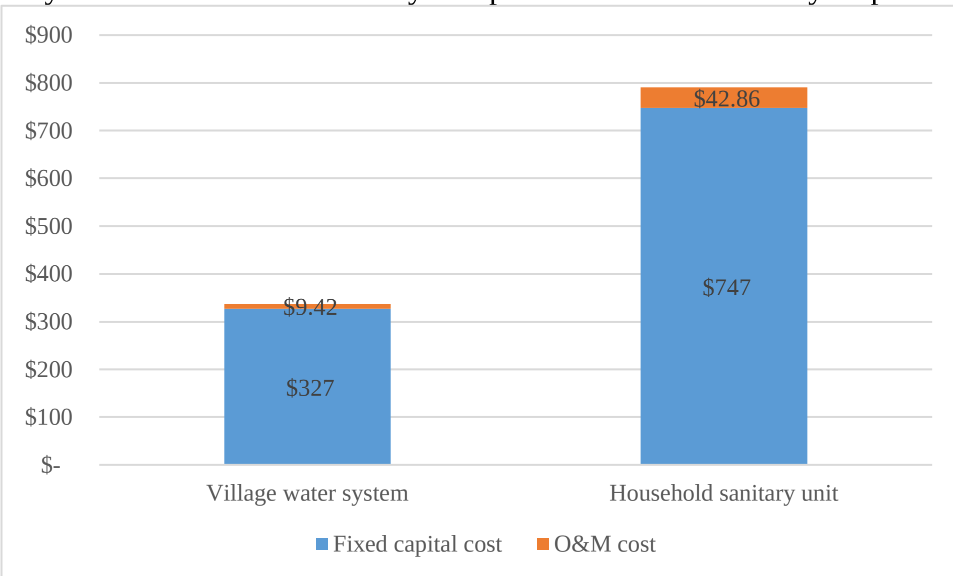
Table 9*: Average fixed capital cost components of the village water system and household sanitary units over a 10-year time period		
Cost component	*Total cost (in 2015 dollars)*	*Cost per household (in 2015 dollars)*
Village water system		
Skilled labor	$1,218,918	$12
Unskilled labor	$70,489	$0.70
Materials	$31,885,644	$315
Village water system total	$33,175,051	$327
Household sanitary unit		
Skilled labor	$8,591,658	$85
Unskilled labor	$23,017,159	$227
General materials	$43,984,420	$434
Additional materials	$123,635	$1.22
Household sanitary unit total	$75,716,873	$747

*Includes the fixed capital costs of labor and materials associated with the village water system and household sanitary unit, excludes costs of one-time trainings per village and household contributions to the Corpus Fund

Operation and maintenance

Overall, the recurring operation and maintenance (O&M) costs of the village water system and household sanitary units make up a small proportion of the total cost of the MANTRA program over the 10-year study period. The operation and maintenance costs for both the village water system and household sanitary units combined account for approximately 4% of the total cost of the program over the 10-year analytical period. Figure 5 illustrates the fixed capital costs of the village water system and the household sanitary units versus the O&M costs associated with each system. The majority of the village annual costs are due to the pump electricity costs and the pump operator salary. The average village O&M cost was about $9.42 per household for the 10-year analytical period. This was based on the assumption that 8.6% of villages would require major repairs and/or improvements per year. The low O&M cost associated with the village water system was partially due to the fact that some of the costs are covered by the annual households' village water system maintenance fee, which was incurred as a cost at the household level.

Figure 5: Fixed capital costs and O&M costs of the village water system and household sanitary unit per household over a 10-year period



The O&M costs associated with the household sanitary unit accounted for approximately 3.8% of the total MANTRA program costs over the 10-year analytical period. These costs included the annual village water system maintenance fee, the cost of materials and labor for major repairs and/or improvements, as well as the cost for waste disposal. The total O&M cost for the household sanitary unit was about $42.86 per household for the course of the 10-year analytical period. This was based on the assumption that 1.4% of households required major repairs and/or improvements per year and that an average of 1.1% of households' utilized FSM services, as standardized per year. Table 10 highlights the recurring costs associated with the village water system and the household sanitary unit per year.

Table 10*: Breakdown of O&M costs of the village water system and household sanitary unit per household per year	
Cost component	*Cost per household per year (in 2015 dollars)*
Village water system	
Water treatment fee	$0.11
Pump electricity	$2.3
Pump operator salary	$0.99
Maintenance – skilled labor	$0.01
Village water system total	$3.42
Household sanitary unit	
Village water system fee	$2.5
Waste disposal	$0.13
Maintenance – skilled labor	$0.02
Maintenance – unskilled labor	$1.61
Maintenance – materials	$0.05
Household sanitary unit total	$4.29

* Includes O&M costs of the village water system and household sanitary unit per household per year

It is likely that as time progresses, the number of households requiring repairs and/or improvements, and the number of households requiring their latrines to be emptied will increase. A sensitivity analysis around the percentage of households requiring repairs or improvements demonstrated that a 5x increase in the percentage of households requiring repairs and/or improvements did not greatly affect the total O&M cost per household for the 10-year analytical period ($45.50 vs. $42.86). Similarly, a 5x increase in the percentage of villages requiring repairs and/or improvements on the village water system causes a minimal increase in the village water system O&M cost per household for the 10-year analytical period (from $9.42 to $10).

Local contributions

While the unit of analysis was per household, the households were not responsible for all costs of the MANTRA program. Figure 6 shows the proportion of costs of the MANTRA program for which each stakeholder – Gram Vikas, the Government of India, the household members. Households were responsible for approximately 80% of the fixed capital costs for the household sanitary units and for almost all recurring costs for the village water system and household sanitary units. However, since this cost analysis took into consideration a societal perspective of labor, this figure also includes labor that was monetarily valued at 2015 minimum wage in Odisha, but was not actually a monetary cost incurred by the household members. Rather this cost attributed to the household members represents the time household members contributed to the construction of the village water system and household sanitary unit. Figure 7 illustrates aggregates the actual monetary cost of the village water system and household sanitary unit (fixed capital and recurring costs for the 10-year analytical period) and the cost attributed to household members' contributed labor. Household member contributed unskilled labor was a minimal proportion of the village water system cost (fixed capital and O&M costs), worth approximately $1 per household over the 10-year analytical period. However, household member contributed unskilled labor was a more significant proportion of the fixed capital and O&M costs for the household sanitary unit. Household contributed unskilled labor accounted for approximately 30% of the cost of the sanitary unit (fixed capital and O&M cost) per household for the 10-year analytical time period.

Figure 6: Percentage of the MANTRA program cost shared by each stakeholder

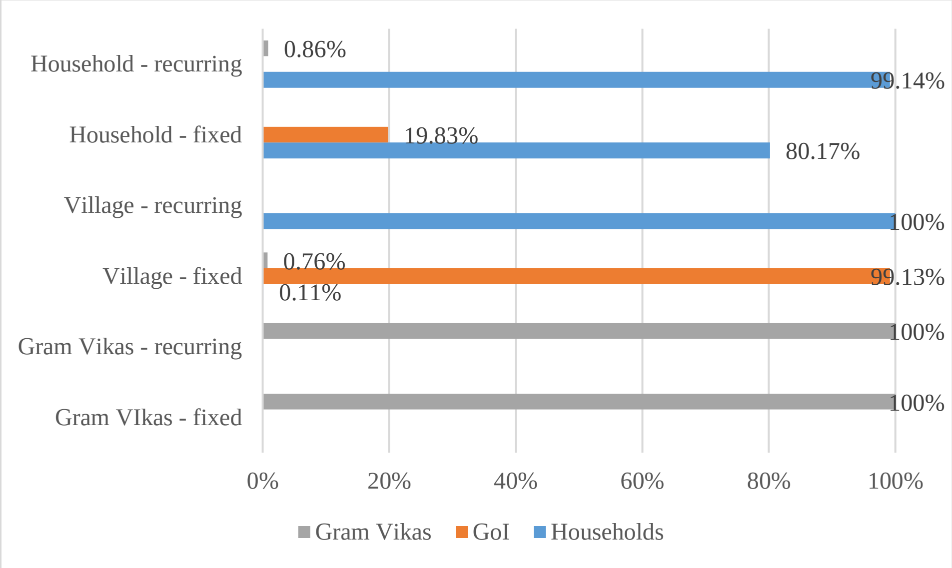


Figure 7: Actual monetary cost, per household, of the village water system and household sanitary unit, and contributed labor cost over a 10-year period

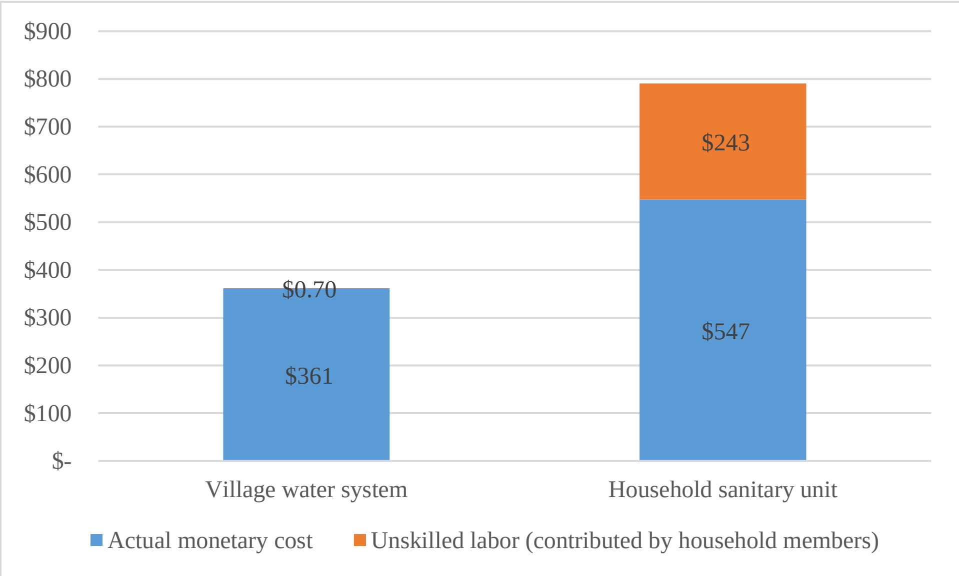
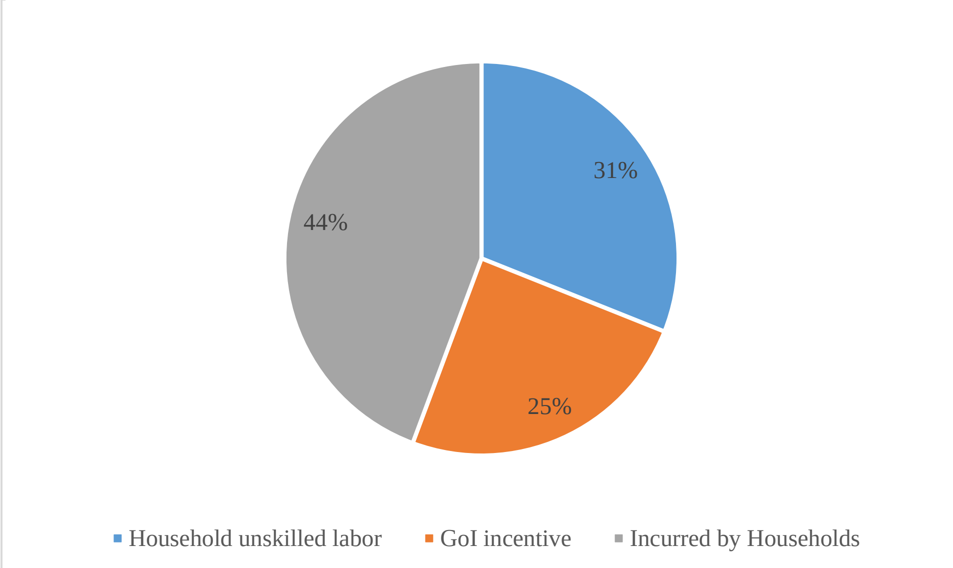


Figure 8 illustrates the breakdown of the household sanitary unit fixed capital cost by stakeholder. Unskilled labor contributed by household members for the construction of the sanitary unit equated to about $227 per household. The Government of India (GoI) provided households with an incentive worth Rs. 12,000 or approximately $180 (in 2015 dollars) to construct their latrines. Therefore, household members were responsible for to covering the remaining $324 fixed capital cost for their sanitary unit.

Figure 8: Breakdown of household sanitary unit fixed capital cost by stakeholder



Government support

The Government of India played an instrumental role in reimbursing the village water system and the household sanitary unit costs. Based on conversations with Gram Vikas, India's Rural Development Department reimbursed the cost of the construction for the village water system, except for 10% of the unskilled labor contributed by community members. Further, through SBM, the Ministry of Drinking Water and Sanitation provided household members with an incentive of Rs. 12,000 or about $180 (in 2015 dollars) to construct their sanitary unit. According to Gram Vikas, in many circumstances, Gram Vikas provided households with a monetary advance to procure materials required for the sanitary unit. It was expected that households would use part of the incentive (approximately Rs. 5,000, $75) to reimburse Gram Vikas for these materials and allocate the remaining incentive toward the construction of their household sanitary unit. The Government of India's support amounted to a contribution of approximately $350 per household for the construction of the village water system and household sanitary unit.

Discount rate

The total cost and per household cost of the MANTRA program was sensitive to the discount rate used over the 10-year analytical period. A 3% discount rate was used based on WHO guidelines (WHO, 2003). Should the discount rate be based on the Government of India's 10-year bond yield, the average 2015 discount rate would be approximately 7.8%, resulting in a total cost of the MANTRA program over the 10-year analytical period to be about $102,500,000 with a per household cost of approximately $1,010 (Reserve Bank of India, 2015).

DISCUSSION

Programmatic costs

Taking a societal approach in which all activities by all stakeholders involved in the MANTRA program were assigned a monetary value, resulted in a per household cost of $1240 to implement and maintain the household piped-water and sanitation intervention throughout a 10-year period. Gram Vikas was able to keep its proportion of costs per household relatively low due to its high-commitment to working with villages that enter the Motivation Phase of the MANTRA program to ensure the villages completely implement the intervention and reach the Completion phase. Should the dropout rate between phases of the intervention increase, the cost per household in the program would increase. In addition, the costs of an NGO, such as Gram Vikas, implementing the intervention may be able to be kept lower than government-incurred costs, as NGO workers tend to be paid less (and have lower fringe rates) than government employees.

The costing model assumed that over 10 years, Gram Vikas would continue to function at its current capacity, utilizing 15 field offices which recruit five new villages per year into the Motivation phase of the intervention. An increase in efficiency as seen in an increase in the number of villages recruited per field office would decrease the intervention cost per household. Should Gram Vikas expand MANTRA by establishing additional field offices, the model would need to adjust for the supplementary costs associated with the expansion, as well as an increase in number of households reached.

Village water system & household sanitary unit costs

The largest cost component of the MANTRA program was due to fixed capital cost of the village water system and the fixed capital cost of the household sanitary unit. The fixed capital cost of the village water system was approximately $327 per household and the fixed capital cost of the household sanitary unit was about $747 per household. While the types and size of the water tanks/towers and water distribution systems vary, the average useful life of a water tank in India is approximately 50 years (Masood *et al*., 2008). And so, the $327 per household fixed capital cost of the water system should enable households to have access to piped-water for approximately 50 years, with the addition of yearly costs for O&M of the water system. According to the World Bank, the useful life of the latrines is at least 10 years (Mara, 1984). Therefore, taking into consideration the value attributed to household unskilled labor ($227) and the Government of India's household incentive ($180), the cost of a household sanitary unit lasting for 10 years becomes $340 per household, accounting for the fixed capital cost of the sanitary unit, plus approximately $4.29 for O&M per year. As this analysis was conducted at the household level, village fixed capital costs, including the cost of the village water system are subject to economies of scale. To lower the cost per household related to the village water system, Gram Vikas should target villages with a greater average number of households. The cost of the household sanitary units could also be reduced if households are able to purchase materials for their units in bulk, thus lowering the material cost per sanitary unit. In regards to the operation and maintenance costs of the village water system and household sanitary unit, these costs are likely to increase overtime. Further, the costing model assumed operation and maintenance costs for the 10-year analytical period; however, in reality these O&M costs exist in perpetuity and so, the cost analysis may have undervalued the recurring costs.

Key stakeholders

The main stakeholders identified by this analysis were Gram Vikas, the Government of India, village leaders and the household members. In particular, the Government of India played a crucial role in monetarily supporting the MANTRA program, covering the majority of the cost of the village water system and providing households with a $180 incentive for their sanitary units. While some have criticized the Government's sanitation efforts for not including a household level connections to piped water supplies or to a sewage system, the results of this analysis demonstrated that the cost per household to provide for adequate sanitary infrastructure including piped water, is greater than the $180 incentive provided by the government (Chandran, 2017). Further, this analysis identified the key role that household members play in contributing manual labor to the construction of the village water system and to their household sanitary unit, as well as financially providing for the materials required for the household sanitary unit that are not covered by the Government incentive. Further, the results demonstrated that given the considerable investment made by households to construct their sanitary unit, it is very important that Gram Vikas works to ensure the mandate of 100% participation by all households in a village is upheld so that the households' receive the benefits of a household level piped water system.

Comparison to other programs

Given the differences in technology and inclusion of both hardware and software, it was difficult to compare Gram Vikas' MANTRA program to other WASH-related program. Breaking down the two main cost components – the fixed capital cost of the village water system and the fixed capital cost of the sanitary units – the fixed capital cost of the village water system, approximately $327 per household, was similar to the range of per capita estimates ($161-$322) of providing household piped water in a study that assessed various cost scenarios (Hutton and Bartram, 2008) on a per person basis. Based on the 2011 Census, the average household size in India is approximately 4.8 people (Census of India, 2011). When accounting for the average number of people per household, the fixed capital cost of MANTRA's village water system falls below the range of per capita estimates in Hutton and Bartram study ($327/4.8 = $68.13 per capita cost over 10 years) (2008). Further, the annual O&M costs for a MANTRA village water system equated to approximately $3.42 per household, which is lower than the $9.6 annual cost of household piped water in Asia found in a WHO sponsored global cost analysis (Hutton and Bartram, 2008).

Based on the WHO's global cost analysis for water and sanitation, the high range of unit costs amount to approximately $161 fixed capital cost per capita for other sanitation improvements (not sewerage) (Hutton and Bartram, 2008). MANTRA's $520 fixed capital cost for the household sanitary unit, which was calculated per household, is similar to the $161 estimate that was calculated per person when taking into consideration there are approximately 4.8 people per household ($520/4.8 = $108 per capita cost over 10 years or $10.8 per capita, per year over the estimated life of the sanitary unit). The fixed capital cost of the sanitary unit, excluding the cost of household contributed unskilled labor, $520 was greater than the costs of sanitation hardware ($208) per household found in a World Bank study conducted in India, but similar to the costs of sanitation hardware found in Ecuador and Senegal (Trémolet *et al*., 2010). The MANTRA sanitary unit included the cost of an adjacent bathing room and three household water connections, which may contribute to at least some of the cost difference when comparing sanitary hardware costs in India.

Strengths

WASH expenditure data is limited. It is also often difficult to assess the amount of WASH expenditure as there are many projects or programs in the space that involve multiple stakeholders contributing to implementation (GLAAS, 2017). This analysis overcomes these difficulties by detailing the proportion of costs of the MANTRA program allocated to each major stakeholder – Gram Vikas, the Government of India and households. Thus, this analysis provides insights into the relative burden of cost that each key stakeholder bears for this water and sanitation intervention and can be used as a baseline to inform the development of future WASH programs in India. Overall, this WASH cost analysis is one of the few studies that incorporates both upfront fixed capital costs for the hardware and software, as well as the O&M costs associated with the water system and sanitary units over a 10-year analytical period to provide an accurate representation of the costs to implement and maintain a WASH intervention.

Limitations

There were several limitations of this study that may influence the interpretation of the results. In general, the retrospective nature of this cost analysis lends itself more to the potential for incomplete data and inaccurate information due to recall bias (Crocker *et al*., 2017). This analysis relied on the aggregation of costs from multiple sources, including an enumeration exercise and interviews with Gram Vikas, Gram Vikas financial records, village-level surveys and household-level surveys. The varying sources occasionally provided conflicting information on the frequency of activities and inputs. In these situations, the parameter estimate included in the model was derived from the source most closely associated with the activities and resources. Therefore, the cost of the intervention may vary slightly depending on the sources of information used for the analysis. Further, given that the majority of the inputs on the village and household level relied on respondent-report data, the cost estimates may have been over reported, as studies have documented that respondent-reported data regarding sanitation-related issues may be over-estimated relative to objective measures (Delea *et al*, 2017; Sinha *et al*., 2016). In addition, price changes due to inflation were not considered, which may underestimate the total cost given the analytical period covered 10-years and so, it was unlikely that prices would remain the same over this time.

In addition, there were a few cost drivers that were not accounted for in the analysis as the information was missing. In the cost enumeration exercise conducted with Gram Vikas, it was noted that a royalty was required to pay for the ‘leasing’ of the land from which materials for the sanitary units derive. However, it was not possible to obtain the exact cost of this royalty from Gram Vikas for this study. Further, this study did not account for exact travel distances that may have altered the cost of the intervention. For instance, the cost model used an estimate of 30% of Gram Vikas staff to determine the food allowance cost allotted to staff for meetings and trainings more than 10 kms from their Supervisor’s house. Actual transportation costs for other activities, such as the cost Gram Vikas and households bore for transporting external materials for the construction of the village water system and household sanitary units were not taken into consideration. Further analyses may attempt to calculate this cost by using GoogleEarth and spatial analysis software to map the distance between the location of the vendors for external supplies and the MANTRA villages.

While this model accounted for operation and maintenance costs, these costs were likely undervalued. The cost for a government lab fee to test the microbiological quality of the water was indicated by Gram Vikas as an activity that occurs three times per year. However, a cost for the government lab fee was not provided and so, the model does not account for this cost. The costs for maintenance were based on the village and household surveys, which indicated that a small proportion of villages and households had incurred inputs associated with repairs and/or improvements as of the completion of the survey in 2016. However, the village surveys did not report any material inputs required for maintenance and so, these costs were not accounted for in the model.

Further, this study did not consist of an in-depth analysis of capacity utilization. On the village level, data regarding the opportunity cost of village water systems not running at full capacity was not analyzed, as the capacity level of the village water systems was not documented. On the household level, capacity utilization was vaguely captured by the information regarding waste disposal derived from the household surveys. These surveys provided some information on the useful life of the sanitary units and the costs associated with reaching maximum capacity, mainly the costs associated with pit emptying. However, the accuracy of the costs regarding waste disposal is limited given that few households had reached maximum capacity of their latrines and had required their latrines to be emptied as of 2016, when the household surveys were completed. Therefore, the cost of waste disposal is likely to increase over time as more households' latrines reach maximum capacity and require emptying. These costs may be difficult to assess given the variability and inconsistency of information regarding pit latrine emptying. However, it is important to the sustainability of the MANTRA program and to its potential health impact, to ensure that households are safely disposing their waste and that the waste does not re-contaminate the environment (Jenkins *et al*., 2015).

Conclusions and Implications

Conclusions

Taking a societal approach, the total cost of the MANTRA program over the 10-year analytical period was about $125,250,000, equally approximately $1,240 per household. This cost included the programmatic costs of developing and implementing the MANTRA program, the fixed capital costs of the village water system and household sanitary unit, as well as the O&M costs associated with the village water systems and household sanitary units over the 10-year analytical period. During this 10-year period, the model assumed that MANTRA would be implemented in 641 villages, reaching approximately 101,318 households. The largest cost components of the intervention are the fixed capital costs of the village water systems ($327 per household) and the fixed capital cost of the household sanitary units ($747 per household). The Government of India is a crucial supporter of the MANTRA program, as the Government covered the majority of the cost of the village water system, as well as provided households with a $180 incentive for their sanitary units. Gram Vikas' ability to engage households to participate in the MANTRA program was also essential as 100% of participation by households is required for the village water system to be turned on. Household participation required household members to contribute their time in the form of unskilled labor for the construction of their household sanitary unit and the village water system, as well as to provide approximately $324 to cover the sanitary unit materials' cost.

Overall, this study determined the cost of developing and maintaining a WASH intervention that provides household piped water connections and household sanitary units over a 10-year time period in Odisha, India. The model assumptions and limitations of this study should be taken into consideration when applying the results of this study to a larger context. In general, the study found that household buy-in, both in the form of labor and financial contributions are essential to the completion of the WASH intervention. Further, the results indicate the Government expenditure per household would need to be significantly increased in order to cover the true cost of providing adequate and safe WASH, with the inclusion of piped water, at the household level in India. While the provision of household level piped water increases the cost per household, this system (household piped water connections and bathing room within the household compound) may serve to interrupt the environment in which open defecation typically occurs.

Implications

The results of this analysis may indicate a possible means of reducing open defecation in India. In 2007, only 10% of rural households in Odisha (then Orissa) had access to a toilet facility (Government of India, 2007). Even with the initiation of the Government's total sanitation campaign, the increase in latrine coverage in Odisha from 2001 to 2011 was only 7%, with 85% of the population continuing to openly defecate (Census of India, 2011). This intervention assists in increasing the number of households in Odisha with access to a household toilet facility. More importantly, each sanitary unit consists of a latrine and a washroom. The washroom is essential to eliminating open defecation. The inclusion of a washroom along with piped water at the household level provides the means for individuals, particularly women, to wash themselves post-defecating, as well as providing a space to bathe, thus eliminating the need to go to a water source where open defecation typically occurs (Sahoo *et al*., 2015). Disruption of environments that support unimproved behaviors is a forgoing principle for breaking those behaviors and simultaneous habituating improved behaviors (Wood and Neal, 2016). Evidence suggests habituating defecation in comfortable, durable, and hygienic improved latrines leads to health benefits (Freeman *et al*., 2017). As a result, there is added value in the inclusion of the washroom in terms of both utilization of facilities, as well as health impacts.

Further, reports have indicated inadequate technology and poor quality have contributed to a lack use of the Government-sponsored latrines, (WSP, 2010; Routray *et al*., 2015). In contrast, the provision of household piped water can reduce the issue regarding a lack of resources needed to use the latrine that often hinder latrine usage (Routray *et al*., 2015). India is currently responsible for roughly two-thirds of the global population who continue to practice open defecation (WHO/UNICEF, 2012). The structure of the MANTRA program may provide an economical means of reducing India's burden of open defecation, assisting India in its goal of being open defecation free by 2019 and in achieving Goal 6 of the SDGs (PMINDIA, 2014; UN General Assembly, 2015).

Future directions

It is anticipated that the results of this cost analysis will be used to inform a cost benefit and/or a cost effectiveness analysis. A cost benefit analysis estimates the net social benefit of a program as the total benefits of the program minus the total costs of the program, measured in US dollars (Cellini, 2010). Based on the aggregation of the costs associated with the benefits of a program and the costs of the program itself, a cost-benefit ratio can be calculated. In general, projects and programs with a benefit-cost ratio greater than 1 are considered an efficient allocation and use of resources (Cellini, 2010). A cost benefit analysis of this study may identify the benefits as those costs associated with prevented medical expenses and time saved due to the MANTRA program. The total cost of the MANTRA program would then be subtracted from the total benefits to determine the total net benefit of the MANTRA program.

This analysis also provides the cost information required to perform a cost-effectiveness analysis. A cost-effectiveness analysis assesses the amount saved (in U.S. dollars) per disability adjusted life year (DALY) averted. Research has demonstrated that WASH interventions can be cost-effective. A study that analyzed a wide range of WASH-related interventions found that almost all interventions were cost-effective, particularly those set in developing countries with high mortality rates due to WASH-related issues (Haller *et al*., 2007). In this study, to determine cost-effectiveness, the costs of all resources required to establish and maintain the WASH intervention were totaled, whereas the "effectiveness" was derived from the reduction in incidences of diarrhea due to the intervention. The research determined that the estimated cost-effectiveness ratios varied between $20 per DALY averted for point of use water disinfection interventions to $13,000 per DALY averted for improved water and sanitation facilities (Haller *et al*., 2007). Therefore, this cost analysis provides the foundation to evaluate the cost-effectiveness of Gram Vikas' MANTRA program. Preliminary results indicated that the MANTRA program has a protective impact against stunting and STH infection. A cost-effectiveness analysis for the MANTRA program could determine the cost per DALY averted associated with stunting and STH infection. The results of a cost-effectiveness analysis for the MANTRA program could provide guidance on how the Government of India and nonprofits should allocate resources in order to combat WASH-related diseases.

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Appendix A - Model Cost Assumptions Chart

Note: Village survey data was filtered to include only those villages that had a functioning water distribution system (N=58) and household survey data was filtered to include only households with a functioning sanitary unit (latrine and washroom) that had received the assistance of Gram Vikas (N=284).

Level	Parameter Estimate	Assumptions	Assumption Calculations (required to determine model # of units and unit costs)	Data Source
Gram Vikas – fixed capital costs	All parameters	Assumed costs were incurred in the base year (2015)		Gram Vikas data
Gram Vikas – fixed capital costs & recurring costs	All Head Office-related parameters	Assumed 80% of general GRAM VIKAS costs are allocated to the MANTRA program	Multiplied all shared costs by 80%	Gram Vikas correspondence
Gram Vikas – recurring costs	Head Office rent	Based on the average monthly rent for GRAM VIKAS's Field Offices adjusted for square footage	Calculated average rental cost per square foot of Field Office, multiplied by square feet of Head Office to arrive at cost	Gram Vikas CEA costing extraction
Gram Vikas – recurring costs	Field Office rent	Assumed 15 Field Offices over the 10-year study period (8 rented; 7 GRAM VIKAS owned) Average rental value of the 8 rented Field Offices was applied to all 15 Field Offices	Calculated average rental cost per square foot of Field Office, multiplied by the average square feet of the Field Offices, multiplied by 15 Field Offices	Gram Vikas CEA costing extraction
Gram Vikas – recurring	All trainings	Assumed the cost of trainings provided by GRAM VIKAS was inclusive of all costs incurred by the training		Gram Vikas CEA costing extraction
Gram Vikas – recurring	School sanitation and hygiene training + Self-help group trainings	Assumed the unit costs for school sanitation and hygiene trainings, and for the self-help group trainings are the same as the unit costs for other trainings and that the # of units is one per month per Field Office		Gram Vikas cost enumeration exercise
Gram Vikas – recurring	Food allowance – all staff, trainers, training/meeting participants	Assumed 1/3 of staff, trainers, training/meeting participants lived more than 10 kms from the Field Supervisor and were thus, eligible for	Multiplied number of units by 1/3	Gram Vikas CEA costing extraction

		the Food Allowance (Unit number based on 1/3 of the unit costs from local transportation)		
Village – fixed capital	Village hygiene training	Assumed the village hygiene training has the same unit cost as the other trainings and that the cost is incurred per village in the Implementation Phase		Gram Vikas cost enumeration exercise
Village – fixed capital	Travel for exposure visits	Assumed the unit cost for exposure visits is the same as the local transportation unit cost and that the number of units is 4 (3-5 villagers attend the exposure visit per village in the Motivational Phase)		Gram Vikas CEA costing extraction, Gram Vikas cost enumeration exercise
Village – fixed capital	Labor (skilled)	Based on the value for labor provided in the water system specifications		Gram Vikas provided water system estimates
Village – fixed capital	Labor (unskilled)	Unit based on the average number of village members who contributed labor to the village water system, multiplied by the average number of labor days, multiplied by the 2015 minimum wage for unskilled labor Assumed village members ONLY contribute unskilled labor		Village surveys, Labour & E.S.I. Department, 2015
Village – fixed capital	Electro-chlorinator	Assumed the cost was accounted for in the water system specifications		Gram Vikas provided water system estimates
Village – fixed capital	Water system	Assumed 70% of villages used a bore well, 15% of villages used a gravity flow and 15% used a well Based the costs of each type of water system on estimates for a water system that had the capacity to service 100-200 households to accommodates for an average of 158 households per village		Village surveys, Gram Vikas provided water system estimates
Village – recurring	Water treatment fee	Assumed the water treatment fee is an average from all villages that provided a numerical value (including 0) for the		Village surveys

		question regarding water treatment fees		
Village – recurring	Pump electricity	Assumed the electric cost is an average of all villages reporting electric costs		Village surveys
Village – recurring	Pump operator salary	Assumed the pump operator salary is an average of the villages reporting pump operator salary		Village surveys
Village – recurring	Maintenance (overall)	Assumed that the percentage of villages requiring repairs/improvements per year is the same as the percentage of villages requiring repairs/improvements per year from the Village surveys Assumed this percentage remained constant over the 10-year analytical period	On average villages began construction on their water system in 2007, with completion of the water tank and distribution network taking an average of 27 months, finishing in approximately 2009. Thus, these villages have been operational for about 7 years when the survey occurred. Over 7 years 36/58 villages required repairs/improvements = approximately 5 villages per year or 8.6% of total villages required repairs/improvements per year. All maintenance related parameter estimates are multiplied by 8.6% per year.	Village surveys
Village – recurring	Maintenance (labor, skilled)	Assumed that the percentage of villages requiring skilled labor for repairs/improvements is the same per year, derived from the percentage of villages requiring skilled labor for repairs/improvements in the Village surveys Assumed price of labor is based on market value (minimum wage, 2015) Assumed unit cost is total person-days worked. Person-days worked was calculated based on the average number of skilled laborers required for repairs/improvements multiplied by the average number of days worked	31/36 (85%) villages requiring repairs and/or improvements used skilled labor for repairs and/or improvements since original construction. Thus, the number of units of skilled labor for repairs and/or improvements post original construction is multiplied by 85%	Village surveys, Labour & E.S.I. Department, 2015
Village – recurring	Maintenance (labor, unskilled)	Limitation – No data		No data provided in Village surveys
Village – recurring	Maintenance (materials)	Limitation – No data		No data provided in Village surveys

Village – recurring	Household water system maintenance fee	Total village recurring costs were net the average village water system fee total households pay per year		Household surveys
Household – fixed capital	Corpus Fund	Assumed all households contributed Rs. 1000 to Corpus Fund upon entering into the Motivational Phase		Gram Vikas correspondence
Household – fixed capital	Sanitation hardware (material)	Assumed average amount of each material based on reporting households Assumed 2015 market price for all materials required for sanitation hardware		Household surveys, Gram Vikas provided market prices
Household – fixed capital	Additional Hardware	Assumed not all households used these materials based on the proportion of households reporting the use of these materials. Calculated percentage of households requiring these materials per year based on the proportion of households that used these materials per year in the Household Cost survey Assumed average amount of each material based reporting households Assumed market prices for all additional hardware	Based on the household surveys, 28/284 (10%) of households indicated they utilized tiles for the construction of their sanitary units, so the model multiplies the units for tiles used for the original construction of household sanitary units by 10% Based on the household surveys, 110/284 (40%) of households indicated they utilized pre-fabricated grill for the construction of their sanitary units, so the model multiplies the units for pre-fabricated grill used for the original construction of household sanitary units by 40%	Household surveys, Gram Vikas provided market prices
Household – fixed capital	Labor (skilled)	Assumed price of labor is based on market value (minimum wage, 2015) Assumed unit cost is total person-days worked. Person-days worked was calculated based on the average number of skilled laborers multiplied by the average number of days worked		Household surveys, Labour & E.S.I. Department, 2015
Household – fixed capital	Labor (unskilled)	Assumed that household members ONLY contributed unskilled labor Assumed price of labor is based on market value (minimum wage, 2015)		Household surveys, Labour & E.S.I. Department, 2015

		Assumed unit cost is total person-days worked. Person-days worked was calculated as follows: average # of household members who provided unskilled labor + (% of households with additional unskilled laborers*average number of additional unskilled laborers) multiplied by the average number of days worked		
Household – recurring	Water system maintenance fee	Assumed 90% of households paid a village water maintenance fee per month based on reporting households Assumed the average monthly fee based on reporting households		Household surveys
Household – recurring	Maintenance (overall)	Assumed that the percentage of households requiring repairs/improvements per year is the same as the percentage of households requiring repairs/improvements per year from the Household surveys Assumed this percentage remained constant over the 10-year analytical period	On average households began construction on their sanitary units in 2008, with completion of the sanitary unit taking an average of 4 months, finishing in approximately the same year, 2008. Thus, these households have been operational for about 8 years when the survey occurred. Over 8 years 30/284 villages required repairs/improvements = approximately 4 households per year or 1.4% of total households required repairs/improvements per year. All maintenance related parameter estimates are multiplied by 1.4% per year	Household surveys
Household – recurring	Maintenance (labor, skilled)	Assumed the percentage of households requiring skilled labor for repairs/improvements is the same per year, derived from the percentage of households requiring skilled labor for repairs/improvements in the Household surveys Assumed price of labor is based on market value (minimum wage, 2015)	12/30 (40%) of the households requiring repairs and/or improvements used skilled labor for repairs and/or improvements since original construction. Thus, the number of units of skilled labor was multiplied by 40%	Household surveys, Labour & E.S.I. Department, 2015

		Assumed unit cost is total person-days worked. Person-days worked was calculated based on the average number of skilled laborers required for repairs/improvements multiplied by the average number of days worked		
Household – recurring	Maintenance (labor, unskilled)	Assumed that the percentage of households requiring unskilled labor for repairs/improvements is the same per year, derived from the percentage of households requiring unskilled labor for repairs/improvements in the Household surveys Assumed that household members ONLY contributed unskilled labor for repairs/improvements Assumed price of labor is based on market value (minimum wage, 2015) Assumed unit cost is total person-days worked. Person-days worked was calculated based on the average number of household members and additional people who contributed unskilled labor required for repairs/improvements multiplied by the average number of days worked	10/30 (33.33%) of the households requiring repairs and/or improvements had household members contribute unskilled labor for repairs and/or improvements since original construction. Thus, the number of units of household contributed unskilled labor for households requiring repairs and/or improvements was multiplied by 33.33% 2/30 (6.67%) of the households requiring repairs and/or improvements had additional people contribute unskilled labor for repairs and/or improvements since original construction. Thus, the number of units of additional unskilled labor for households requiring repairs and/or improvements was multiplied by 6.67%	Household surveys, Labour & E.S.I. Department, 2015
Household – recurring	Maintenance (materials)	Assumed the same percentage of households requiring repairs/improvements that used each material is the same per year Assumed the amount of each material required for repairs/improvements per household is the same per year Assumed 2015 market price for all materials	Sand – 2/30 (6.67%) of households requiring repairs and/or improvements used sand and so, the unit of sands used for household repairs and/or improvements was multiplied by 6.67% Cement – 8/30 (26.67%) of households requiring repairs and/or improvements used cement and so, the unit of cement used for household repairs and/or improvements was multiplied by 26.67% U-pipe – 10/30 (33.33%) of households requiring repairs and/or improvements used a U-pipe and so,	Household surveys, Gram Vikas provided market prices

			the unit of U-pipe used for household repairs and/or improvements was multiplied by 33.33% Y-connection – 2/30 (6.67%) of households requiring repairs and/or improvements used a Y-connection and so, the unit of Y-connection used for household repairs and/or improvements was multiplied by 6.67% Joint pipe – 4/30 (13.33%) of households requiring repairs and/or improvements used a Joint pipe and so, the unit of Joint pipe used for household repairs and/or improvements was multiplied by 6.67% Supports – 4/30 (13.33%) of households requiring repairs and/or improvements used supports and so, the unit of supports used for household repairs and/or improvements was multiplied by 13.33% Poles/bamboo/timber – 4/30 (13.33%) of households requiring repairs and/or improvements used sand and so, the unit of sands used for household repairs and/or improvements was multiplied by 13.33% Whitewash – 2/30 (6.67%) of households requiring repairs and/or improvements used whitewash and so, the unit of whitewash used for household repairs and/or improvements was multiplied by 6.67% Pre-fabricated pit cover – 2/30 (6.67%) of households requiring repairs and/or improvements used sand and so, the unit of pre-fabricated pit covers used for household repairs and/or improvements was multiplied by 6.67% Colored paint – 2/30 (6.67%) of households requiring repairs and/or improvements used colored paint and so, the units of colored paint used for	

			household repairs and/or improvements was multiplied by 6.67% Tiles – 2/30 (6.67%) of households requiring repairs and/or improvements used tiles and so, the unit of tiles used for household repairs and/or improvements was multiplied by 6.67%	
Household – recurring	Waste Disposal	Assumed percentage of households requiring pit emptying per year is the same based on the Household surveys Assumed the average number of times a pit is to be emptied per household is the same per year based on the Household surveys Calculated the cost per pit emptying based on the average cost of pit emptying from the Household surveys	On average households began construction on their sanitary units in 2008, with completion of the sanitary unit taking an average of 4 months, finishing in approximately the same year, 2008. 44/284 households indicated that their sanitary units had filled, with an average fill date being 2015. Therefore, on average, it took approximately 7 years for a household sanitary unit to fill. This equates to approximately 2.2% of households with filled latrine pits per year. All waste disposal parameter estimates were multiplied by 2.2% per year (22/44) 50% of the households with filled latrines indicated they had the pit emptied and so, the unit of pit emptying was multiplied by 50%, equating to 1.1% of households requiring FSM services per year	Household surveys

Appendix B – Detailed Cost Estimates by Level

Table 11: 10-Year total cost of the MANTRA program (in 2015 Indian Rupees)

	0	1	2	3	4	5	6	7	8	9	10
Cost Level	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Gram Vikas (fixed capital)	8,093,800	-	-	-	-	-	-	-	-	-	-
Gram Vikas (recurring)	64,673,245	64,673,245	64,673,245	64,673,245	64,673,245	64,673,245	64,673,245	64,673,245	64,673,245	64,673,245	64,673,245
Village (fixed capital)	96,110,475	284,047,113	284,047,113	284,047,113	284,047,113	284,047,113	284,047,113	284,047,113	284,047,113	187,936,638	0
Village (recurring)	-	-	1,754,806	3,509,612	5,264,418	7,019,224	8,774,030	10,528,836	12,283,642	14,038,448	15,793,254
Household (fixed capital)	226,123,242	654,734,015	654,734,015	654,734,015	654,734,015	654,734,015	654,734,015	654,734,015	654,734,015	428,610,773	0
Household (recurring)	-	-	7,986,441	15,972,883	23,959,324	31,945,765	39,932,206	47,918,648	55,905,089	63,891,530	71,877,972
Total per annum	395,000,761	1,003,454,372	1,013,195,620	1,022,936,867	1,032,678,114	1,042,419,361	1,052,160,609	1,061,901,856	1,071,643,103	759,150,634	152,344,470

NPV	8,362,856,356.11
Total Cost per Household (Rs.)	82,563.42
Total Cost USD	125,248,709.84
Total Cost per Household (USD)	1,236.20

Table 12: 10-Year Gram Vikas fixed capital costs by cost component (in 2015 Indian Rupees)

	0	1	2	3	4	5	6	7	8	9	10
Cost Component	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Head Office											
Generator	660,000	-	-	-	-	-	-	-	-	-	-
Photocopier	224,000	-	-	-	-	-	-	-	-	-	-
Server	240,000	-	-	-	-	-	-	-	-	-	-
Firewell	120,000	-	-	-	-	-	-	-	-	-	-
UPS	8,800	-	-	-	-	-	-	-	-	-	-
AV Equipment	216,000	-	-	-	-	-	-	-	-	-	-
MANTRA Specific		-	-	-	-	-	-	-	-	-	-
Computers	700,000	-	-	-	-	-	-	-	-	-	-
Printers	150,000	-	-	-	-	-	-	-	-	-	-
Vehicles	4,800,000	-	-	-	-	-	-	-	-	-	-
Motorbikes	975,000	-	-	-	-	-	-	-	-	-	-
Total per annum	8,093,800	-	-	-	-	-	-	-	-	-	-

NPV	8,093,800.00
Total Cost per Household (Rs.)	79.89
Total Cost USD	121,219.11
Total Cost per Household (USD)	1.20

Table 13: 10-Year Gram Vikas recurring costs by cost component (in 2015 Indian Rupees)

					0	1	2	3	4	5	6	7	8	9	10
Cost Component	Rate (LoE)	unit	unit cost	# of units	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Labor															
Head Office Staff															
Executive Director	0.6	average yearly base salary	2,760,000	1	1,656,000	1,656,000	1,656,000	1,656,000	1,656,000	1,656,000	1,656,000	1,656,000	1,656,000	1,656,000	1,656,000
Finance Manager	0.8	average yearly base salary	600,000	1	480,000	480,000	480,000	480,000	480,000	480,000	480,000	480,000	480,000	480,000	480,000
MANTRA Project Director	1	average yearly base salary	1,440,000	1	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000
Senior Project Manager	1	average yearly base salary	600,000	2	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Project Manager	1	average yearly base salary	480,000	6	2,640,000	2,640,000	2,640,000	2,640,000	2,640,000	2,640,000	2,640,000	2,640,000	2,640,000	2,640,000	2,640,000
Chief/Head Accountant	0.8	average yearly base salary	312,000	1	249,600	249,600	249,600	249,600	249,600	249,600	249,600	249,600	249,600	249,600	249,600
Assistant Accountant (Head Office)	0.8	average yearly base salary	240,000	10	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000
Procurement Officer (Head Office(	0.5	average yearly base salary	240,000	1	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000
PM&ED Officer	0.8	average yearly base salary	240,000	6	1,152,000	1,152,000	1,152,000	1,152,000	1,152,000	1,152,000	1,152,000	1,152,000	1,152,000	1,152,000	1,152,000
Senior Field Office Assistants	1	average yearly base salary	270,000	2	540,000	540,000	540,000	540,000	540,000	540,000	540,000	540,000	540,000	540,000	540,000
Engineer	1	average yearly base salary	240,000	5	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Executive Director's Assistant	0.6	average yearly base salary	168,000	1	100,800	100,800	100,800	100,800	100,800	100,800	100,800	100,800	100,800	100,800	100,800
HR and Administration	0.5	average yearly base salary	432,000	1	216,000	216,000	216,000	216,000	216,000	216,000	216,000	216,000	216,000	216,000	216,000
HR Assistant	0.5	average yearly base salary	216,000	1	108,000	108,000	108,000	108,000	108,000	108,000	108,000	108,000	108,000	108,000	108,000
Driver	0.5	average yearly base salary	150,000	3	225,000	225,000	225,000	225,000	225,000	225,000	225,000	225,000	225,000	225,000	225,000
Fringe Benefits	0.56		8,388,000	42	7,418,544	7,418,544	7,418,544	7,418,544	7,418,544	7,418,544	7,418,544	7,418,544	7,418,544	7,418,544	7,418,544
Total Head Office Labor per annum					20,665,944	20,665,944	20,665,944	20,665,944	20,665,944	20,665,944	20,665,944	20,665,944	20,665,944	20,665,944	20,665,944
Field office staff															
Project Coordinator	1	Average yearly salary	300,000	15	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000
Accountant (Field office)	1	Average yearly salary	180,000	15	2,700,000	2,700,000	2,700,000	2,700,000	2,700,000	2,700,000	2,700,000	2,700,000	2,700,000	2,700,000	2,700,000
PM&ED Officer (Field office)	1	Average yearly salary	120,000	15	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000
Office Assistant (Field office)	1	Average yearly salary	180,000	1	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000
Field Supervisor	1	Average yearly salary	120,000	92	11,040,000	11,040,000	11,040,000	11,040,000	11,040,000	11,040,000	11,040,000	11,040,000	11,040,000	11,040,000	11,040,000
Field technician	1	Average yearly salary	144,000	5	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000
Cook (field ofice)	1	Average yearly salary	96,000	5	480,000	480,000	480,000	480,000	480,000	480,000	480,000	480,000	480,000	480,000	480,000
Driver (field office)	0.05	Average yearly salary	1,500,000	8	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Fringe benefits (~56%) - Field Office Staff															
Fringe	0.56	Average yearly salary	22,020,000	All field staff	12,331,200	12,331,200	12,331,200	12,331,200	12,331,200	12,331,200	12,331,200	12,331,200	12,331,200	12,331,200	12,331,200
Total Field Office Labor per annum					34,351,200	34,351,200	34,351,200	34,351,200	34,351,200	34,351,200	34,351,200	34,351,200	34,351,200	34,351,200	34,351,200
Buildings															
Head Office	0.8	average yearly expenditure	419,170	1	335,336	335,336	335,336	335,336	335,336	335,336	335,336	335,336	335,336	335,336	335,336
Field office rent	1	average yearly expenditure	78,000	15	1,170,000	1,170,000	1,170,000	1,170,000	1,170,000	1,170,000	1,170,000	1,170,000	1,170,000	1,170,000	1,170,000
Printing (Head Office)	0.8	yearly allocation	78,000	1	62,400	62,400	62,400	62,400	62,400	62,400	62,400	62,400	62,400	62,400	62,400
Stationary (Head Office)	0.8	yearly allocation	66,000	1	52,800	52,800	52,800	52,800	52,800	52,800	52,800	52,800	52,800	52,800	52,800
Electricity & Water (Head Office)	0.8	average yearly expenditure	54,000	1	43,200	43,200	43,200	43,200	43,200	43,200	43,200	43,200	43,200	43,200	43,200
Electricity & Water (Field offices)	1	average yearly expenditure	18,000	15	270,000	270,000	270,000	270,000	270,000	270,000	270,000	270,000	270,000	270,000	270,000
Internal Audits	0.8	yearly allocation	1,800,000	1	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000
External Audits	0.8	per annum	250,000	1	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
Fuel for equipment (Head Office - generator)	0.8	average yearly expenditure	30,000	1	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
Total Building Costs per annum					3,597,736	3,597,736	3,597,736	3,597,736	3,597,736	3,597,736	3,597,736	3,597,736	3,597,736	3,597,736	3,597,736
Trainings															
Trainer - Income Generation Activities (horticulture, fish, culture	1	daily rate/honorarium	3,000	60	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000
Health Camp consultants (Health Staff)	1	daily rate/honorarium	3,000	540	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000
School sanitation and hygiene training	1	daily rate/honorarium	3,000	30	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000
Training of self-help groups	1	daily rate/honorarium	3,000	30	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000
Total Trainings Cost per annum					1,980,000	1,980,000	1,980,000	1,980,000	1,980,000	1,980,000	1,980,000	1,980,000	1,980,000	1,980,000	1,980,000
Travel															
Local transportation - all staff, trainers, training/meeting participants		round trip	800	1,269	1,015,200	1,015,200	1,015,200	1,015,200	1,015,200	1,015,200	1,015,200	1,015,200	1,015,200	1,015,200	1,015,200
Fuel for motorbikes (all motorbikes)	0.8	average yearly expenditure	36,000	12	345,600	345,600	345,600	345,600	345,600	345,600	345,600	345,600	345,600	345,600	345,600
Fuel for vehicles (all vehicles)	0.8	average yearly expenditure	72,000	12	691,200	691,200	691,200	691,200	691,200	691,200	691,200	691,200	691,200	691,200	691,200
Motorbike maintenance (all motorbikes)	0.8	average yearly expenditure	7,200	12	69,120	69,120	69,120	69,120	69,120	69,120	69,120	69,120	69,120	69,120	69,120
Vehicle maintenance (all vehicles)	0.8	average yearly expenditure	14,400	12	138,240	138,240	138,240	138,240	138,240	138,240	138,240	138,240	138,240	138,240	138,240
Total Travel Cost per annum					2,259,360	2,259,360	2,259,360	2,259,360	2,259,360	2,259,360	2,259,360	2,259,360	2,259,360	2,259,360	2,259,360
Other Direct Costs															
Food allowance - All staff, trainers, training/meeting participants		daily rate	150	381	57,105	57,105	57,105	57,105	57,105	57,105	57,105	57,105	57,105	57,105	57,105
Hall rent for Leadership trainings, meeting etc.		Event/lump sum	3,000	119	355,500	355,500	355,500	355,500	355,500	355,500	355,500	355,500	355,500	355,500	355,500
Printing (Project Office)		average yearly expenditure	42,000	12	504,000	504,000	504,000	504,000	504,000	504,000	504,000	504,000	504,000	504,000	504,000
Stationary (Project Office)		average yearly expenditure	60,000	12	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000
Guests expenses	0.8	average yearly expenditure	180,000	1	144,000	144,000	144,000	144,000	144,000	144,000	144,000	144,000	144,000	144,000	144,000
Office tea & snacks (Head Office)	0.8	average yearly expenditure	48,000	1	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400
Water quality testing kit		For villages in completion phase	380	2	760	760	760	760	760	760	760	760	760	760	760
Total Other Direct Costs per annum					1,819,005	1,819,005	1,819,005	1,819,005	1,819,005	1,819,005	1,819,005	1,819,005	1,819,005	1,819,005	1,819,005

NPV					616,349,139.91										
Total Cost per Household (Rs.)					6,083.34										
Total Cost USD					9,230,929.16										
Total Cost per Household (USD)					91.11										

Table 14: 10-Year village fixed capital costs by cost component (in 2015 Indian Rupees)

						0	1	2	3	4	5	6	7	8	9	10
Stage	*Cost Component*	*Rate*	*unit*	*unit cost*	*# of units*	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	Trainings															
Motivational	Geo-hydrologist/local deviners		daily rate/honorarium	3,000.00	1	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
Implementation	Village hygiene training		daily rate/honorarium	3,000.00	1	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
Motivational	Trainer - leadership development training		daily rate/ honorarium	3,000.00	8	22,500.00	22,500.00	22,500.00	22,500.00	22,500.00	22,500.00	22,500.00	22,500.00	22,500.00	22,500.00	22,500.00
	Travel															
Motivational	Travel to exposure visits for participants		daily rate	800.00	4	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00
	Labor															
Implementation	Unskilled labor		daily rate	200.00	42	8,400.00	8,400.00	8,400.00	8,400.00	8,400.00	8,400.00	8,400.00	8,400.00	8,400.00	8,400.00	8,400.00
	Water System															
	Bore Well															
Implementation	Labor for Construction	0.7	per water system	157,160.00	1	157,160.00	157,160.00	157,160.00	157,160.00	157,160.00	157,160.00	157,160.00	157,160.00	157,160.00	157,160.00	157,160.00
Implementation	Materials for construction	0.7	per water system	727,060.00	1	727,060.00	727,060.00	727,060.00	727,060.00	727,060.00	727,060.00	727,060.00	727,060.00	727,060.00	727,060.00	727,060.00
Implementation	Distribution system	0.7	per water system	3,257,428.00	1	3,257,428.00	3,257,428.00	3,257,428.00	3,257,428.00	3,257,428.00	3,257,428.00	3,257,428.00	3,257,428.00	3,257,428.00	3,257,428.00	3,257,428.00
	Total Bore Well					4,141,648.00	4,141,648.00	4,141,648.00	4,141,648.00	4,141,648.00	4,141,648.00	4,141,648.00	4,141,648.00	4,141,648.00	4,141,648.00	4,141,648.00
	Gravity Flow															
Implementation	Labor Costs for Construction	0.15	per water system	79,260.00	1	79,260.00	79,260.00	79,260.00	79,260.00	79,260.00	79,260.00	79,260.00	79,260.00	79,260.00	79,260.00	79,260.00
Implementation	Materials for construction	0.15	per water system	308,828.00	1	308,828.00	308,828.00	308,828.00	308,828.00	308,828.00	308,828.00	308,828.00	308,828.00	308,828.00	308,828.00	308,828.00
Implementation	Distribution system	0.15	per water system	1,415,434.00	1	1,415,434.00	1,415,434.00	1,415,434.00	1,415,434.00	1,415,434.00	1,415,434.00	1,415,434.00	1,415,434.00	1,415,434.00	1,415,434.00	1,415,434.00
	Total Gravity Flow					1,803,522.00	1,803,522.00	1,803,522.00	1,803,522.00	1,803,522.00	1,803,522.00	1,803,522.00	1,803,522.00	1,803,522.00	1,803,522.00	1,803,522.00
	Well															
Implementation	Labor for Construction	0.15	per water system	155,690.00	1	155,690.00	155,690.00	155,690.00	155,690.00	155,690.00	155,690.00	155,690.00	155,690.00	155,690.00	155,690.00	155,690.00
Implementation	Materials for construction	0.15	per water system	1,307,911.00	1	1,307,911.00	1,307,911.00	1,307,911.00	1,307,911.00	1,307,911.00	1,307,911.00	1,307,911.00	1,307,911.00	1,307,911.00	1,307,911.00	1,307,911.00
Implementation	Distribution system	0.15	per water system	3,704,939.58	1	3,704,939.58	3,704,939.58	3,704,939.58	3,704,939.58	3,704,939.58	3,704,939.58	3,704,939.58	3,704,939.58	3,704,939.58	3,704,939.58	3,704,939.58
	Total Well					5,168,540.58	5,168,540.58	5,168,540.58	5,168,540.58	5,168,540.58	5,168,540.58	5,168,540.58	5,168,540.58	5,168,540.58	5,168,540.58	5,168,540.58
	Average Water System					3,944,962.99	3,944,962.99	3,944,962.99	3,944,962.99	3,944,962.99	3,944,962.99	3,944,962.99	3,944,962.99	3,944,962.99	3,944,962.99	3,944,962.99
	Other Direct Costs															
Motivational	Carbon paper (for village agreements)		item	50.00	1	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
	Total cost for new villages in each stage per annum															
	Motivational					2,156,250.00	2,156,250.00	2,156,250.00	2,156,250.00	2,156,250.00	2,156,250.00	2,156,250.00	2,156,250.00	2,156,250.00	-	-
	Implementation					93,954,224.58	281,890,862.82	281,890,862.82	281,890,862.82	281,890,862.82	281,890,862.82	281,890,862.82	281,890,862.82	281,890,862.82	187,936,638.24	-
	Completion					-	-	-	-	-	-	-	-	-	-	-
	Total					96,110,474.58	284,047,112.82	284,047,112.82	284,047,112.82	284,047,112.82	284,047,112.82	284,047,112.82	284,047,112.82	284,047,112.82	187,936,638.24	-
	NPV					2,234,071,558.10										
	Total Cost per Household (Rs.)					22,050.20										
	Total Cost USD					33,459,211.59										
	Total Cost per Household (USD)					330.24										

Table 15: 10-Year village recurring costs by cost component (in 2015 Indian Rupees)

					0	1	2	3	4	5	6	7	8	9	10
Cost Component	Rate (LoE)	unit	unit cost	# of units	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Operation															
Water treatment fee		per year	2,959.08	1	2,959.08	2,959.08	2,959.08	2,959.08	2,959.08	2,959.08	2,959.08	2,959.08	2,959.08	2,959.08	2,959.08
Pump electricity costs		yearly expenditure	60,249.00	1	60,249.00	60,249.00	60,249.00	60,249.00	60,249.00	60,249.00	60,249.00	60,249.00	60,249.00	60,249.00	60,249.00
Pump operator costs		yearly salary	25,903.44	1	25,903.44	25,903.44	25,903.44	25,903.44	25,903.44	25,903.44	25,903.44	25,903.44	25,903.44	25,903.44	25,903.44
Maintenance															
Skilled labor	0.086	daily rate	240.00	2	360.54	360.54	360.54	360.54	360.54	360.54	360.54	360.54	360.54	360.54	360.54
Net Out															
Household water system maintenance fee			410.40	1	64,843.20	64,843.20	64,843.20	64,843.20	64,843.20	64,843.20	64,843.20	64,843.20	64,843.20	64,843.20	64,843.20
Per village cost (- Household maintenance fee)					24,628.86	24,628.86	24,628.86	24,628.86	24,628.86	24,628.86	24,628.86	24,628.86	24,628.86	24,628.86	24,628.86
Total cost per annum					0.00	0.00	1,754,806.01	3,509,612.01	5,264,418.02	7,019,224.02	8,774,030.03	10,528,836.03	12,283,642.04	14,038,448.04	15,793,254.05

NPV	63,714,882.03
Total Cost per Household (Rs.)	628.86
Total Cost USD	954,244.15
Total Cost per Household (USD)	9.42

Table 16: 10-Year household fixed capital costs by cost component (in 2015 Indian Rupees)

						0	1	2	3	4	5	6	7	8	9	10
Stage	*Cost Component*	*Rate*	*unit*	*unit cost*	*# of units*	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Motivational	Corpus Fund		lump sum	1,000.00	1	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
	Sanitation Hardware (Toilet & Washroom)															
Implementation	Cement		bag (50-kg)	240.00	12	2,784.00	2,784.00	2,784.00	2,784.00	2,784.00	2,784.00	2,784.00	2,784.00	2,784.00	2,784.00	2,784.00
Implementation	Sand		tractor	4,000.00	2	6,400.00	6,400.00	6,400.00	6,400.00	6,400.00	6,400.00	6,400.00	6,400.00	6,400.00	6,400.00	6,400.00
Implementation	Brick		pieces	5.66	1,241	7,025.14	7,025.14	7,025.14	7,025.14	7,025.14	7,025.14	7,025.14	7,025.14	7,025.14	7,025.14	7,025.14
Implementation	Chips		tractor	1,200.00	1	1,104.00	1,104.00	1,104.00	1,104.00	1,104.00	1,104.00	1,104.00	1,104.00	1,104.00	1,104.00	1,104.00
Implementation	Metal		tractor	5,000.00	1	4,600.00	4,600.00	4,600.00	4,600.00	4,600.00	4,600.00	4,600.00	4,600.00	4,600.00	4,600.00	4,600.00
Implementation	Stone		tractor	1,200.00	1	1,632.00	1,632.00	1,632.00	1,632.00	1,632.00	1,632.00	1,632.00	1,632.00	1,632.00	1,632.00	1,632.00
Implementation	Pre-fabricated doors		pieces	530.00	2	1,060.00	1,060.00	1,060.00	1,060.00	1,060.00	1,060.00	1,060.00	1,060.00	1,060.00	1,060.00	1,060.00
Implementation	20" porcelain pan/foot rest and P-trap		pieces	380.00	1	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00
Implementation	White washing (materials)		kg	15.00	3	45.60	45.60	45.60	45.60	45.60	45.60	45.60	45.60	45.60	45.60	45.60
Implementation	Soil		tractor	350.00	1	332.50	332.50	332.50	332.50	332.50	332.50	332.50	332.50	332.50	332.50	332.50
Implementation	Pre-fabricated pit cover		pieces	300.00	2	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Implementation	"U-pipe" (ie. P-trap, water seal)		piece	80.00	1	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Implementation	Y connections		Piece	130.00	1	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00
Implementation	Pipe used		Feet	30.00	23	697.80	697.80	697.80	697.80	697.80	697.80	697.80	697.80	697.80	697.80	697.80
Implementation	Joint (pipe fitting or junction)		piece	35.00	5	172.55	172.55	172.55	172.55	172.55	172.55	172.55	172.55	172.55	172.55	172.55
Implementation	Gum (to glue together pipe and joint)		piece	0.50	85	42.45	42.45	42.45	42.45	42.45	42.45	42.45	42.45	42.45	42.45	42.45
Implementation	Rods		kg	36.00	37	1,328.76	1,328.76	1,328.76	1,328.76	1,328.76	1,328.76	1,328.76	1,328.76	1,328.76	1,328.76	1,328.76
Implementation	Ring		piece	250.00	7	1,625.00	1,625.00	1,625.00	1,625.00	1,625.00	1,625.00	1,625.00	1,625.00	1,625.00	1,625.00	1,625.00
Implementation	Binding wire		kg	27.00	2	55.89	55.89	55.89	55.89	55.89	55.89	55.89	55.89	55.89	55.89	55.89
Implementation	Supports (Centering and shuttering work)		pieces	800.00	1	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00
Implementation	Poles/timber/bamboo		pieces	42.00	19	807.66	807.66	807.66	807.66	807.66	807.66	807.66	807.66	807.66	807.66	807.66
Implementation	Tin		pieces	540.00	2	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00
Implementation	Pre-fabricated slab		pieces	320.00	1	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00
Implementation	Colored paint		liters	70.00	1	70.58	70.58	70.58	70.58	70.58	70.58	70.58	70.58	70.58	70.58	70.58
	Total Materials					33,173.93	33,173.93	33,173.93	33,173.93	33,173.93	33,173.93	33,173.93	33,173.93	33,173.93	33,173.93	33,173.93
	Additional Hardware															
Implementation	Tiles	0.1	pieces	18.00	3	56.45	56.45	56.45	56.45	56.45	56.45	56.45	56.45	56.45	56.45	56.45
Implementation	Pre-fabricated grill	0.4	kg	46.00	1	36.80	36.80	36.80	36.80	36.80	36.80	36.80	36.80	36.80	36.80	36.80
	Total Additional Hardware					93.25	93.25	93.25	93.25	93.25	93.25	93.25	93.25	93.25	93.25	93.25
	Labor															
Implementation	Skilled labor		daily rate	240.00	27	6,480.00	6,480.00	6,480.00	6,480.00	6,480.00	6,480.00	6,480.00	6,480.00	6,480.00	6,480.00	6,480.00
Implementation	Unskilled labor		daily rate	200.00	87	17,360.00	17,360.00	17,360.00	17,360.00	17,360.00	17,360.00	17,360.00	17,360.00	17,360.00	17,360.00	17,360.00
Implementation	*Total Labor*					23,840.00	23,840.00	23,840.00	23,840.00	23,840.00	23,840.00	23,840.00	23,840.00	23,840.00	23,840.00	23,840.00
	Total cost for new households in each stage per annum															
	Motivational					11,850,000.00	11,850,000.00	11,850,000.00	11,850,000.00	11,850,000.00	11,850,000.00	11,850,000.00	11,850,000.00	11,850,000.00	-	-
	Implementation					214,273,242.14	642,884,014.83	642,884,014.83	642,884,014.83	642,884,014.83	642,884,014.83	642,884,014.83	642,884,014.83	642,884,014.83	428,610,772.69	-
	Total					226,123,242.14	654,734,014.83	654,734,014.83	654,734,014.83	654,734,014.83	654,734,014.83	654,734,014.83	654,734,014.83	654,734,014.83	428,610,772.69	-
	NPV					5,150,648,960.10										
	Total Cost per Household (Rs.)					50,836.72										
	Total Cost USD					77,140,167.14										
	Total Cost per Household (USD)					761.37										

Table 17: 10-Year household recurring costs by cost component (in 2015 Indian Rupees)

					0	1	2	3	4	5	6	7	8	9	10
Cost Component	Rate	unit	unit cost	# of units	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Operation															
Village water system maintenance fee		yearly	410.40	1.000	410.40	410.40	410.40	410.40	410.40	410.40	410.40	410.40	410.40	410.40	410.40
Maintenance															
Labor															
Skilled labor	0.014		240.00	0.017	2.69	2.69	2.69	2.69	2.69	2.69	2.69	2.69	2.69	2.69	2.69
Unskilled labor	0.014		200.00	1.335	266.83	266.83	266.83	266.83	266.83	266.83	266.83	266.83	266.83	266.83	266.83
Materials															
Sand	0.014	tractor	4,000.00	0.001	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87
Cement	0.014	bag (50-kg)	240.00	0.012	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
U-pipe	0.014	piece	80.00	0.007	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Y connection	0.014	piece	130.00	0.001	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Joint pipe	0.014	piece	35.00	0.011	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Supports	0.014	piece	800.00	0.003	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
Poles/bamboo/timber	0.014	piece	42.00	0.028	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Whitewash	0.014	kg	15.00	0.003	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Pre-fabricated pit cover	0.014	piece	300.00	0.003	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
Colored paint	0.014	liters	70.00	0.003	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Tiles	0.014	piece	18.00	0.056	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
Waste Disposal															
Pit emptying (labor + materials)	0.011	lump sum	1,425	0.015	21.32	21.32	21.32	21.32	21.32	21.32	21.32	21.32	21.32	21.32	21.32
Total cost per annum					-	-	7,986,441.28	15,972,882.56	23,959,323.83	31,945,765.11	39,932,206.39	47,918,647.67	55,905,088.95	63,891,530.23	71,877,971.50

NPV	289,978,015.97
Total Cost per Household (Rs.)	2,862.07
Total Cost USD	4,342,938.68
Total Cost per Household (USD)	42.86