Zentrum für Entwicklungsforschung

Water, sanitation and agriculture linkages: impact on health and nutrition outcomes in peri-urban Gujarat, India

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Dedication

I express my deepest gratitude to my parents and my family members for their endless love, care, patience, and prayers. Thank you for always giving me strength and letting me chase my dreams. I would never have made it here without your continuous support.

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ABSTRACT

In the rural and peri-urban settings, where agriculture is one of the main sources of livelihood, the multi-purpose character of irrigation and drainage infrastructure creates several interlinks between water, sanitation (WATSAN) and agriculture. These interlinkages have health and nutrition impacts. This study looks at the determinants of household water quality and child health outcomes among households in areas where communities are using different irrigation water types. Using econometric models based on an original survey done for this research, we analyze household water quality, longitudinal diarrhea prevalence, malnutrition and parasitic prevalence among children under 5 years in the study area.

The survey conducted collected information on anthropometric measures, stool sample testing for the presence of parasites and a biweekly follow up survey to collect information on diarrhea among under 5 children. In addition, assessment of the microbial quality of stored drinking water and source drinking water were done. The number of Escherichia coli (E.coli) colony-forming units per 100ml water was used as an indicator of fecal contamination and the results demonstrate that the microbiological water quality was poor, with water at both point of use (80 %) and point of source (73 %) cannot be considered potable. Drinking water quality was positively impacted by proper storage and water treatment practice such as reverse osmosis. Safe water storage and point-of-use water treatment should be the focus of intervention to ensure the quality of water being consumed. Hygiene and sanitation indicators had mixed impacts on the quality of drinking water, and the impacts were largely driven by hygiene behavior rather than infrastructures. Community open defecation and high village-household density deteriorate household stored water quality. Household improved toilet had no significant effect on water quality but lead to 8 percent reduction in diarrheal incidence. Stunting, an important indicator of chronic malnutrition, was affected by household improved toilet and open defecation in the community. Efforts to improve the sanitation infrastructure will prevent poor health outcomes.

The mean longitudinal prevalence of diarrhea per person years is 1.6. Among the variables having a significant impact on diarrhea were wastewater irrigation, household stored water quality, and sanitation infrastructure. We found that the under 5 children of farmers using wastewater in irrigation have a statistically significant higher incidence risk ratio of 2.19, a two times increase in the diarrheal incidence in comparison to canal water irrigators. With the unprecedented population growth, measures should be undertaken to scale up the existing sewage treatment plants and exploring alternative ways as river bed filtration for wastewater treatment. The study observed that as the stored water quality deteriorates, the diarrheal incidence risk ratio increases significantly. Stunting rates in the study were high with 52 % stunted under 5 children. Stunted kids had a significantly higher incidence of diarrhea and vice versa increased diarrheal incidence increased stunting with a marginal effect of 7 percent at a significance level of $p<0.05$. Parasitic prevalence was high (26%) with hygiene and water quality significantly affecting parasitic prevalence. Agriculture, WATSAN, and health are closely interlinked and the AG-WATSAN nexus requires a cross sectorial engagement to design interventions with wastewater management, WATSAN infrastructure and behavioral interventions to improve child health and nutrition outcomes in rural and peri-urban settings of India.

KURZFASSUNG

AIm ländlichen und peri-urbanen Raum, wo die Landwirtschaft eine der Hauptquellen für den Lebensunterhalt ist, führt der Mehrzweckcharakter der Bewässerungs- und Entwässerungsinfrastruktur zu mehreren Verzahnungen zwischen Wasser, Abwasserentsorgung (WATSAN) und Landwirtschaft. Diese Verknüpfungen haben Auswirkungen auf Gesundheit und Ernährung. Diese Studie untersucht die Bestimmungsfaktoren der häuslichen Wasserqualität und des Gesundheitsniveaus von Kindern in Gebieten, in denen die Gemeinschaften auf unterschiedliche Bewässerungstypen zurückgreifen. Mit Hilfe von ökonometrischen Modellen, die auf Daten aus einer für diese Studie durchgeführten Umfrage angewendet werden, analysieren wir die Wasserqualität, die Langzeitdurchfallprävalenz, die Unterernährung und die parasitäre Prävalenz bei Kindern unter 5 Jahren in Haushalten im Untersuchungsgebiet.

Die durchgeführte Befragung sammelte Informationen über anthropometrische Maßzahlen, die Untersuchung von Stuhlproben auf Parasiten und eine zweiwöchentliche Nachfolgebefragung über Durchfallerkrankungen bei Kindern unter fünf Jahren. Zusätzlich wurde die mikrobielle Qualität von gespeichertem Trinkwasser im Vergleich zu Trinkwasser von der Quelle getestet. Die Anzahl von Kolonie-bildenden *Escherichia coli* (*E.coli*) Einheiten pro 100 ml Wasser wurde als Indikator für die Kontamination mit Fäkalien benutzt. Die Ergebnisse zeigen, dass die mikrobiologische Qualität des Trinkwassers schlecht war und weder das Wasser am Ort der Benutzung (80%) noch an der Quelle (73%) als trinkbar erachtet werden kann. Die Trinkwasserqualität wurde positiv beeinflusst durch geeignete Lagerung und Behandlung des Trinkwasssers, beispielsweise mit Umkehrosmose. Die sichere Lagerung von Wasser sowie die Behandlung des Trinkwassers vor dem Konsum sollten im Fokus der Interventionen stehen, um eine gute Qualität des Trinkwassers zu gewährleisten. Hygiene- und Sanitärindikatoren hatten gemischte Auswirkungen auf die Trinkwasserqualität, und die Auswirkungen waren weitgehend auf Hygieneverhalten und nicht auf die Infrastruktur zurückzuführen. Öffentliche Defäkation und eine hohe Haushaltsdichte im Dorf verschlechterten die Qualität des in den Haushalten gelagerten Trinkwassers. Verbesserte Toilleten in Haushalten hatten keinen signifikanten Effekt auf die Wasserqualität, führten allerdings zu einem Rückgang von Durchfallerkrankungen um 8%. Stunting, ein wichtiger Indikator für chronische Mangelernährung, wurde von verbesserten Toilleten in den Haushalten sowie öffentlicher Defäkation beeinflusst. Bemühungen zur Verbesserung der sanitären Infrastruktur werden sich positiv auf die Gesundheit auswirken.

Die mittlere Längsprävalenz von Durchfall pro Personenjahre beträgt 1,6. Unter den Variablen mit erheblichen Auswirkungen auf Durchfall waren Bewässerung mit Abwasser, Qualität des im Haushalt gelagerten Wassers und Sanitär-Infrastruktur. Unsere Ergebnisse zeigen, dass Kinder unter fünf Jahren in Bauernfamilien, die Abwasser zur Bewässerung nutzen, eine statistisch signifikant höhere Inzidenzrate von 2,19 aufweisen, d.h. doppelt so oft an Durchfall erkranken wie in Haushalten mit Kanalbewässerung. Vor dem Hintergrund des beispiellosen Bevölkerungswachstums sollten Maßnahmen unternommen werden, um die existierenden Abwasserkläranlagen auszuweiten sowie alternative Möglichkeiten zu erforschen, wie zum Beispiel Flussbettfiltration zur Abwasserklärung. In der Studie beobachten wir, dass die Inzidenzrate von Durchfallerkrankungen mit abnehmender Qualität von gespeichertem Trinkwasser signifikant ansteigt. Stunting-Raten waren hoch mit 52% Stunting bei Kindern unter fünf

Jahren. Unter Kindern, die von Stunting betroffen sind, bestand eine signifikant höhere Inzidenz von Durchfallerkrankungen und umgekehrt erhöhte dies das Vorkommen von Stunting mit einem marginalen Effekt von 7% (Signifikanzlevel $p<0.05$). Das Vorkommen von parasitärem Befall war hoch (26%) und signifikant beeinflusst von Hygiene und Wasserqualität. Landwirtschaft, WATSAN und Gesundheit sind eng vernetzte Bereiche. Daher bedarf der AG-WATSAN Nexus eines sektorenübergreifenden Ansatzes mit Maßnahmen zu Abwassermanagement, WATSAN Infrastruktur and Verhaltensänderungen, um Gesundheits- und Ernährungsoutcomes unter Kindern in ländlichen und stadtnahen Gebieten Indiens zu verbessern.

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ABBREVIATIONS

AMC	Ahmedabad Municipal Corporation
BPL	Below Poverty Line
E.coli.	Escherichia coli
FGDs	Focus Group Discussions
IEC	information, education, and communication
IIPS	International Institute for Population Sciences
IRR	Incidence Risk Ratio
KM	Kilometers
JMP	Joint Monitoring Programme
LPD	Longitudinal Prevalence of Diarhoea
MDG	Millennium Development Goals
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee *Act*
MPN	Most Probable Number
NSS	National Service Scheme
POS	Point of Source
POU	Point of Use
PSU	Primary Sampling Units
RBF	River Bank Filtration
RO	Reverse Osmosis
STP	Sewage Treatment Plants
TDS	Total dissolved solids
UNICEF	United Nations Children's Fund
WASMO	*Water and Sanitation Management Organisation*
WATSAN	Water and Sanitation
WHO	World Health Organization

1 INTRODUCTION

1.1 Background

Having recognized the major role played by water and sanitation (WATSAN) in improving health and nutritional status, one of the Millennium Development Goals (MDGs), targets aimed at halving by 2015 (from 1990 levels), the proportion of the population without sustainable access to safe drinking water and basic sanitation. Although India achieved the MDG target of access to improved drinking-water of 94 percent in 2015, only 39.6 percent of the population has access to improved sanitation facilities while 44 percent of still practice open defecation with a wide urban (10%) to rural (61 %) gap (JMP, 2015).

WATSAN challenges not only include the backlog of the population which are yet to be provided with basic sanitation but this challenge increases due to population growth and rapid urbanization. The ever-growing population of India with the subsequent increasing competition for water consumption among different sectors, especially irrigated agriculture and related local multi-purpose water systems, is a challenge to improve water quality and sanitation.

The growing urban population has increased the need for food, water supply, and also sewage generation during the past decade. The sewage treatment facilities in India are highly insufficient, and untreated sewage is rapidly polluting the water bodies where it is being disposed (Palrecha et al., 2012a). Urban agriculture utilizing urban waste stream as inputs for production has emerged as a strategy to simultaneously tackle food insecurity in the face of scarcity of fresh water resources for irrigation purpose. In fact, wastewater has now become an important resource for agriculture and generates economic benefits to farmers, since it allows farmers to grow multiple cycles in one year. Additionally, urban wastewater is rich in essential plant nutrients, therefore reducing the need for artificial fertilizers. Although the nutrients in the wastewater are beneficial to agriculture, the contaminants present in it pose environmental and health risks. In particular, the farmers and population in the neighborhoods suffer from diseases due to direct as well as indirect exposure through groundwater contamination of seepage pollutants and evolution of habitats of mosquitoes and other disease vectors (Shuval, 1990, Palrecha et al., 2012a, Drechsel et al., 2009).

Agriculture is one of the main sources of livelihood and consumes around 90% of the overall water withdrawal. Different types of water use (i.e., surface water, groundwater, wastewater) in irrigated agriculture yield complex human and animal interactions which directly or indirectly affects the drinking water quality and sanitation among the communities exposed. Inadequate access to safe drinking water and sanitation services, involvement in irrigated agriculture together with poor hygiene due to knowledge gaps could lead to water-borne and water-related infectious diseases and malnutrition. Rapid urbanization of peri-urban, rural settings adds further stress to the inadequate water supply and sanitation. Increased human activity has already lead to the degradation of water quality and eutrophication of the waterways. The FAO water report (2008) shows eutrophication is a frequent trend in wetlands in Asia (Wood and van Halsema, 2008).

A study by Reiff (1987a) noted that water pollution is both a cause and an effect in the linkages between agriculture and human health. Most wastewater-related research in developing countries has largely focused on issues related to improvements in water quality, environmental and health impacts (Srinivasan and Reddy, 2009, Drechsel et al., 2009 Gupta, 2005). Many studies have also looked at the impact of WATSAN and hygiene on health. For example, the systemic reviews to assess the impact of inadequate water and sanitation on diarrheal disease in low and middle-income settings have shown that overall improvements in drinking water and sanitation were associated with decreased risks of diarrhea (Wolf et al., 2014, Kumar and Vollmer, 2012, Fink et al., 2011, Waddington et al., 2009). However, most of these studies focused on one or the other aspect in isolation thereby ignoring the environmental-health-economic linkages and trade-offs inherent in wastewater use. This study differs from the previous studies by using a holistic approach with inclusion of agricultural, WATSAN, hygiene and community characteristics to explain the AG-WATSAN nexus and its impact on health. The study includes a rigorous biweekly follow up for the outcome longitudinal diarrhea prevalence, anthropometric measurements for malnutrition, stool testing for parasites and a WHO-recommended ‘Most Probable Number’ (MPN) technique for household microbiological water testing.

1.2 Expected Contribution

The increasing scarcity of water, with the increasing population and urbanization, requires a better understanding of the interactions between water uses for irrigation and domestic purposes and their associated effects on health outcomes. There is a rapidly growing literature on water, sanitation and hygiene practices in India but empirical work on WATSAN and irrigation linkages is deficient. This study identifies the linkages between WATSAN and agriculture activities by examining the effects of irrigated agriculture on water quality, WATSAN and health outcomes. It explores how an understanding of water, sanitation, hygiene and irrigation linkages help to develop preventive measures aimed at improving health and overall living conditions among agricultural communities. The importance of this study lies in identifying the nexus between WATSAN, hygiene and irrigated agriculture, and assessing their implication for prioritizing investments in improving water quality, health, and nutrition among communities exposed to different irrigation types while taking into account context-specific constraints.

Hence, the expected contributions of the research, in addition to filling the research gap in the empirical literature, will provide key inputs to policymakers to design evidence-based WATSAN and irrigation water system policies in Gujarat and other states in India. This study could lead to potential scaling-up to other regions and areas of similar characteristics and provide effective and sustainable water sanitation and hygiene (WASH) services.

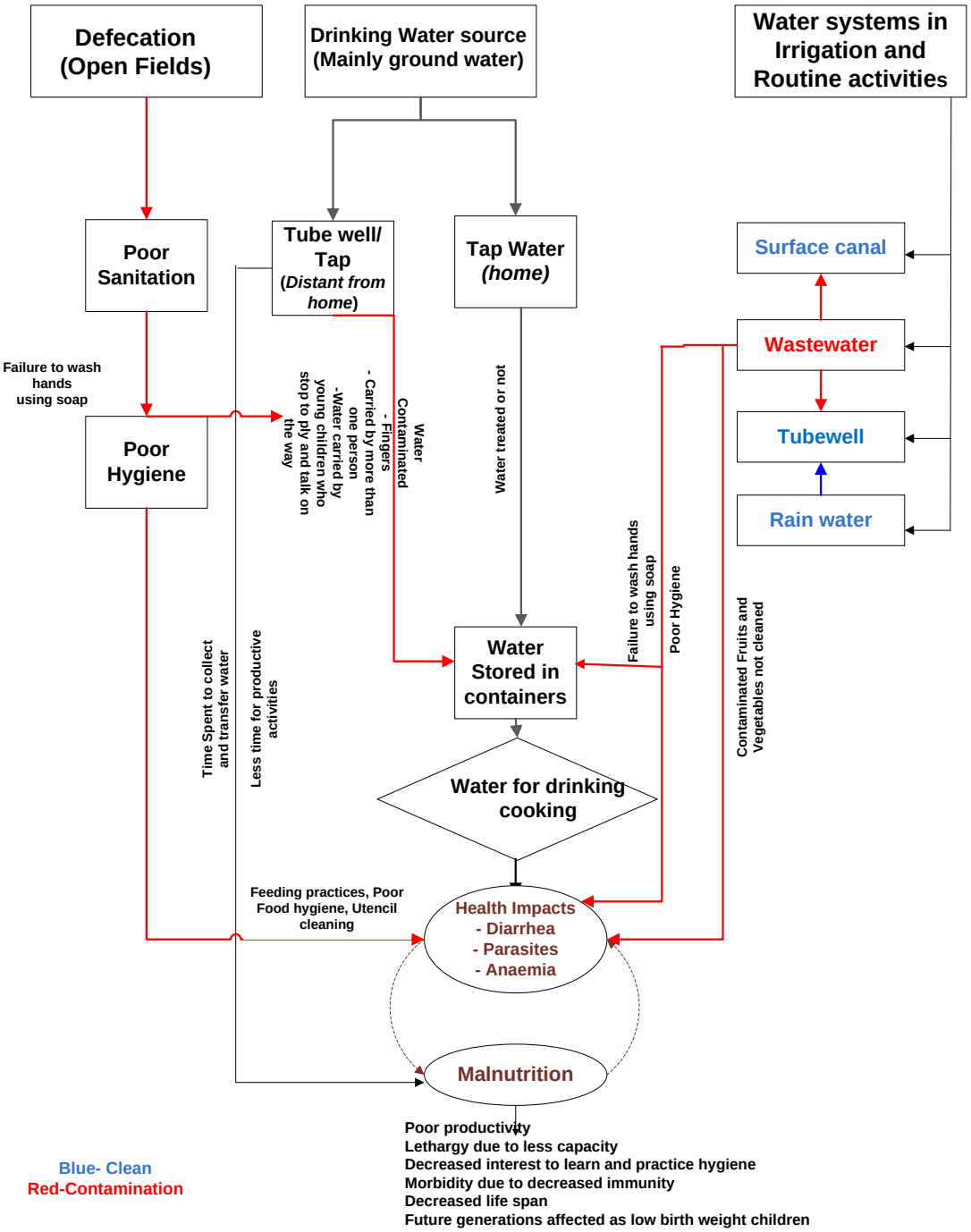

Figure 1-1: Conceptual Framework

(Source: Own illustration based on field observations and Predis et al. 2011)

1.3 Conceptual Framework

Figure 1.1 shows the conceptual framework for the study and depicts the interlinkages and contamination pathways that could lead to health effects:

- Irrigation water plays an important role in determining the distribution of microbial contamination through interactions between animals, humans and household food and drinking water.
- Irrigation water types used in farming are mainly freshwaters viz. rain, tube well or surface canal water; and wastewater (sewage water after primary treatment).
- The farmers working in wastewater areas are highly exposed to fecal contamination in water, and the chances of household water contamination increase if farmers do not perform proper protection and handwashing activities after the field work.
- Open defecation in a population increases exposure of fecal matter to the household through poor hygiene and behavior (by not performing regular handwashing with soap). The fecal contamination enters the household water easily and makes water non-potable for drinking.
- Direct piped water connection to the household is considered to provide sanitary protection from fecal contamination. However, the bacteriological quality of drinking water significantly declines post collection.
- Besides, after collecting water, some households would treat their drinking water based on their education level and available resources before storing for consumption.
- Poor water and sanitation systems, hygiene, and behavior increase exposure to household water contamination. A systemic review of microbiological contamination between point-of-source and point-of-use (POS and POU) showed significant contamination with fecal and total coliforms after collection in approximately half of the included studies (Wright et al., 2004).
- Unsafe water, inadequate sanitation, and poor hygiene are linked to diarrhea cases worldwide (WHO, 2008). Diarrhea prevents children from achieving normal growth, while malnutrition increases the frequency and the duration of diarrheic events, thereby creating a vicious cycle (Preidis et al., 2011).

- Moreover, children exposed to fecal coliforms suffer from intestinal infections and chronic infections that lead to chronic inflammation of the gastrointestinal tract and prevent absorption of calories and nutrients leading to malnutrition (Guerrant et al., 2008).

1.4 Objectives, Hypothesis and Research Question

1.4.1 Objectives

The overall objective of the study is to identify the social, economic and health trade-offs, and synergies among domestic water quality, sanitation, and hygiene behavior, and irrigated agriculture systems in peri-urban areas of Gujarat to eventually identify better strategies for linking water uses for 'WATSAN' and irrigated agriculture activities for the improvement of health and nutrition status.

1.4.2 Hypotheses

1. *The design of irrigation water systems matters for health,* i.e., the communities exposed to different types of water systems for irrigation are affected differently on their health and nutritional status- due to the interaction of irrigation water with sanitation and hygiene.

2. *Information and behavior can overcome adverse health effects of irrigation,* i.e., the hygiene and sanitation behavior of the individual household and community with their use of information regarding linkages between WATSAN and irrigation reduces the negative effects on health outcomes.

1.4.3 Research question

What are the health, nutrition, economic and environmental linkages and trade-offs involved in different types of irrigated agriculture in peri-urban areas of Gujarat?

Specific Research Questions

1. What are the impacts of different types of irrigation and WATSAN systems on drinking water quality in peri-urban in Gujarat, India?

2. What are the effects of different irrigation and WATSAN systems on the health outcomes (particularly, the longitudinal prevalence of diarrhea, malnutrition and parasitic prevalence) in under-five children among the communities residing in peri-urban areas in Gujarat, India?
3. What are the economic trade-offs of enhancing health outcomes through facilitating behavioral change by providing information to communities versus changing WATSAN-infrastructure services (e.g., for improved drinking water and sanitation) versus design of wastewater treatment interventions or the combination of the three intervention options?

1.5 The Study Setting, Sampling Design, Survey

1.5.1 The setting and background facts

The study was conducted in the peri-urban areas of Ahmedabad, Gujarat along the upstream, downstream and midstream of the Sabarmati River. With a population of over 60 million, Gujarat is one of the most urbanized states in India. Between 2001 and 2011, the urban population of Gujarat rose from 37% to 43% (Registrar General, 2011). While the sewage treatment facilities in Gujarat, as elsewhere in India are highly insufficient and untreated sewage is rapidly polluting the water bodies where it is being disposed (Palrecha et al., 2012a). This wastewater from the downstream river is utilized for irrigation in this increasingly urbanized and water scarce dry state of Gujarat (Bavadam, 2001).

The Sabarmati River, one of the major rivers in the western region of India, is a monsoon-fed river that flows mainly in Gujarat except for its initial 9.5 kilometers. Settlements of communities have settled along the river bank, and the river has been an integral part of Ahmedabad since the city was founded. Initially, the river was the city's primary source of water. Today, water is supplied from many distant sources. Nonetheless, the river continues to be an important source of irrigation water for farms situated along the banks, mainly in the downstream of the river. However, through the years of use and abuse, along with rampant urban growth, the Sabarmati River has become polluted and neglected. Sewage-contaminated stormwater outfalls and the dumping of industrial waste in the river pose major health and environmental hazard.

In 2010, the Central Pollution Control Board of India listed the Sabarmati as the third most polluted river in the country, with the highest levels of fecal coliforms in the country.

The fecal coliform level in the river was estimated to be 2.8 million MPN per 100 ml. Random checks conducted by the Comptroller and Auditor General (CAG) in early 2012 declared that "fecal coliforms increased by 860%, beyond the permissible limit. The WHO guideline for the microbiological quality of treated wastewater used in agriculture for restricted irrigation is 0.1 million fecal coliform bacteria/100 ml (Blumenthal et al., 2000).

Water flows from rivers, canals and tube wells to the farms for irrigation purpose. In turn, wastewater from urban households is disposed of into rivers after primary treatment, and utilized for agricultural production. The water, sanitation and drainage systems in a village are interlinked, and on-site sanitation systems are a possible source of groundwater contamination. Figure 1.2 below shows a schematization of water linkages in the context of village irrigation and WATSAN systems.

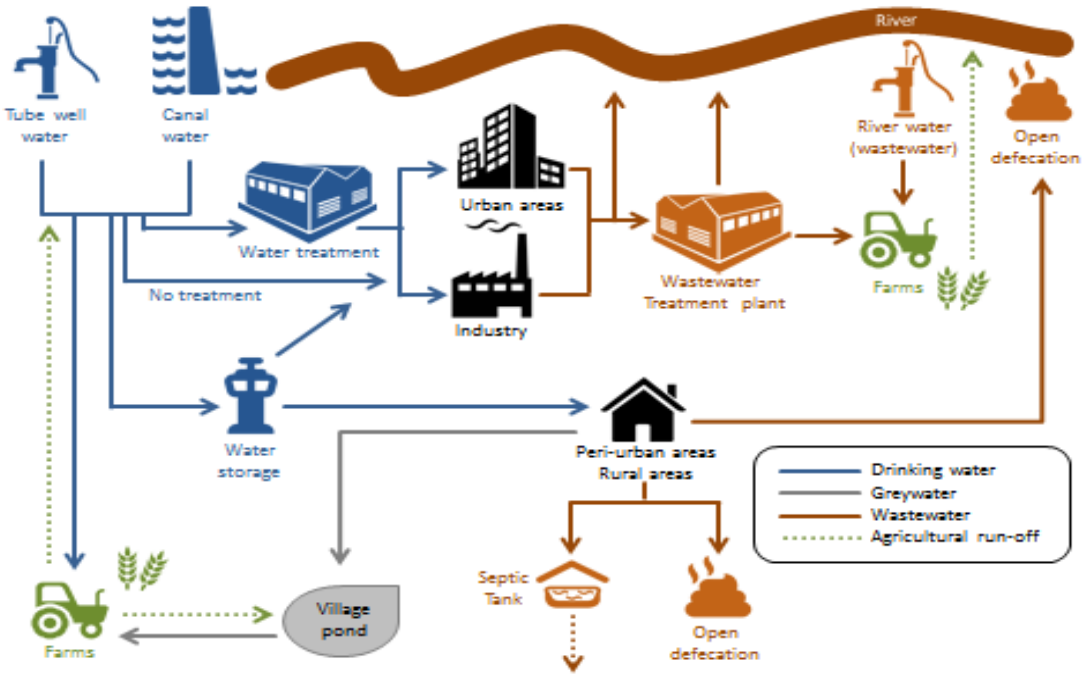

Figure 1-2: Schematization of the water and sanitation system in the study area
Source: Designed by Samantha Antonini, logos source-Creative Commons license available at http://creativecommons.org/licenses/by/3.0/) acessed July 2015

As depicted in the figure the fresh water after treatment is utilized for drinking purposes in the urban and peri-urban areas. The sewage water produced from the urban communities undergoes wastewater treatment in the sewage treatment plants and discharged into the river after primary or secondary treatment based on the capacity of STPs.

Besides, some community and industrial wastewater find its way into the river directly without undergoing any treatment. The downstream wastewater from the river is utilized for irrigation purposes by the villages residing on these downstream riverbanks.

The gray water generated from village households is drained into the village ponds, and farmers utilize this at times for irrigation purposes. The common type of sanitation systems in rural areas are pit latrines and septic tanks. These on-site sanitation systems designed improperly in the rural areas, contaminate the groundwater through seepage. A study conducted in peri-urban areas of India found seepage of sewage into groundwater from improperly designed rural sanitation facilities (Shivendra and Ramaraju, 2015).

1.5.2 Sampling Design

The survey sampling was designed to ensure that the sample was random and representative of the overall population exposed to irrigation farming. The overall sample size was determined by taking into account the prevalence of key indicators, the subgroups for which the indicators are required, the desired precision of the estimates, the availability of resources, and logistical considerations. According to the 2009 Coverage Evaluation Survey India, the national incidence of acute diarrhea in children aged 0-2 years was 24 percent (UNICEF, 2010). After applying the expected diarrhea incidence at a precision of 0.05, the sample size required in this study was 280 under-five children. The prevalence of malnutrition in Gujarat in 2006 was 45% (IIPS, 2007); therefore, a sample size of 380 was needed for each group to achieve a precision of 0.05. In the present study, we chose a lower precision of 0.06, so a sample size of 280 in each group (wastewater and freshwater) was sufficient. The study included 660 households with 50% households in each group having an average family size per household of five with one under-five child.

The sample selection was done in two stages. First, primary sampling units (PSU) were randomly chosen from peri-urban villages in which irrigation was performed. Second, the systemic random selection was performed to select households from each PSU. The sampling frame included the 2011 census administrative atlas and map, using the peri-urban areas along the upstream, downstream and midstream of the Sabarmati River. A total of 16 PSUs were chosen from the peri-urban areas of Ahmedabad and Gandhinagar located around

15-20 km away from the Sardar Patel Ring Road[1]. The study selected a total of 660 households from the 16 PSUs, with 330 households using wastewater, 165 households using water from a tube-well, and 165 households using water Narmada Canal water as their main water resource for irrigation purpose (Figure 1.3).

[1] The Sardar Patel Ring Road is a 76 km long ring road encircling the city of Ahmedabad, Gujarat.

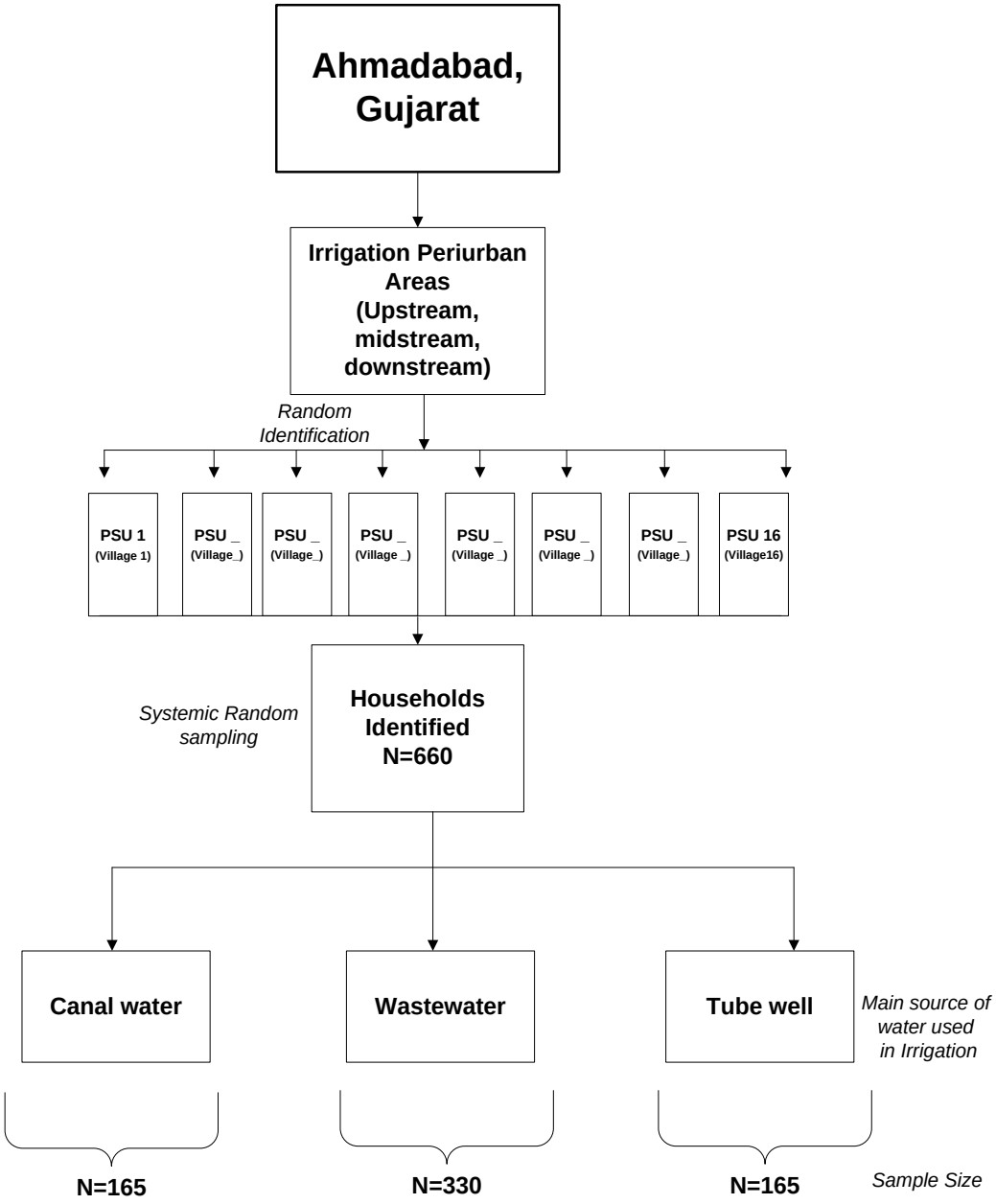

Figure 1-3: Survey Design
Source: Own illustration

In Ahmedabad, a total of 45 villages along the downstream of the Sabarmati River use wastewater for irrigation, and seven villages in Gandhinagar utilize wastewater released from sewage treatment plants (STPs) into the wastewater canals (Palrecha et al., 2012b). The present study sample (shown in Figure 1.4) included four villages in the Ahmedabad district (Timba, Miroli, Navapura, and Khodiyar) and two villages in the Gandhinagar district

(Sabaspur and Jaspur) that used wastewater for irrigation. Timba, Miroli, and Navapura obtained wastewater from the downstream of the Sabarmati River using lift irrigation.

Figure 1-4: Survey Areas
Source: Own Illustration using google earth

Other sources of irrigation water for agriculture in Ahmedabad and Gandhinagar include the Narmada Canal, freshwater tube wells, and rainwater. Ten villages were chosen from these freshwater areas for the survey. The villages using water mainly from tube wells for irrigation include Shahpur and Amiyapur in the north along the upstream of the Sabarmati River, and Rancharda and Palodiya villages located in the northwest. A few households in Jaspur, a village that mainly relied on tube-well water for irrigation, were included in the sample. Some farmers in the villages Unali, Rancharda, Sanavad, Santej, Rajnagar, Khatraj, and Jaspur also used water from the Dholka branch of the main Narmada Canal. Some farmers had access to canal water, while others used diesel pumps to pump water from the canal for irrigation.

1.5.3 Questionnaire and Ethical consideration

a) Survey Questionnaire

The quantitative survey was divided into two parts: baseline survey and a follow-up survey. The baseline survey comprised a household module, a WATSAN infrastructure module, an expenditure module, a child Module, and a hygiene module. The household module collected basic socioeconomic and demographic information of household members. The expenditure module collected information on household expenditure, including their non-food expenditure in the past month and past 12 months, and their food expenditure in the seven days before the survey. The WATSAN module collected information on household's drinking water source, the location of the source, the household member involved in collecting water, water collection time, water charges, washing frequency of water storage container, storage container coverage, waste disposal methods, hand-washing practices and hygiene behavior. Besides the survey had an additional hygiene module which consisted of a spot check on household hygiene, a subjective approach to assessing household hygiene behavior (Webb et al., 2006). The spot check included a checklist divided into five broad categories, namely environment, sanitation, water, food and personal. The child module collected information on birth weight, breastfeeding, immunization and brief food intake of under-five children.

After the baseline survey, the follow-up survey included households visits on a biweekly basis for eight months to collect information on waterborne diseases viz. diarrhea, skin diseases, fever on a two-week recall among all household members. We collected information on symptoms, treatment and health care costs incurred among the diseased household members.

The study also conducted focus group discussions (FGDs) and qualitative in-depth interviews to measure the community sanitary conditions and behavior towards hygiene and sanitation. The FGDs/in-depth interviews were conducted with villagers and the sanitation committee separately. Around 20 female respondents from the community were asked to gather, and discussions were done on water and sanitation situation including their perception, system response and improvement needed. The village sanitation community members of the village were questioned separately to see their viewpoint on the WATSAN

situation. The FGD themes for villagers and sanitation committee are mentioned in the Appendix 2. FGDs were recorded in the local language in an audio tape and later transcribed.

The data collection exercise was undertaken by social health workers with the requisite training and experience in conducting surveys. The survey team comprised of supervisors and enumerators who identically went through mandatory training sessions to equip them with the skills and techniques needed for collecting data. During the training, the questionnaire sections, questions, and instructions were discussed in detail. Demonstration interviews were conducted in front of the class as examples of the interviewing process. Each enumerator practiced reading the questionnaire aloud to another person from the team several times as a role-playing exercise. Additionally, a field practice interviewing was done with household respondents to check if the questionnaire design was appropriate.

Supervisors in the team conducted cross-check on some of the households selected for the interview to make sure that the interviewers interviewed the correct households and reviewed the questionnaire to ensure that the interviewers were asking the questions in the right manner and recording the answers correctly. The supervisors helped the interviewers to resolve any problems that they had with finding the assigned households, understanding the questionnaire or dealing with respondents who were not keen to answer the expenditure module.

b) Ethical Consideration

The study was conducted in accordance with the ethical guidelines for human experiments as laid down in the Helsinki Declaration of 2000. The ethical committee at Indian Institute of Public health, Gandhinagar (IIPHG) approved the protocol. The Gram Panchayats of the respective villages were approached to receive the consent to conduct the study in their area. Informed consent was obtained from the household head. During the fieldwork, a two-page consent form was read out to a household head in the local language with an introduction and purpose of the research, types of research intervention, voluntary participation, participation benefits, confidentiality, and right to refuse or withdraw from the study at any stage. The consent form is attached in the Appendix 2. Privacy, confidentiality, and anonymity of the study subjects were guarded and scientific objectivity of the study subjects was maintained with honesty and impartiality.

Overall the response from the households was good (less than 5% drop out rate) in the baseline and follow-up survey. However, the respondents later demanded improvement in their water and sanitation conditions as well as asked for medications when they were sick, but this was beyond the scope of the study. After the study completion a written water quality and stool report results with recommendations was given to the participating households.

1.5.4 Water sample testing, Anthropometric measurements, and Stool sample testing

a) Drinking water samples testing

The source and storage water quality in each household were assessed for the presence of thermotolerant fecal coliforms. Disease-causing organisms transmitted via drinking water are predominantly of fecal origins (Ashbolt et al., 2001, Hunter et al., 2002). The common fecal indicator bacterium Escherichia coli (*E.coli.*) extremely sensitive to disinfection is used to measure the efficacy of drinking water treatment in removing bacterial pathogens responsible for enteric diseases (LeChevallier, 2003, Edberg et al., 2000, Enriquez et al., 2001).

The multiple tube fermentation method of 'Most Probable Number (MPN), was used to identify thermotolerant fecal coliforms and *E.coli.* in water in the laboratory. WHO considers a water sample non-potable if one or more *E.coli.* are present in the water sample. To conduct water testing the water samples were filled in sterile containers labeled with a unique household ID, and transported in a cool box to the laboratory. In the MPN method, a series of tubes containing a suitable selective broth medium is inoculated with the water sample. After a specified incubation time at a given temperature, any tubes showing gas formation are "presumptive positive" tubes since the gas indicates the possible presence of coliforms. The positive tubes are further inoculated into a more selective culture medium for the confirmatory test. The confirmatory tests consisted of the eosin methylene blue sheen test, the indole-negative test, and the citrate-positive test. The MPN of bacteria present in a sample was then estimated from the number of tubes inoculated and the number of positive tubes obtained in the confirmatory test, using specially devised statistical tables (Collee et al., 1996). The detail water testing procedure is mentioned in the appendix 1.

b) Anthropometric measurements

The height and weight of under-five children were measured as per the WHO anthropometric guidelines (Lohman et al., 1988). The anthropometric measurements of under-five children were taken from each sampled households during the data collection period. The measurements were carried out at the Anganwadi[2] centers where the measurements are regularly undertaken for the growth chart recording of each child enrolled in the Anganwadi. The measurements for the present study were carried out by the Anganwadi workers and myself with the assistance of the field interviewers. Following the DHS standards, children younger than 24 months were measured lying down (recumbent length), and older children were measured while standing. The weight of young children was obtained by subtracting his/her mother's weight from the combined weight of mother and child. The parameters of weight-for-age, height-for-age, and weight-for-height/length were calculated based on the WHO child growth standards using stataigrowup_package (WHO, 2009).

c) Stool samples testing

The stool testing of under-five children in the study was done to check the prevalence of parasites in the stool. The study collected a total of 498 stool samples representing 78 percent of under-five children. The caretaker of the under-five children was given a labeled container a day before and informed to collect the child's stool. The sample was collected the next day and transferred to the laboratory for examination. To maintain the internal validity, the head microbiologist examined all stool samples. After an Initial macroscopic examination of the stool to find the presence of blood, mucus, parasitic segments or whole parasites; microscopic examination was performed. A direct unstained wet smear (saline mount) examination was carried out, and a drop of 1% Lugol's iodine was placed at the edge of the coverslip to convert it into an iodine mount. The direct saline and iodine mounts were systematically examined under the low-power objective (10×) with low light intensity and were then switched over to the high dry objective (40×). All stool samples were then processed by formalin-ether sedimentation concentration. The saline and iodine

[2] Anganwadi's are the government run day care centers started as a part of the Integrated Child Development services to combat malnutrition

preparations from each concentrated sample were examined similarly under 10× and 40× magnifications (WHO, 1991).

1.6 Structure of the dissertation

1.6.1 Households and community behavior and perception of WATSAN and hygiene—Qualitative Assessment

This dissertation starts with an introduction chapter briefing the survey design and survey methods followed by the household and community behavior and perception about their water and sanitation situation and hygiene behavior through qualitative focus group discussions (FGDs), qualitative in-depth interviews and household behavioral patterns from the quantitative analysis. The quantitative and qualitative findings of the study were triangulated to understand the household behavior and their perception of the WATSAN and hygiene behavior in their community. The study hypothesis is that the hygiene and sanitation behavior of the community and their use of information regarding linkages between WATSAN to irrigation would improve household water quality and health outcomes among the communities. Household percrptions and behavior on WATSAN and hygiene would eventually lead to the identification of better strategies for linking water uses for 'WATSAN' and irrigated agriculture activities to improve health and nutrition status.

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1.6.2 Determinants of different irrigation and WATSAN systems on drinking water quality

The third thesis chapter explores the determinants of microbiological quality of stored drinking water among households residing in peri-urban areas where communities use different types of irrigation water and WATSAN systems. In the rural and peri-urban settings, where agriculture is one of the main sources of livelihood, the type of water use (i.e., Wastewater surface canal and ground tube well water) in irrigated agriculture has complex interactions with drinking water and sanitation. In particular, the multi-purpose character of irrigation and drainage infrastructure creates several interlinks between WATSAN and agriculture, and there is a competition for water quantity between domestic water use and irrigated agriculture. There has been considerable literature available over the drinking water

quality in rural settings which has ignored taking into account the irrigation water used by these communities which can affect the household drinking water quality. Agriculture being an important source of livelihood consumes 90% of the water, the type of water used in irrigation may affect household water quality through its human and animal interactions and groundwater contamination. This study analyzes the effect of different irrigation systems along with household and community hygiene and WATSAN characteristics to determine the household drinking water quality. This study uses the multiple tube fermentation method 'Most Probable Number (MPN) technique, to identify thermotolerant fecal coliforms and *E.coli.* in water in the laboratory setting. The factors determining the household drinking water quality was analyzed using the ordinary least square (OLS) model for the natural log of *E.coli.* and logit regression model to estimate the risk of having contaminated stored water (i.e., water having one or more *E.coli.* MPN/100 ml).

1.6.3 Impact of different irrigation and WATSAN systems on child health outcomes

The fourth chapter of the dissertation analyses the impact of different irrigation water types, WATSAN infrastructure, and hygiene and sanitation behavior on child health outcomes. Inadequate access to safe drinking water and sanitation services, irrigation water involvement together with poor hygiene due to knowledge gaps leads to water-borne and water-related infectious diseases and malnutrition. This study hypothesizes that the communities exposed to different types of water systems for irrigation are affected differently by the health and nutritional status due to the interaction of irrigation water with sanitation and hygiene. Studies on wastewater and its impact on health show higher rates of morbidity in the wastewater irrigated villages when compared to the control village (Srinivasan and Reddy, 2009). The importance of this study lies in identifying the nexus between WATSAN, hygiene and irrigated agriculture, and assessing their implication for prioritizing investments in improving the health, and nutrition among communities exposed to different irrigation types while taking into account context-specific constraints. The health outcomes were analyzed using the Poisson and Probit models with instrumental variable and fixed effect methods.

1.6.4 Summarized findings, discussion of opportunities for actions, and conclusions

The final thesis (fifth) chapter of this dissertation summarizes the main factors affecting water quality and health outcomes and presents recommendations with potential policy implications. The main explanatory variables of the study include irrigation water type, hygiene practices, water treatment, WATSAN infrastructure and community variables viz. open defecation, village household density. Based on the main study results, we examine the opportunities of action between enhancing health outcomes through facilitating behavioral change by providing information to communities (e.g. about infectious pathways, precautions), versus changing WATSAN-infrastructure services (e.g. for improved drinking water and sanitation), versus wastewater treatment interventions, or a combination of the three intervention options.

2 HOUSEHOLDS AND COMMUNITIES' BEHAVIOR AND PERCEPTION ON WATER AND SANITATION AND HYGIENE: A QUALITATIVE ASSESSMENT

As a method of social inquiry, qualitative research developed from the post-Cartesian intervention by Immanuel Kant. It aims to discover new meanings and concepts rather than establishing causal relationships. Qualitative research is a necessary supplement to the quantitative research that helps to answer important questions and elaborates the issues relevant to public health in a comprehensive manner. Indeed qualitative and quantitative research methods can be seen as complementary, and both are necessary to provide an understanding of a phenomenon.

In the present study, we conducted qualitative research to know the community behavior, their perception and system responses on WATSAN and hygiene in the peri-urban areas of Gujarat. The results are expected to lead to better understanding of the linkages between WATSAN and hygiene which are required to be used to improve health outcomes in the study areas. Chapter 2 describes community perceptions about their water, sanitation and hygiene behavior in the qualitative focus group discussions (FGDs), in-depth interviews and observed household behavior patterns from the quantitative survey.

2.1 Focus Group Discussions

Focus group discussions (FGDs) and in-depth interviews were conducted with the villagers and sanitation committee separately; the purpose of these discussions was to identify their perceptions about water, sanitation, and hygiene. A total of 20 FGDs and in-depth interviews were conducted, 13 with the village women and 7 with the heads of sanitation committees of the target village. Few communities had sanitation committees while in most areas the *Sarpanch* who is the head of the village and is the sole responsible person for water and sanitation in the community. The FGDs with the villagers were conducted by requesting women from about 20-25 households in a village to gather at a predefined area. Similarly, the sanitation committee/ *Sarpanch* was informed a day before the scheduled meeting, and in-depth interviews were conducted. With the consent of the participants, FGDs were recorded in the local language with an audio tape and transcribed later. The FGDs focused on water and sanitation situation including subsidy schemes related

to toilet construction which had benefited the villagers. The themes also included the perception of a clean environment and its effect on their lives, system response to WATSAN issues and improvement needed. During the interviews, participants answered about their perception of water quantity versus water quality interventions, sanitation versus hygiene interventions, and multiple versus single-use of water interventions. The FGD themes discussed are described in detail in the Appendix no. 2.

The section below summarizes the FGDs/in-depth interviews conducted with the village women and sanitation committee/*Sarpanch*. Some of the important phrases as narrated by the participants are written in italics. The summaries of narrations of all the FGDs/in-depth interviews with the Sanitation committee and village women are mentioned in Appendix no. 1.

2.1.1 Village Women

a) Water situation

The participants were questioned about the situation of water in their community regarding quantity and quality, and the overall response was positive for both quality and quantity from most of the communities. Mostly, villagers were happy with the water situation in their community. They had a household tap connection and received water in the tap with an average duration of 2-3 hours a day, and water quantity was quite sufficient for regular household activities. The participants responded that new water pipes are being set up to improve the situation further. The villagers took pride that they do not have to travel to the village pond/"Dhobi Ghat" for washing clothes as the household tap water is sufficient. A few females said that they had to wash clothes at the village pond/"Dhobi Ghat" even if they had enough water from the household tap due to less space in their household for cleaning clothes. Some households in the elevated areas of the village receive water at low pressure hence the water quantity received is not adequate. The villagers perceived their drinking water quality to be good (clear and transparent without any impurities) which was in contrast with the water quality testing results showing the poor microbiological quality of drinking water at both the points of use and the point of source.

A few communities, however, complained about the salinity of water as the metal containers used to store water had a layer of salt deposited on them. They said,"*There is*

salinity, we can see them on the vessels, so don't know what happens to our stomach." Only one community mentioned that the water they receive is of poor quality and that they go to fetch water for drinking purposes from nearby bore-well which is 2-3 km away.

In all the villages, the villagers mentioned that there are some days in a month when the motor of the water pump does not work, and therefore water is not available in household taps. The motor problems happen once in 7-8 months, and the village head acts immediately to get the motor repaired in approximately 2-3 days. When water is not available due to motor problems the villagers fetch water from a nearby bore-well in the community or farm. Water from these wells is available to all villagers, and there is usually not a long queue except in a few communities where they have to wait for half an hour for their turn to get the tap water. According to the visual observation, there were no water logging issues in the collection area. The water received from the bore-wells was "sweat" and of good quality. There was one community where people fetched water from an open well and the villagers didn't consider its water quality to be good.

b) Sanitation Situation

Open defecation was common as many households did not have a toilet; the community surveys showed that only 20%-50% households had a household toilet. The villagers also mentioned "*Some of the households may have a toilet but still go for open defecation as they are habitual to open defecation. If we say the household members to use the toilet, they will stop us to interfere*". When asked about their perception on open defecation they responded that it smells bad especially in the monsoon season. They also mentioned that open defecation has an adverse effect on the pregnant women, especially in monsoon due to walking during their pregnancy term.

The villages with higher open defecation compared themselves with nearby villages having less open defecation and felt that the nearby village was cleaner than their community. The villagers believed that open defecation leads to illness but considered that it is not the only cause of illness as open defecation areas were far from households. They considered other factors as poor drainage, solid waste spread in the community and outside food were causes of illness among household members. The villagers emphasized more on the cleanliness issues such as bad smell, walking farther distances and difficulty to pregnant and old people going for open defecation. Moreover, it is considered a status symbol to have a

toilet as the households who had toilets took pride in having them while those without toilets felt inferior.

The villages usually are divided into sub-communities with different groups by caste and sub-caste residing together. In the richer communities in the village, almost all households owned a toilet, while in the poor communities, only a few had toilets.

The community toilets were present only in one community. However, these toilets were not used by the villagers even in the absence of a household toilet as they preferred going for open defecation instead. The community toilets were mainly used by the people who come to perform work-related activities in the village. The villagers mentioned that the community toilets are not cleaned regularly and create more nuisances to the community. Some of the schools in the villages had toilets; the toilets were clean, but kids did not use them. Most communities did not have an Anganwadi toilet and if there was any, it was not under-use either due to broken door or no water facility. The villagers mentioned that the kids defecate at home and then come to the Anganwadi. If a kid defecates in the Anganwadi, the Anganwadi worker would call the kid's mother to clean.

We asked the villagers about any subsidy schemes in their village for building a toilet. We observed that there was not complete awareness about the schemes among the villagers for some knew about subsidy schemes while others did not knew. Villagers mentioned that the Nirmal Gram scheme was there but had stopped around 3 – 4 years back. While in other villages, the residents said that there was no scheme and that they had constructed a toilet, pit (named as Khalkuan by villagers) with their own expenses. The below poverty line (BPL) families also mentioned that they did not get a subsidy and there is no scheme for toilet and bathroom construction. One respondent said "*no nothing, not a single paisa (coin) was given. Only those three tiles were placed where you cannot even go to the bathroom".* One village which had already received the Nirmal gram award, an award given to open defecation free village; has a proper solid waste disposal in-place; the villagers in that village were also oblivious about any such scheme. Some other communities were aware that such a scheme exists, but there is no approval given for toilet construction to their household. They said, "*The approval happens from Gandhinagar, and we have been living since last 21 years in the community, we have an election card, but still we don't get the approval".* Others mentioned,

"our names were taken, but there is no progress yet. Some authorities came in the community two months ago, and half of the names were written while half left; they came only once, but there is no progress." While others said, *"a few households were approved before sometime, but nothing is done."* Some others mentioned that the money is being given to the BPL households to build the toilet, but they are not happy with the amount of money received. As narrated by the villagers "*half of the money was given for toilet construction while the family paid half; the scheme is there but we have to fill a form in Panchayat, and we get 1,200 Rs*[3]".

Also, some villagers mentioned that a few years back the government constructed pit latrines, but they are now full and cannot be used. Besides, the pit latrines constructed were too small for the villagers to use and are rather used by them as storehouses while they continue to go for open defecation.

c) Drainage

Water disposal was a big issue in almost in all villages that were studied. There were no drainage systems, or if the gutter (drainage) lines were present, they were Kucha (no cemented pipes) drainage, and in all villages, the drain will eventually find its way to the village pond. The final disposal ends up in the village pond while meanwhile the villagers also throw excreta into the pond which become breeding grounds for mosquitos. Some people from the community said that the situation was better when they had less water available hence less sewage was generated which was thrown into the surrounding mud around each household and all the water got soaked.

Most villagers emphasized the issue of drainage due to which there was a lot of dirt. They said *"Drainage is a big problem* (*water is not an issue, but the gutter line is an issue.)-In Monsoon season it becomes problematic. We don't waste water, but the gutter line would be better".* When there is no gutter line the household sewage drains into the pits and if it is not present then for bathing etc. activities they had to go to *Dhobi Ghat*. Some areas had no drainage issues because they had gutter lines which had been installed two years ago and drained the effluents into the village pond. Even in the monsoon season, they had no issues, and excess water from pond would find its way to farms. In most villages, the villagers usually

[3] Rupees (Rs.) is the official currency of the the Republic of India

break something in the monsoon for water disposal to prevent water logging inside the community.

Overall, the villagers were more concerned with the drainage problems compared to open defecation because open defecation areas were usually at least 1-2km away from the village. The poor drainage system is more evident as one enters into the community. The rainy seasons are worse as animal feces contaminate the open drainage and pollute the environment. It was also experienced that the areas with no drainage systems (vs. some *kutcha* drainage) were very dirty and walking inside these communities was difficult and dangerous too due to soft mud holes around in the community.

d) Solid waste, Cleanliness, and Maintenance

One of the main issues of several communities in the study region had been the solid waste presence and careless disposal in the surrounding irrespective of the potential threats that it might be causing for the community. Usually, there are no bins for waste disposal in the village. In addition to this, there is no door to door collection of the resultant waste from the community, and therefore the garbage is thrown in the vicinities of the local dwellings. As a routine exercise, waste is thrown next to the pond or otherwise on the road next to the garbage dump, and there was dirt everywhere on the road and all sides which are dispersed by local scavengers as well as animals in the surrounding area. During the interviews, the respondents mentioned that waste got disposed of into the pond habitually where they use to wash their clothes and utensils as well as defecate there too. Some of the respondents mentioned that the village is clean, but since the boundary areas are dirty, there is a bad odor in the whole area. In some communities, villagers mentioned that dustbins were placed but people misused them by throwing animal excreta into it and caused a foul smell in the area, and that's why these bins were removed from the area to avoid problems that could be caused by the misuse. At other places, dustbins were placed, but people do not dispose their garbage into it and instead throw it anywhere it is easier for them to access. While in some communities there were bins in the village where people throw trash and a designated person who takes all waste in collection vehicle and buries it outside the village on a daily basis; this was a private arrangement done by Panchayat.

The cleaning of the solid waste in the study sites ranged from every 4th day to 6 months. Some said that there had been no cleaning at all, while in other areas villagers

mentioned that cleanliness was done near the school area only. Villagers also mentioned that village cleaning usually took place on special occasions such as weddings. And every 6th month when there is an audit in the village then the sanitation committee would spray medicines for mosquito prevention. In other communities, the cleaning was done by private sweepers who were paid by the households as there is no government sweeper and the Gram Panchayat sweeper either never comes or does only the road sweeping and does not take the solid waste. In another community, people mentioned that sometimes sweeper comes after three days or more.

All villages had some areas clean while some areas were dirty. Mostly in all the villages, there was a richer community who were having *pucca*[4] households had toilets and were cleaner in comparison to the community who were keeping cattle and had animal feces around their household. Then there were the poor income groups with no household toilets and lacked cleanliness. The richer Patel communities said that their area is clean and that they are better while the area where the Thakur or Vaghri or Rabari live is not clean, and they make the village dirty. The Patel community representative further said "*They throw waste anywhere and make the area dirty that we don't get a passage to walk, but whom to tell? If we tell them they will come to fight. How would we feel when it's unclean around us? Nobody cleans; we can clean only our premises but can't force others. And even if their area gets cleaned it becomes the same as before".* When they were asked that why the other area is not clean in comparison to your area, they said *"Here we all are educated, and therefore we don't litter while there they do, the people there throw water and waste on the road. They also have cattle on their premises hence you will find that area dirty".* In the absence of regular sanitation services, communities in the peri-urban areas make their arrangements, and this results in increasing levels of local inequities as the upper-income group can install privatized basic services, but there is a complete absence of these services for the poor.

Some communities mentioned that it used to be dirty before, but then the situation has changed and that there were facilities. One village which had only 45 houses in their community was clean. The villagers proudly considered their village clean, and there are no

[4] *Pucca* houses are solid houses typically made of concrete, stone, clay tiles and/or metal in contrast to the *kutcha* houses made of mud and organic material

illnesses in their community according to them. Other people who visit their community also would comment about the cleanliness in their community which the villagers proudly mentioned. However last year in April many people suffered from dengue fever which the villagers understood was a viral illness and was not linked to any dirt or mosquitoes. The community had the solid waste cleaning done by a sweeper once in a week who burned the collected trash.

When we asked the villagers if they complained the village head for waste collection, they said they had complained, but it mainly depends on the leader in the community to call the sweepers to clean. They said,"i*f the is collection vehicle comes daily there will be no waste."*

The peri-urban areas often lie outside the legal jurisdiction of the city and are thus not provided with many of the basic services provided in the city which makes them no different from the villages of rural India, however unlike these villages, they face a bigger environmental burden stemming from their transitional nature. With no municipal services, solid wastes lie uncollected along roadsides, or if collected, are dumped in any low-lying lands. These practices are not only damaging the local landscape but are a huge health hazard.

e) Perception

We asked the villagers about their perception of a clean village and its benefits; the villagers said: "*When we live in a clean environment, and there is no illness and children would be healthy*." They said"*Swachhata tya prabhuta"* meaning where there is cleanliness there is God. The villagers mentioned that "*The whole village has to be clean but who would do it; even if we clean our houses, children may fall ill as children go out to play in the village. So if the village is clean, there will be no illness*". They also said that when there is littering and water logging, it makes the environment dirty and causes foul smell and mosquitos that could lead to illness like malaria, fever. While the general perception on open defecation is that it improves the social status, but the villagers also mentioned that those who have toilets, the illnesses in their houses have reduced.

The village cleanliness is perceived to be the responsibility of *Sarpanch*. Though some villagers mentioned, "how many times *Sarpanch* could perform the cleanliness activities if all the people in the village are littering: and it is the joint responsibility of the villagers and

Sarpanch to keep the community clean." They said, "*To make the village clean we all have to spread awareness and undertake collective efforts."* They further said *"only 2-3 women like us cannot do? If the waste bins are full what to do? Where to go"?*

We asked the villager's perception on water quality vs. quantity interventions, and they replied that water quality was more important than the quantity.

f) Improvement needed

We asked the villagers on what improvement is needful in their village, on which most villagers responded on drainage, solid waste disposal, cleanliness issues and their betterment as well as toilet construction for households who do not have a toilet. The villagers also wished that if the village pond water was cleaned or released to farms, there would be no mosquitoes in the area.

g) Multi-use water system or single-use water system

We asked the villagers about their preference for multi-use versus a single-use water supply. The villager's preference was on separate single-use water systems where for drinking and domestic purposes water shall come through the water tank in the village residential area and for farming purposes, there should be a separate supply to the farms. The setting in most survey areas was such that farmers have a household in the central residential area in the village with their farms 1-2 km distant from the household and hence separate water supply would be better for them. Very few villagers mentioned that some households have a borewell in farms and they used to take water for all purposes from there which was also good.

2.1.2 Sanitation Committee/*Sarpanch*

a) Water Situation

We questioned the sanitation community on the water situation in the village. The committee in most villages mentioned that water situation was good with no major issues. All villages had good household tap connectivity with water available for 2- 3 hrs in most places and households could extract as much water as needed. If the village is big and has some elevated areas, then the water pressure to such areas is slow, and the household's receive water later in the day.

The water supply is mainly through borewell which is sufficient in most villages, but in a few areas either the water quantity is not sufficient for the entire population, or the borewell is now old, and a new bore well is required. Procuring a new borewell needs permission from higher authorities, and the committee members have initiated the process for the same.

The water quality is good, and the Primary Health Centre also does chlorination of water tank. However, at some places, the *Sarpanch* mentioned that chlorination was not done but the water tank was cleaned at regular intervals. The sanitation committee maintains the repair process as smooth as possible in most areas. In some villages, the *Sarpanch* mentioned that there was no plumber in their village and therefore it was difficult to get a plumber come to their village from the city because of which there were delays in the repair and maintenance process.

b) Sanitation Situation

As mentioned by the committee the open defecation in communities ranged from ranged from 20-70%. Most communities had or were having toilet schemes. Although some sanitation committees mentioned that either they did not have the scheme or they were not interested in the benefit from the scheme as the amount of money the households receive was not at all sufficient to build a toilet, besides there is a long waiting process with lots of paperwork for approval. Toilet construction normally costs Rs. 15,000-20,000 and the subsidy granted is Rs. 4,500 so the households construct the toilets on their own. The educated richer communities preferred a private toilet to be built in their household by their expenses while the poor continue using open defecation. Some *Sarpanch* said that they tried hard to convince the villagers in the meetings to avail the subsidy benefits for household toilet construction. In some other areas, the *Sarpanch* said that even if they tried to educate people, they wouldn't like to take advice and would continue using open defecation.

The *Sarpanch* want their village to be awarded the Nirmal gram award and were keen to improve the number of households with the toilet in the community. The *Sarpanch* would fill the forms and supervise when the toilet construction starts. They also take a picture of the built toilet to send the report to the block office for receiving the funds. In one of the community, the *Sarpanch* said that before Nirmal Gram there were 25 toilets built, at that time there was less monetary support from block level. But now the amount has been

increased, so people are ready to build a household toilet but it takes six months for payment, and the villagers are agitated.

c) Drainage

Most communities had gutter (drainage) lines for the sewage collected from household washing and cleaning activities. The drainage lines eventually drain to the village pond, and in monsoon, the water from the pond moves further into the farms. Except in low lying communities where the water gets logged and becomes difficult for villagers. Most *Sarpanches* were concerned that drainage to village pond had created more mosquitoes in the pond and surrounding areas as the water is dirty and stagnant. One *Sarpanch* mentioned that the disposal through gutter line planning has become unsuccessful. From his viewpoint in village areas, there should be no gutter lines.

The *Sarpanches* in the communities preferred to have a deep pit created outside the village where all drainage lines get drained or through some mechanism the drainage water from the village pond pumped into the farms for utilization in irrigation.

d) Solid waste, Cleanliness, and Maintenance

Most *Sarpanches* said that waste disposal was a big issue as the cleaners did not come daily, only a few mentioned that their village is clean except certain areas. In most of the areas, the cleaners have to come from outside as they do not have the sweeper community in their village. Some communities were cleaned daily while others in 15 days to a month time which is arranged by the Sanitation committee/*Sarpanch*. Otherwise, village people clean their premises. The *Sarpanch* mentioned that since they did not get laborers from outside for cleaning work, therefore if villagers themselves get involved in village cleaning activities it will be better and they should create a clean environment in their village. He further said that people should also change their behavior; they eat gutka (betel nut with tobacco) and litter here and there and defecate along the road. However, we have recently stopped open defecation along the roads.

The bins were kept, but they usually get full, and people threw liquefied cow dung into it and therefore spoil the bins, and hence they get removed besides the removal of trash from these bins is problematic. Some communities have created a pit near the village to dump the solid waste which is burnt or picked by the tractor after some time. Households pay tariffs

which included both water and sanitation however at some places, the collection is difficult as households are poor and do not pay taxes on time.

The rapid growth of population in peri-urban areas in the last decade has meant that the volume of solid and liquid wastes has increased, but the institutional capacities to handle them, remain largely absent. Case studies conducted in the peri-urban communities have concluded that tasks such as solid waste management cannot be left to local level initiatives lack sufficient resources and the capacity to provide such a service in its entirety. Policy-makers need to give such areas more civic autonomy or provide, via the state government, a modicum of basic environmental services. Local level initiatives can augment such efforts, but local level initiatives with no backing by local government/state are unlikely to succeed (Shaw, 2005).

e) Multi-use or Single-use water systems

Similar to the villagers the Sanitation committee preference is for single-use water systems where for drinking and domestic purposes water shall come through the water tank in the village residential area and for farming purposes, there should be a separate supply to the farms.

2.2 Observed Household Behavioral Patterns

The quantitative survey showed that 98% of the sample households had access to an improved water source (mostly tap water). However, water at both the point of use (POU) (80 %) and point of source (POS) (73 %) had poor microbiological quality and could not be considered potable as per the WHO standards of drinking water quality. Nevertheless, most households considered their drinking water quality has no major issues. The table 2.1 below shows household's perception on drinking water issues (This self-reported perception of respondents on their drinking water quality includes all conditions that applied to a household, the replies are not mutually exclusive).

Table 2-1: Perception of water problems

Category	N	%
No Problem	451	68.54
Water is dirty	73	11.09
Water is Saline	156	23.71
Supply is irregular	35	5.32
Source is far	3	0.46
Source dries	0	0

Source: Own calculation from survey data

Most households in the study subjectively considered their water as of good quality and continued to use the more conventional particle filters, such as sieve or cloth. However, from our observation, we noticed that the households do not change these filters regularly and had organic matter deposits on the filters. In such circumstances these filters are not even effective, rather would contaminate the water samples. Though the household members considered their water quality good and still considered employing water treatment methods to improve water quality further, they lacked proper knowledge of availability, cost, and advantages of different water treatment methods. They either used simple sieve/mesh filters or the electric RO filters (5% households) based on their affordability. Gravity non-electric filters were not commonly seen in the survey households.

In total, around 99% households reported cleaning their clay water storage utensils, mainly using simple water rinsing method. At the community level, water tanks are supposed to be cleaned by the bore operators in the community; and most of the areas surveyed had a designated bore operator who is supposed to chlorinate the water stored in the tanks daily and clean the water storage tanks on a regular basis. However, water chlorination and tank cleaning are not done on a regular basis. One probable explanation was given by the bore operators not to chlorinate water tanks was that the villagers disliked the taste of chlorinated water. Besides, most areas surveyed had community health workers who used to go door-to-door to distribute chlorine tablets to the households, but this also takes place rarely (once a week or seasonally/any outbreak of the disease in the community) and also did not cover all areas in the village. The probable explanation for this could be the reluctance of health workers to visit households when the households are unwilling to use the chlorine tablets.

In the study, 42% of the households had an improved toilet facility as defined while 47 percent of the households reported practicing open defecation. The self-reported

perception of respondents on issues related to open defecation showed that 85 percent households perceived that for open defecation people have to walk a long distance. While only seven percent households perceived that open defecation causes disease or environmental/water pollution in the community (Table 2.2). *(The self-reported perception of all households whether practicing open defecation or not was recorded on all conditions that a respondent would mention, hence the replies given are not mutually exclusive).*

Table 2-2: Household perception on issues related to open defecation

Category	N	%
Has to walk long distance	560	85.11
Difficult during rainy season	516	78.42
Has to wake up in the morning	451	68.54
Illness worsens the situation	350	53.19
No Privacy	296	44.98
Foul smell	211	32.07
Difficult for old and disabled	203	30.85
Fly menace	183	27.81
Difficult during pregnancy and delivery	158	24.01
Low status in society	113	17.17
Difficult for adolescent females	91	13.83
Diseases common	48	7.29
Environment Pollution	29	4.41
Water Pollution	16	2.43
Time loss	13	1.98
Others	6	0.91

Source: Own calculation from survey data

When we questioned the households about their opinion on diarrhea, the respondents believed that it was due to bad quality food (70%) or water (63%). Only a few households perceived that open defecation (3%) or poor hygiene (6%) was responsible for diarrheal episodes. Similarly, when households were questioned on the best way to prevent diarrhea, their perception was mainly on clean food (67%) and water (63%). The use of latrine (8%) or good hygiene (5.5%) (washing hands with soap) was not perceived much important by the households (Figure 2.1). On the contrary, when households were asked on what are the attributes of a clean & healthy village, 52.6% of the households responded that every household should own a latrine (Figure 2.2).

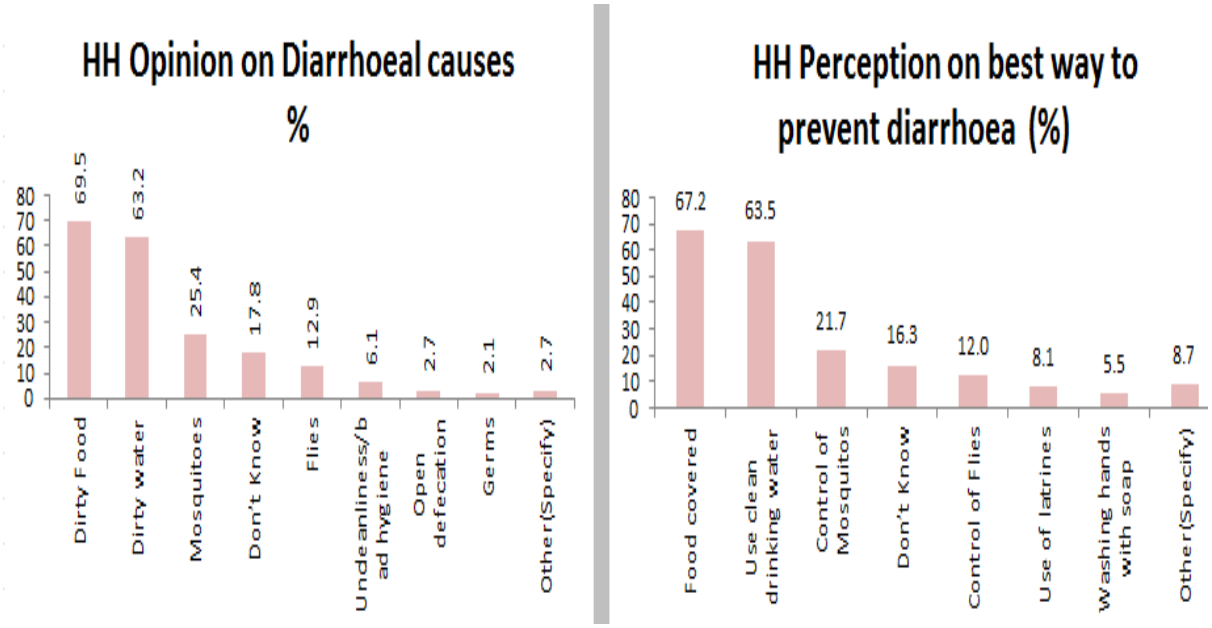

Figure 2-1: HH Opinion on Diarrheal causes and the best way to prevent diarrhea
Source: Own Illustration based on field data collected

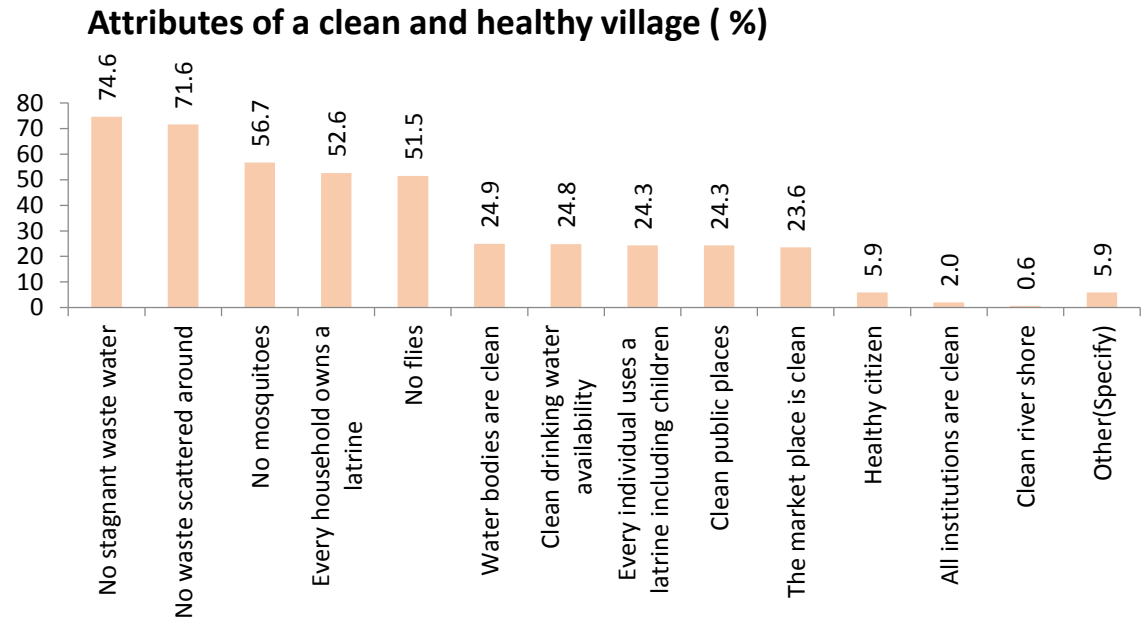

Figure 2-2: Attributes of a clean and healthy village
Source: Own Illustration based on field data collected

The above findings suggest that though most households do not directly attribute open defecation to diarrhea, 50% households still perceived that for clean and healthy village household should own a latrine. From the focus group discussions, on the issues related to

open defecation, the main inference was that the communities with higher open defecation compared themselves with nearby communities where there is less open defecation, and would sense that the nearby community is cleaner and better than their community. We also observed the same difference, that a nearby community within 2km distance with less open defecation was cleaner and healthier in comparison to the next community with higher open defecation. Since two villages in the close vicinity have similar baseline characters, it is the political will of the leaders of that community who take an interest in facilitating the process to get households build a toilet under the subsidy scheme of Nirmal Bharat program.

With respect to irrigation water, it was observed that the households remained reluctant to take proper precautions to protect themselves or continue to use simple methods as wearing shoes. The main issues faced by wastewater farmers about irrigation water used was mainly foul smell reported by 90% farmers and mosquitoes in the area reported by 77% farmers. Only about 14% wastewater user farmers perceived infections in the community due to wastewater. In terms of protection, only 56% wastewater farmers reported wearing protective footwear in the fields, while almost all farmers (99%) reported washing hand and feet after work. Freshwater user farmers had no major issues related to irrigation water quality used in farming though there were complaints of scarcity of water. The freshwater farmers also use protective shoes while farming (41%) and wash hands after work (82%). The main health issues perceived by the farmers with the use of wastewater irrigation were foul smell and skin diseases. They do not perceive that intestinal infections/diarrhea in kids is related to wastewater use in irrigation. There is some awareness of mosquito-related illnesses in their community however besides wastewater irrigation water, community open drainage and village ponds were also breeding grounds for mosquitoes. In general, farmers were more concerned that the use of wastewater has and will decrease soil fertility further over the years. However as of now, the use of wastewater generates good economic benefits to the farmers, and there is an overall content in using wastewater in irrigation, being cheaper and available throughout the year.

2.3 Conclusions

The villagers and the sanitation committee considered their water good in terms of availability, quantity as well as quality which was in contrast to the microbiological testing of

samples conducted in the study. Water treatment at the point of use is very important and proper knowledge, and awareness of villagers is necessary. Beside this, chlorination at the water source is an important step which is not done regularly due to its bad taste as experienced by the villagers. Experimental research studies should be conducted to find the dose that can be optimal for residual chlorine in water where water for drinking purpose is stored for the shorter duration of time due to sufficient water availability. Smaller doses may not affect the taste, and residual chlorine can be sufficient for keeping the water safe for a shorter duration.

Open defecation was high in the study areas. The richer educated peri-urban households who can afford to build a toilet have understood the importance of having a household toilet as it is safer for the females particularly in the night. It also comes to the view of status/competence with the nearby household of similar caste to invest in having a toilet. The recent government advertisement emphasizing of having a household toilet before marrying a daughter into the household having a toilet probably will have more impact than educating about illnesses caused by open defecation which though proven by the scientific data is difficult to be quite obvious and understood by the villagers. The households see the obvious social impact of having a toilet in the household which helps the family especially females safety and marriage and are perceived far more important at least in the Indian context.

Since the water supply for cleaning is not an issue, more and more households are considering to construct toilets. Though the poor, temporary, kuccha/ mud households or small households do not prefer having a household toilet and continue using open defecation. Some small households who had a septic tank constructed a few years before were concerned that it was then full which caused contamination, so they now have again started going for open defecation. Such concerns of households should be evaluated and also proper planning and maintenance is required while constructing a toilet in smaller settings. The villagers do not prefer community toilets hence proper measures should be undertaken to understand a local community before planning community sanitation infrastructures. The toilet subsidy schemes seemed to work in few communities while not in others due to unawareness, long wait period and a lesser amount of money received in comparison to the cost of a toilet.

The villagers were more concerned with the drainage problems as compared to open defecation as the open defecation areas were usually far from the households while the poor drainage was more evident as soon as one enters into the community. The rainy seasons were worse as the animal fecal contamination into open drainage further creates the environment very dirty. Water disposal was a big issue in almost all communities studied. There were no drainage systems or otherwise even if the gutter (drainage) lines were present they were *kutcha* (no cemented pipes) drainage, and in all communities, the drains eventually discharge to the village pond based on gravity which becomes breeding sites for mosquitos. Usually, water is available in sufficient quantity, but the dilemma for the study region is the water wastage and overuse. Some people from the community even said that the situation was better when they had no gutter lines, less water was available hence less sewage generated drained into the surrounding mud around each household, and all got soaked. The *Sarpanches* in the communities preferred to have a deep pit created outside the village where all drainage lines get drained or through some mechanism the drainage water from the village pond can be pumped into the farms and can be used for irrigation. Sewage water from household washing activities directed to farms for irrigation purposes can be a good intervention strategy.

Solid waste was an issue in many communities. There were no bins in the village, there is no door to door collection and garbage is not thrown to any designated area but rather dispersed within the neighborhood which creates environmental hazards and pollution. The cleaning of the solid waste done, ranged from every 4th day to 6 months or on special occasions like a wedding in the village, in the areas surveyed. Most villagers said that if there was a collection vehicle which could come daily, then there would have been no waste in the community. Some richer areas in the village had a private arrangement for waste collection where the households paid the laborer. Almost all villages had some areas clean while some areas dirty. Mostly in all the villages, there used to be a richer community who had *pucca* households with toilets which were cleaner in comparison to the other community who were either poorer or had cattle and animal feces in their household premises. There is always some fight between different areas/ communities in the village about village cleanliness.

One small village in the study area which had only 45 houses in their community and was very clean. The community used to clean the solid waste with the help of a sweeper, once per week, and burnt the trash. These examples can be applied to other villages which though are bigger but segregated into smaller areas/communities by caste, sub-caste. Localized leaders in smaller areas in the village can manage the solid waste disposal by regular collection and burn the trash so that there is no garbage dump lying around and the area gets clean. These localized leaders should then also become the part of sanitation committee to bring issues from their area if there was any.

Overall household and community perceptions gives us insights into the water, sanitation, hygiene and behavior issues in the community. The qualitative perceptions traingulated with the quantitative findings from study will help to design simple cost-benefit interventions to improve health outcomes.

3 IMPACTS OF DIFFERENT IRRIGATION SYSTEMS ON WATER QUALITY IN PERI-URBAN AREAS OF GUJARAT, INDIA

3.1 Introduction

In the rural and peri-urban settings, where agriculture is one of the main sources of livelihood, the type of water used in irrigated agriculture has complex interactions with drinking water and sanitation. The multi-purpose character of irrigation and drainage infrastructure creates several interlinks between water, sanitation (WATSAN) and agriculture.

Studies have noted that water pollution is both a cause and an effect in the linkages between agriculture and human health (Reiff, 1987). Since 90 percent of water is used mainly in irrigation, it plays an important role in the microbial contamination of domestic drinking water through the interaction of humans and animals. For instance, irrigation canals are used by villagers for domestic purposes, and by animals, mainly cattle, and have high levels of fecal coliform bacteria (Rajasooriyar et al., 2013). After sitting in contaminated surface water, livestock return to their shelter with high amounts of fecal coliforms, which could contaminate household drinking water through human interactions. Farmers working in paddy fields using wastewater for irrigation are exposed to fecal coliforms, and without proper protection, hand washing and hygiene could contaminate their household drinking water.

Sabarmati, one of the major rivers in the western region of India flowing mainly in Gujarat continues to be an important source of irrigation water. It has been listed as the third most polluted river in the country by Central Pollution Control Board of India. Sewage-contaminated stormwater outfalls and the dumping of industrial waste in the river pose major health and environmental hazard. Sources of urban effluent include urban household sewage, industrial wastes and hospital effluent (Emmanuel et al., 2005). Microbiological characterization studies in several industrialized countries have found pathogenic microorganisms in hospital effluent, some of which are multi-resistant to antibiotics (Emmanuel et al., 2009). A recent study by (Walsh et al., 2011) gained worldwide attention after finding bacteria that produce purely nosocomial NDM-1 β-lactamase (New Delhi Metallo-beta-lactamase-1) in environmental samples, including some drinking water samples

in New Delhi. This enzyme makes bacteria resistant to beta-lactam antibiotics, therefore posing a serious threat to public health.

Surface runoff, and consequently non-point source pollution, contributes significantly to high pathogen levels in surface water bodies. In turn, the seepage of pollutants from surface and subsurface sources leads to groundwater pollution. A study conducted in an urban setting in India found that none of the groundwater samples were suitable for drinking because they contain a high concentration of total and fecal coliform (Sukumaran et al., 2015).

Studies have also found a negative relationship between the proximity of latrines to groundwater and the groundwater's microbiological quality in a rural setting (Megha et al., 2015, Mahadevan and Krishnaswamy, 1984). Groundwater contamination is an even bigger problem in peri-urban areas, where the population is dense, drainage systems are not developed, and water infrastructure is located closely to on-site sanitation systems. Pit latrines and septic tanks are common types of on-site sanitation facility in rural areas of India and are sources of groundwater contamination. A study conducted in peri-urban areas of India found seepage of sewage into groundwater from improperly designed rural sanitation facilities (Shivendra and Ramaraju, 2015).

In addition, drinking water in distribution systems can suffer serious contamination because of breaches in the integrity of pipework and storage reservoirs. Many outbreaks of waterborne diseases have been attributed to such events. For instance, a study on a cholera outbreak in a Kolkata slum community identified that leakages in the main pipeline led to *E.coli.* contamination of the drinking water source, (Sur et al., 2006).

To allow for international comparability, the Joint Monitoring Program (JMP) for Water Supply and Sanitation by the WHO and UNICEF classifies drinking water sources and sanitation facilities as "improved" or "unimproved." Studies have shown that improved drinking water sources can significantly reduce the occurrence of waterborne pathogens at the source (Cutler and Miller, 2005). However, global access to safe drinking water, which the JMP defined as access to improved sources, does not account for measures of water quality. A systematic review by (Bain et al., 2014), concluded that while an improved source provides a measure of sanitary protection, it does not ensure water is free from fecal contamination.

Further, the bacteriological quality of drinking water significantly declines after collection in many instances, thus pointing to a more complex issue than the quality of drinking water at the source. A systematic review of difference in the level of microbiological contamination between the point of the source (POS) and point of use (POU) conducted by (Wright et al., 2004) found a significant drop in water quality in approximately half of the included studies. A study conducted by Satapathy (WHO. 2014) showed that in urban slums of India, the fecal coliform level in water at the POU was on average 22 percent higher than at the POS.

3.2 Theory and Empirical Strategy

The proximate determinants of an individual's health usually are decisions made by the individual or by the household in which he or she lives- given the assets, cost, time and community endowments. Therefore the starting point in the determination of individual health starts at the household level. In a static household production model (Becker, 1965) the households are assumed to maximize their household utility function subject to constraints. According to the theory, households allocate resources to purchase different goods and combine them with time into a household production system to produce various commodities and services. These purchased goods and produced commodities directly enter into the household's utility function.

The utility is assumed to depend on the health of each of the household individuals, consumption of goods and leisure. The household preference function is maximized subject to constraints. One of the constraints of production function is water intake which depends upon water infrastructure, quality at source, household treated water for storage, the time spent by the household members collecting water assumed to be a function of distance to the source of water, knowledge of good practices as handwashing with soap and hygiene as they relate to water collection, storage, and use. Besides the communities exposed to different types of water systems for irrigation are affected differently with respect to their household storage water quality due to the linkages from irrigation water with sanitation and hygiene behavior. Essentially the household behavior on hygiene and sanitation and their use of information regarding linkages between WATSAN to irrigation water affects household water quality.

The study analyzes the impact of irrigation water type on drinking water at the POU using a counterfactual framework approach in which each household has an outcome either with or without exposure to wastewater. We specified the following econometric model to estimate water quality:

$$Y_h = \beta X_{hc} + \alpha W + \varepsilon_i$$

Where Y_h is the outcome variable, the quality of drinking water of each household, X_{hc} is a vector of household and community exogenous variables that are expected to affect the quality of drinking water. These variables measured at household or community level and their impact was captured by the parameters vector β. *W* is the treatment variable, in this case, the type of irrigation water. The effect of using wastewater was measured by the coefficient of the treatment parameter α. We hypothesized that this parameter has a positive and statistically significant effect on Y, indicating that households exposed to wastewater irrigation are significantly more likely to have poor drinking water quality than those exposed to freshwater irrigation. We used two different specifications of the outcome variable: a) level variable expressed as the log of *E.coli.* MPN count per 100 ml of drinking water; b) binary variable assuming the value of zero when the water is not contaminated (zero *E.coli.* per 100 ml of water) and one if it is contaminated (one or more *E.coli.* per 100 ml of water). The WHO drinking water quality guideline stipulates that the number of *E.coli.* bacteria per 100 ml should be zero for drinking water to be considered potable. The level variable should allow us to pick up incremental effects of the water treatment on household water quality; given that the vast majority of the households in the sample have poor-quality water, it could be difficult to correlate a binary outcome with the treatment or the set of characteristics in vector X. We fitted an ordinary least square (OLS) regression for the level variable and a logit model for the binary variable. Finally, ε is the usual error term, to which the standard assumptions apply.

3.3 Descriptive Statistics

3.3.1 Variables

The outcome variable of interest is the point of use (POU) drinking water quality. POU is expressed in two ways: First, as log (1+ MPN) of *E.coli.* count for a continuous variable in one

model specification. Second, as a categorical variable (contaminated/not contaminated) in another specification. The determinants of water quality include agricultural characteristics, household characteristics, WATSAN infrastructure, hygiene, and behavior. The main characteristics used in the subsequent analysis are reported in Table 3.1.

Table 3-1: Main drivers of drinking water quality used in the analysis

Main Characteristics	Variable	Category	N	%
Agricultural Characteristics	Irrigation water	Canal	156	24%
		Tube well / Rain	141	21%
		Wastewater	327	50%
		No farm involvement	33	5%
	Land area (BIGHA)	Continuous	657	100%
	Livestock ownership	No	188	29%
		Yes	469	71%
Household Characteristics-Sanitation	Improved Toilet (Based on JMP definition)	No	385	59%
		Yes	272	41%
Household Characteristics-Water Treatment	Water Treatment: Reverse Osmosis (RO) water plant	No	606	92%
		Yes	51	8%
Hygiene	Hygiene Score (Based on Environment, water, sanitation, food and personal hygiene)	1 Poor	156	24%
		2 Average	264	40%
		3 Good	236	36%
	Soap use (self-reported)	No	404	61%
		Yes	253	39%
	Handwashing post defecation	No	50	8%
		Yes	607	92%
Community Characteristics	Garbage collected by town panchayat	No	297	45%
		Yes	360	55%
	Open defecation prevalence	0 <=25%	215	33%
		1 >25%	442	67%
	Community drainage type	Closed/ Open *Pucca*	210	32%
		Open Kucha/No drainage	447	68%
Total			657	100%

Source: Own Illustration of variables collected in field

The control variables (i.e., determinants of water quality which are not directly linked to the WATSAN context) include wealth quintile, caste, and education level of the head of household. The caste categories are general and other (included the socially economical backward class schedule caste and tribes).Households were divided into five wealth quintiles

using household assets, applying factor analysis as employed in the national level Demographic Health Surveys (DHS). WATSAN infrastructure variable was not included in determining household wealth quintile to avoid collinearity problems; because WATSAN infrastructure variable was used as explanatory variables in the regression models.

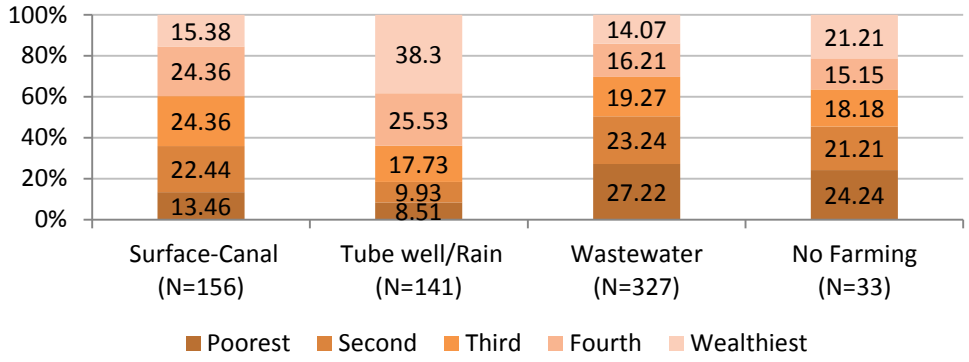

Figure 3-1: Household Irrigation water type by wealth quintile

Source: Own illustration based on data collected

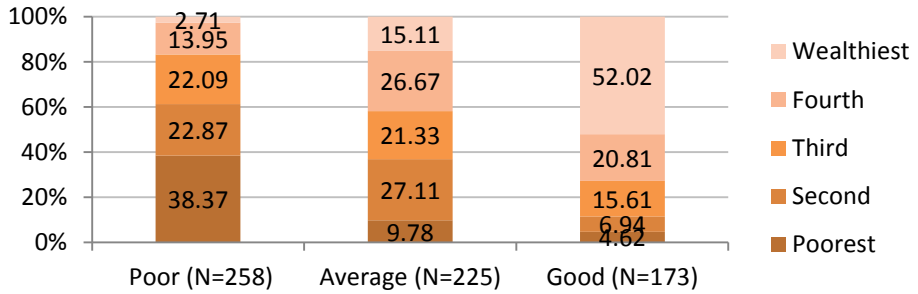

Figure 3-2: Household Hygiene score by wealth quintile

Source: Own illustration based on data collected

(Hygiene score consisted of five components: environment, sanitation, water, food and personal hygiene score. The final score was obtained by summing the scores of all five categories and dividing into quintiles).

Higher percentage of households using tube well water for irrigation were in the wealthiest wealth quintile group (38.3%) in comparison to wastewater (14.07 %) and canal water (15.38%) irrigators (Figure 3.1). Similarly, a higher percentage of households having a poor hygiene score were in the poorest wealth quintile group (38.3%) in comparison to households with average or good hygiene score (Figure 3.2). The reverse osmosis (RO) method of water treatment was used only by eight percent of the households in the survey data. Further categorization by wealth quintile shows that 22 percent of the wealthiest

households used RO method of water treatment while the utilization among the poorest was nil. Caste by wealth quintile categorization shows that the general category households are largely in the wealthiest wealth quintile (Appendix 1, Table A-2). Hence, household wealth quintile is an important control variable in all the regression models.

Garbage collection, drainage type, open defecation prevalence and village household density were the community-level variables included in the regression models. Existing literature suggests open defecation and high population density are perhaps the keys to explaining the unresolved puzzles of the high prevalence of stunting among children in India (Chambers and Von Medeazza, 2013).

Open defecation in the study area was calculated based on 2011 village level census data, study sample quantitative data as well as the information given by the village head. We applied a data-driven observatory approach when defining the open-defecation variable. None of the communities in the survey areas was completely free from open defecation. The minimum open defecation prevalence was 25 percent across the different study areas, a rate which applied to 33 percent of our survey data; therefore, we used this value as a benchmark to form a categorical variable for open defecation. Hence open defecation was computed as a binary variable with more than or less than 25 percent open defecation in the community.

3.3.2 Results

The survey results showed that 99 percent of the sampled households had access to improved drinking water (mostly tap water), 42 percent of the households had an improved toilet facility as defined by the JMP while 47 percent of the households reported practicing open defecation. All these figures are in line with the country-wide estimates published in the recent JMP 2015 report (i.e., 95%, 40%, and 44% respectively). The study sample is thus similar to country statistics for drinking water source, sanitation infrastructure and behavior(JMP, 2015).

We found that the microbiological water quality was not good , with 80 percent of the household having non-potable storage drinking water as per the WHO standards. Some of the water samples showed very high levels of *E.coli.* contamination (an average of 85 MPN/100 ml and a maximum of 1700 MPN/100 ml). The WHO drinking water quality guideline stipulates that the *E.coli.* count in drinking water (MPN/100 ml) should be zero for

it to be considered potable. The risk of waterborne infection increases with higher *E.coli.* levels in water. WHO classifies drinking water into five risk categories according to the *E.coli.* count per 100 ml of water sample: i) 0 (in conformity with WHO guidelines), ii) 1-10 (low risk), iii) 10-100 (intermediate risk), iv) 100-1000 (high risk), v) >1000 (very high risk) (WHO, 1997). Based on the WHO risk categories Table 3.2 reports the distribution of *E.coli.* in household stored drinking water. Notably, contamination at the source was also high, with 73% of the households getting contaminated water. (i.e., one or more *E.coli.* MPN/100 ml water sample) The numbers are comparable to those from another study (Satapathy, 2014) conducted in a poor urban setting in Delhi, which showed a clear relationship between POS fecal contamination (45%) and POU fecal contamination (65%). Empirical studies have shown that the microbiological quality of drinking water significantly declines after collection from the acceptable quality of water sources (Wright et al., 2004).

Table 3-2: *E.coli.* in storage drinking water (WHO risk category classification)

E.coli.. (MPN/100 ml)	Risk Category	Households	
		N	%
0	No risk	124	19.47
1-10	Low risk	187	29.36
11-100	Intermediate risk	226	35.48
101-1000	High risk	88	13.81
1001-1800	Very high risk	12	1.88
Total		637	100

Source: Own calculation from survey data

Good hygiene practices improve the quality of household drinking water (Gwimbi, 2011). Additionally, poor sanitation and a lack of awareness of personal hygiene are responsible for water quality deterioration (Suthar et al., 2009). In the present study we assessed the household hygiene behavior using interviewer's observation. We applied a subjective method (conducting spot checks) to compute a hygiene score for each household (Webb et al., 2006). The hygiene score comprised of five components: environment, sanitation, water, food and personal hygiene. The key components of the environment include visible fecal contamination, waste piles, flies, roaming animals and stagnant water in the domestic and visible peri-domestic surroundings of a household. The category "sanitation" primarily considers the availability of toilet facilities, the cleanliness of toilet facilities and the availability of handwashing facilities near to or at the toilet. The category

"water" considers water availability, cleanliness of a household's water source and water storage. The category "food" assesses the adequacy of food storage in a household. The category "personal hygiene" covers the visible cleanliness of hands and nails of a household's female head, who also answered the WATSAN module of the questionnaire. A score between one and three was given to a household for every category (environment, sanitation, water, food and personal hygiene) based on the enumerator's observation. Based on the scores each category was divided into poor, average and good hygiene score. In every category, the poor score had the highest percentage of households with contaminated water.

Table 3.3 below shows the percentage of households that had drinking water with *E.coli.* MPN count of more than one (i.e., non-potable water) among the different categories of hygiene score. In every category, the poor score had the highest percentage of households with contaminated water (*E.coli.* MPN count of more than one). Chi-square (Fisher's exact) estimations showed there was a statistically significant difference between at least two groups in each category. The Appendix 1 (Hygiene Score) describes how these criteria were applied to each category.

Table 3-3: Hygiene Variables with E coli>=1 by Households

Variable	N	Category	E coli>=1(%)	Chi^2-P value
	156	Poor	90.4	0.000
	264	Average	83.3	
Hygiene Score	236	Good	71.6	
	255	Poor	85.9	0.001
	224	Average	82.1	
Environment Score	177	Good	71.8	
	46	Poor	87	0.043
	325	Average	83.7	
Sanitation Score	285	Good	76.5	
	218	Poor	89.4	0.000
	67	Average	85.1	
Water Score	371	Good	74.9	
	351	Poor	86.3	0.000
	20	Average	90	
Food Score	285	Good	73.3	
	222	Poor	89.6	0.000
	127	Average	81.9	
Personnel Hygiene Score	307	Good	73.9	
Total	657		80.8	

Source: Own Illustration based on survey data analysis

Next, we present an analysis of the simple correlation between the main independent variables, the household and village-level variables (i.e., agricultural, WATSAN and hygiene indicators), and the presence of *E.coli.* in stored drinking water (POU). The bivariate analysis suggests that several of the determinants listed had a clear association with the POU drinking water quality (Table 3.4). Households using wastewater or surface canal water for irrigation had a poorer quality of stored drinking water than those using tube-well or rainwater. Chi-square tests showed that at least two categories of most of the independent variables were statistically different (at 0.01 or 0.05 confidence level). The statistically significant correlation of water quality was also observed with water treatment using reverse osmosis and community variables as open defecation and drainage. We found no statistically significant association for caste, education level, and soap use, handwashing after defecation, livestock ownership, and safe waste disposal.

Table 3-4: *E.coli.* in stored water by households – bivariate analysis

Variable	Category	N	E coli>=1(%)	Chi^2-P value
	Canal	156	86.5	
	Tube well / Rain	141	68.1	0.000
	Wastewater	327	84.4	
Irrigation water	No farm involvement	33	72.7	
	Poorest	130	87.7	
	Second	132	81.1	
	Third	132	83.3	
	Fourth	132	79.5	
Wealth quintile	Wealthiest	131	72.5	0.033
	ST/SC/SEBC	592	81.3	
Caste	Other general	65	76.9	0.400
Education level of the household	Illiterate	267	79.8	
head	Educated P, S or T	389	81.5	0.584
	No	606	82.8	
Reverse Osmosis water plant	Yes	51	56.9	0.000
	No	385	83.1	
Improved toilet	Yes	272	77.6	0.075
	No	404	82.2	
Soap use	Yes	253	78.7	0.264
	No	50	86	
Hand washing after defecation	Yes	607	80.4	0.333
	No	188	78.7	
Livestock	Yes	469	81.7	0.387
	No	588	81.5	
Waste Disposal safe	Yes	69	75.4	0.223
Garbage collected by Town	No	297	87.9	
Panchayat	Yes	360	75	0.000
	0 <.80	450	83.3	
Households with drain	1 >=.80	207	75.4	0.016
	0 <=25%	165	73	
Open Defecation	1 >25%	492	84.6	0.000
	Closed/ Open *Pucca*	210	72.4	
Community drainage	Open Kucha/No drainage	447	84.8	0.000
Total		657	80.8	

Source: Own calculation from survey data

In the following section, we present a regression analysis aimed at finding out the sign and extent of these impacts by considering the variables altogether.

3.4 Regression Results

This section highlights the results of the multivariate regressions which shows the effect of the types of the irrigation system on drinking water quality while controlling for a wide range

of potential microbial transmission pathways. We achieved this by analyzing covariates that reflected farm infrastructures, farm-related activities, drinking water sources, sanitation, hygiene and behavior. An OLS model was used to determine factors associated with the natural log of *E.coli*, a measure of water quality at the point of use storage water. Logit regression was used to estimate the risk of having contaminated stored water (i.e., water having one or more *E.coli.* MPN/100 ml). For both types of regression analysis, different model specifications were estimated to allow for inferences about potential confounders and to test the robustness of the estimated effects.

The OLS regression results shows (Table 3.5, Model I) that in comparision to canal water irrigators, the tube well and wastewater irrigators were significantly negatively associated with the level of *E.coli.* in stored drinking water (the log of *E.coli.* decreases by 93% ($p<0.01$) and 49% ($p<0.05$) respectively). The households using RO water treatment had a statistically significant better drinking water quality (*E.coli.* is 66% lower $p<0.05$). Larger drinking water storage capacity was associated with lower drinking water quality, by a very small decrease in the natural log of *E.coli* of 7.5% at a significance of $p<0.01$. Finally and unexpectedly, livestock ownership, and having an improved toilet had no statistically significant impact on the water quality. As shown below, the results were robust across all specification (Table 3.5 Models I-III).

In the Model II, we added the behavior and hygiene variables to explain the dependent variable on the natural log of *E.coli.* The mean Variation Inflation Factor (vif) of the hygiene and behavior variables was 1.4 with the individual vif maximum of 1.9 which rules out collinearity between the hygiene behavior variables and the natural log of *E. coli.* The simple correlation matrix between the hygiene and behavior variables is presented in the Appendix 1 (Table A.1).

In the OLS regression model after controlling for household hygiene status and behavior (Table 3.5, Model II), the association remains significant for tube well and wastewater irrigators, having better-quality stored drinking water (with 90% and 76% ($p<0.01$) decrease in the natural log of *E.coli.*). Using RO water treatment was associated with a better drinking water quality decreased the *E.coli.* by 69% ($p<0.05$), so the results remained robust with the inclusion of the new covariates in Model II. The covariates that were not statistically significant in Model I remained so in Model II. Among the added hygiene variables,

only the hygiene score appeared statistically significant with average and good hygiene score households negatively associated with *E.coli*. as compared to the poor hygiene households. The *E.coli.* was 53% ($p<0.05$) lower for the average score, 91% ($p<0.01$) lower for the good hygiene score). The other hygiene and behavioral variables showed no significant impact. The hygiene score consisted of five components: environment, sanitation, water, food and personal hygiene score. Each of these five components separately had little or no significant effect on water quality, but the combined hygiene score used in the multivariate model had a higher and statistically significant impact. The individual components had no effect seperately due to the synergistic effect of the individual components, which together give a complete picture of household hygiene.

Finally, we added the community sanitation variables in Model III (Table 3.5), the percentage of people practicing open defecation in a community (binary variable with > or <= 25% population) and the village household density (calculated as the number of households per hectare of land).The results show that water quality remains better for tube well and wastewater irrigating households in comparison to canal water irrigators. Among the added community variables community open defecation (> than 25%) had a statistically significant positive association with the *E.coli.* levels (76% higher, $p<0.01$) in stored drinking water as compared to communities with less than or equal to 25% open defecation. Also, the village household density had a positive association with the *E.coli.* count (1.5 times high increase $p<0.01$) with a unit increase in village household density). We investigated for any interaction between the household density and the prevalence of open defecation in a community and found that there was no significant interaction between the two.

Table 3-5: Household water quality in natural log of *E. Coli.* – Ordinary Least Squares Model

		Model I		Model II		Model III	
Variable	Categories	coef	se	coef	se	coef	se
Irrigation water	Canal			*Reference*			
	Tube well / Rain	-0.932***	-0.261	-0.899***	-0.263	-0.517*	-0.289
	Wastewater	-0.493**	-0.225	-0.762***	-0.243	-0.917***	-0.247
	No farm	-0.564	-0.416	-0.438	-0.42	-0.13	-0.423
Wealth quintile	Poorest			*Reference*			
	Second	0.0902	-0.259	0.283	-0.271	0.16	-0.267
	Third	-0.0096	-0.258	0.197	-0.257	-0.056	-0.255
	Fourth	-0.269	-0.275	0.059	-0.284	-0.155	-0.285
	Wealthiest	-0.0844	-0.312	0.36	-0.337	0.0537	-0.335
Education of Head of Household		0.0461	-0.171	0.0202	-0.176	0.0742	-0.175
Caste		0.358	-0.346	0.566*	-0.342	0.592*	-0.329
Adult female density in House		-0.231	-0.757	-0.242	-0.775	-0.407	-0.761
Livestock		0.0284	-0.187	-0.121	-0.193	-0.111	-0.187
Improved Toilet		-0.0574	-0.183	0.0545	-0.207	0.118	-0.203
Closest drain distance		-0.0008	0	-0.0008	0	-0.0008	0
Main water tank distance		0.0005	0	0.0003	0	0.0006	0
RO water plant		-0.666**	-0.31	-0.687**	-0.313	-0.713**	-0.313
Storage container size		0.075***	-0.021	0.072***	-0.023	0.047**	-0.023
Use soap				-0.0451	-0.202	0.138	-0.202
Clean hands post defecation				-0.46	-0.323	-0.269	-0.32
Waste Disposal safe				-0.114	-0.27	-0.143	-0.258
Toilet facility Cleanliness	No Toilet			*Reference*			
	Poor			-0.126	-0.251	-0.0476	-0.257
	Good			-0.114	-0.254	-0.0629	-0.253
Hygiene Score	Poor			*Reference*			
	Average			-0.530**	-0.242	-0.373	-0.241
	Good			-0.915***	-0.278	-0.658**	-0.277
Open Defecation						0.765***	-0.273
Village Household density						1.541***	-0.294
Constant		2.130***	-0.463	3.126***	-0.635	1.274*	-0.71
Observations		639		639		639	
R-squared		0.09		0.113		0.154	

*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*
Source: Own calculation from survey data

The added community variables had little or no impact on the significance of the other variables included in Models I and II. In particular, the tube well as well as wastewater irrigation, use of RO water treatment, drinking water storage capacity and the hygiene score were still significant determinants of household drinking water quality.

In the final part of the stored drinking water quality analysis, we estimated the determinants of water quality as a binary outcome zero *E.coli.* MPN/100 mL vs. (one or more *E.coli.* MPN/100 mL) in a logit model. The results (Table 3.6, Model I) showed that in comparison to households using canal water for irrigation the tube-well or rainwater irrigators were 12% ($p<0.05$) less likely to have non-potable drinking water. No significant effect was observed among the wastewater irrigators.

Similar to the OLS regression we see that the households using RO water treatment had better drinking water quality, with a statistically significant marginal effect of 14% ($p<0.01$) lower that is 14% less likelihood of having non-potable drinking water. Larger sized drinking water storage capacity was associated with lower drinking water quality, although by a very marginal amount (1% at a significance level of $p<0.01$). Having livestock, an improved toilet or a clean toilet had no statistically significant impact on drinking water quality, similar to the OLS regression results. After controlling for hygiene status and behavior (Table 3.6, Model II), we found that the households using tube well water still had better drinking water quality and the effect was stable. However, the impact of using wastewater for irrigation became statistically insignificant.

Similar to the OLS regression results, the logit model II showed that the households using RO water treatment had improved drinking water quality with a marginal effect of 13% lower (13 %, $p<0.05$ less likelihood of having non-potable drinking water) with robust results. Similarly as observed in the OLS regression larger storage container deteriorated the drinking water quality. The covariates that showed no statistical significance in Model I remained so in Model II. Among the added hygiene variables, only the good hygiene score had a slightly significant impact on the outcome (11 %, $p<0.1$ less likelihood of having non-potable drinking water), while the average hygiene score, which was significant in the OLS model had no impact in the logit model. The other hygiene and behavior variables show no significant impact. After adding the community sanitation variables to Model III (Table 3.6), the results

of the logit model showed that open defecation had no significant impact on household drinking water quality. However, a village's household density had a large impact on drinking water quality; a unit increase in household density increased stored water contamination by 27% at significance level of $p<0.01$.

Due to multicollinearity problems, some of the community-level variables, such as garbage collection and the drainage type, were not included in the regression models owing to their correlation with other community-level variables, such as open defecation. Use of soap water, a self-reported behavior showed no significant effect in the linear model but with a significant effect in the adjusted logit model (III, table 3.6). Although soap water use should ideally improve household water quality which we observe in the simple bivariate analysis, the effect was opposite in the multivariate model logit model. This makes us conclude that soap use, a self-reported behavior did not have a consistent effect in the study and could be a reporting bias by a household member. The wealth status was used as a control variable in the study and had no significant effect on water quality across models.

Table 3-6: Househld water quality- Logit Regression Modelwith the utcome No E coli=0/ One or more *E. coli.)*

	Model I		Model II		Model III	
Variable Categories	Marginal Effect	se	Marginal Effect	se	Marginal Effect	se
Canal			*Reference*			
Tube well / Rain	-0.122**	(0.0539)	-0.114**	(0.0545)	-0.109*	(0.0633)
Wastewater	-0.0157	(0.0396)	-0.0308	(0.0435)	-0.0462	(0.0480)
No farm involvement	-0.0750	(0.0862)	-0.0544	(0.0799)	-0.0533	(0.0811)
Poorest			*Reference*			
Second	-0.0427	(0.0509)	-0.0227	(0.0564)	-0.0355	(0.0506)
Third	-0.0107	(0.0527)	0.00286	(0.0592)	-0.0271	(0.0552)
Fourth	-0.0781	(0.0612)	-0.0528	(0.0636)	-0.0865	(0.0603)
Wealthiest	-0.0842	(0.0639)	-0.0712	(0.0782)	-0.115	(0.0742)
Education of Head of Household	0.0304	(0.0360)	0.0195	(0.0374)	0.0277	(0.0366)
Caste	0.0762	(0.0613)	0.0874	(0.0654)	0.106*	(0.0609)
Adult femal density in House	-0.138	(0.142)	-0.120	(0.139)	-0.132	(0.144)
Livestock	0.0270	(0.0407)	0.00977	(0.0429)	0.0135	(0.0416)
Improved Toilet	0.0228	(0.0401)	0.0422	(0.0426)	0.0541	(0.0427)
Closest drain distance	-0.000239**	(9.95e-05)	-0.000216**	(9.56e-05)	-0.000238**	(9.69e-05)
Main water tank distance	0.000267**	(0.000112)	0.000219**	(0.000109)	0.000244**	(0.000107)
RO water plant	-0.139***	(0.0514)	-0.130**	(0.0522)	-0.153***	(0.0522)
Storage container size	0.0103***	(0.00385)	0.0119***	(0.00429)	0.00783*	(0.00445)
Use soap			0.0655	(0.0431)	0.0950**	(0.0412)
Clean hands post def			-0.102	(0.0782)	-0.0569	(0.0771)
Waste Disposal safe			0.0112	(0.0601)	0.00620	(0.0578)
NoToilet			*Reference*			
Clean Toilet-Poor			-0.00964	(0.0599)	-0.00404	(0.0574)
Clean Toilet-Good			-0.0305	(0.0480)	-0.0300	(0.0477)
Hygiene Score- Poor			*Reference*			
2 Average			-0.0703	(0.0477)	-0.0544	(0.0494)
3 Good			-0.110*	(0.0645)	-0.0850	(0.0623)
Open Defecation					0.0359	(0.0607)
Village Household density					0.271***	(0.0706)
Observations	**645**		**640**		**640**	

*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Source: Own calculation from survey data

3.5 Conclusions

In the study areas, 98% of the households had access to the so-called improved water source based on JMP classification. However, the water at both the POU (80 %) and POS (73 %) had poor microbiological quality and could not be considered potable. One of the study hypotheses is that irrigation water plays an important role in transmitting microbial contamination to domestic drinking water through human and animal interaction with irrigation water. The study results show that the drinking water at storage was potable only among (no *E.coli.*) 16%, 14% and 28% households in wastewater, surface canal water and tube well-irrigated communities' respectively. The tube well irrigators had significantly better water quality in comparison to canal water irrigators both in portability (11 % less likely to have non-potable drinking water) and decrease in the level of the log of *E.coli.* content, with robust result across different models. The wastewater irrigating households had no significant effect in terms of potable drinking water (logit regression results); however, we still see a significant change with a decrease in the levels of the natural log of *E. coli.* in comparison to canal irrigators. The probable explanation for poor drinking water quality among canal irrigating households in comparision to wastewater irrigating households could be that there are a large number of households having non-potable drinking water in both canal (86%) and wastewater (84%) irrigating households. Besides chlorination efforts which were more prevalent in the wastewater community could decrease the quantum of *E.coli.* in contaminated non-potable storage drinking water. Though we observed that the chlorination of water was more prevalent in wastewater areas, none of the communities had a consistent and a regular pattern of chlorination. Besides daily chlorination data was not available or even when available it was not transparent as the bore operator would paint a good image of themselves saying they performed the chlorination of water.

Due to not very concrete data available on chlorination and multicollinearity issues we could not include the chlorination variable in the analysis. The other probable explanation to poor water quality among surface canal water irrigators in comparison to wastewater areas as per our observation of the study areas was the presence of more open drainage areas in many surface water irrigated communities. In the bivariate analysis, we see the effect of drainage

and garbage collection in the community, but due to collinearity issues, the community variables were dropped from the model.

Animals usually carry high levels of fecal coliform bacteria (Rajasooriyar et al., 2013), which may affect household water quality. In our study, however, we found that livestock ownership did not have any impact on household water quality.

The study observed that the households with poor hygiene score were worse off (35% increase) than those with good hygiene score in terms of the level of *E.coli.* in household drinking water quality. In comparison to hygiene score, we see that the soap water use had an opposite effect in the multivariate logit model only. However, the effect is not consistent and also statistically not significant in other models. Hence we conclude that soap use, a self-reported behavior did not have a consistent effect in the study and could be a reporting bias by a household member. Besides hygiene score was a stronger variable based on observation on five hygiene components observed by an enumerator while the soap water use was a self-reported behavior.

The households using RO water treatment had better drinking water quality, and the effect is consistent across models and after controlling for other hygiene, behavioral and community variables (71% decrease in *E.coli*. and 15 % less likely to have non-potable drinking water). Other methods of water treatment are rarely done properly. For example, although almost 90% of the households reported using the straining method of filtration (water is poured through sieve/cloth which removes some suspended solids and pathogens) to treat their water before storage, many were observed to have used old dirty strainers. After straining, water may not be perfectly safe for drinking, but it can be a drinking water improvement step for people with no other treatment options. However, it is very important to use a clean strainer, as dirty strainer may introduce additional pollutants into the water. Larger size storage containers were associated with higher microbiological contamination. As the size of the water storage container increases the water quality deteriorates with significant effect across all models however the effect size is very small (5% increase in the log of E coli). The probable reason for higher contamination in larger size container could be the tendency to refill the container without emptying and cleaning the larger containers in comparisons to a smaller container.

Having an improved toilet did not have any significant impact on household drinking water quality but lowers the open defecation prevalence in a community, which improved household drinking water quality. The results showed that areas with open defecation (greater than 25%) had poor microbiological water quality (76% increases in the log of *E.coli.*) however open defecation did not had a significant effect in increasing the portability of drinking water quality (logit model). A study by (Spears, 2013) revealed that children (about 2.5%) in rich households in India who all live in urban areas and have access to improved toilets, were on an average shorter than the healthy norm. Open defecation is therefore considered a "public bad," meaning that it has spillover effect even on those who use improved toilets.

The study found that high village household density had a significantly negative impact on domestic water quality (1.5 times increase in the log of *E.coli.*). Other community variables such as the type of drainage systems, drainage coverage in community, household density, and garbage collection service played an important role in determining domestic drinking water quality as seen in bivariate analysis, though all the community variables could not enter the regression analysis due to collinearity issues. Since all the community variables have a synergetic effect, a holistic approach should be applied when considering community interventions.

The study found that the households located closer to an area with open drains were more likely to have poorer water quality, although the estimated effects were very small. Studies conducted in the past have also shown that in a rural setting, the proximity of latrines to a groundwater body is negatively related to the microbiological quality of the groundwater (Megha et al., 2015). The present study showed that the distance from a household to their main water supply tank is positively correlated to the household's drinking water quality (Table 3.6). Drinking water may be contaminated in distribution systems because of breaches in the integrity of the pipework and storage reservoirs (Sur et al., 2006).

One of the ways a household benefit from improved water supply coverage is that it reduces the distance they have to travel for cleaning and washing. Improved water supply availability also increases the household's washing and cleaning activities, which improves the overall household hygiene but it also generates a larger amount of sewage. Because the rural

and peri-urban areas of India have poor drainage infrastructure, sewage drains into the open or *kutcha* drainage systems. Eventually, the sewage may make its way into a village pond and turn the pond into a breeding ground for mosquitoes. Also, domestic sewage released into such open *Kutcha* drainage systems gets further contaminated by human and animal feces. The sewage in an open Kucha drainage system then could contaminate household drinking water through children who played around open drains coming into contact with drinking water, or even through sewage seeping into water pipelines through cracks. We see the effect of community drainage variables in the simple bivariate analysis, though these variables were dropped from the regression model due to collinearity issues. We still would emphasize that policy recommendations should require a holistic approach also keeping in consideration the community variables as drainage systems.

3.6 Strengths and Limitations

Since ninety percent of the water is utilized for irrigation purposes, it plays an important role in the hydrological cycle, hence affecting the drinking water quality. One of the strengths of our study is the inclusion of the effect of irrigation water type as an explanatory variable for drinking water quality. Also, our study had a more holistic approach including individual as well as community characteristics that can affect or confound the outcome variable in the study. Besides this, our study used the WHO recommended 'Most Probable Number' (MPN) technique to test the *E.coli.* in household drinking water performed in a laboratory setting.

The main limitation of this study is that it is difficult to establish causality using the empirical approach without a longitudinal data set to test the causal relationships. Endogeneity can arise when there are unobserved covariates within the model that determine the treatment variable (the use of wastewater for irrigation), the WATSAN and hygiene characteristics, and the outcome variable (drinking water quality). In particular, the use of wastewater for irrigation may be an endogenous regressor because of two factors: First, unobservable household heterogeneity may have driven both the treatment (the type of irrigation water) and outcome (drinking water quality) variables. Second, some omitted variables that could not be captured in our data, such as cultural beliefs, historical reasons or migration, may be

correlated with the outcome and explanatory variables as sanitation infrastructure and irrigation water use.

However, we noted that farmers who settled down along the downstream river had inherited their land generations ago and the downstream river water was not highly contaminated by wastewater in the past. Therefore, there was no self-selection bias. For example, poor farmers did not choose to farm in areas using wastewater for irrigation. Farmers did not select the type of water they use for irrigation, but rather it was determined by the location of the farm they inherited from their ancestors. Also, migration hardly takes place among these farmers due to cultural reasons and finding land elsewhere is very difficult. Leaving an area polluted by wastewater is therefore not a matter of choice that is driven by unobserved characteristics. Further, the survey areas were all within 15-20 km of the city and well connected through major highways, and thus the areas are equally served in terms of monitoring, treatment and maintenance of water reservoirs and other government WATSAN interventions. Despite this, farmers using wastewater for irrigation were still poorer than those using tube well water for irrigation. However, they were not poorer than those using surface water for irrigation. Our arguments above nonetheless suggest that poverty did not drive a farmer's choice of location but is rather a consequence of it, and it has impacts on water quality.

4 IMPACT OF DIFFERENT IRRIGATION SYSTEMS AND WATSAN ON CHILD HEALTH AND NUTRITION OUTCOMES IN PERI-URBAN AREAS OF GUJARAT, INDIA

4.1 Background

India has traditionally been an agrarian economy with 70% of the rural households depending on agriculture as a primary source of livelihood. Agriculture consumes around 90% of the overall water withdrawal and the increasing demand of water resources by India's growing population has led to a situation where the consumption of water is rapidly increasing while the supply of fresh water remains constant with groundwater tables in most cities falling at an alarming rate. The increased sewage production from the growing urban population beyond the capacity of the sewage treatment plants has led to untreated sewage left into the water bodies and utilized for irrigation in the urban and peri-urban agriculture. Wastewater has now become an important resource for agriculture which also generates economic benefits to farmers. However, the contaminants present in wastewater pose environmental and health risks. In a country where water is an important determinant factor for livelihoods different types of water use (i.e., surface water, groundwater, wastewater) in irrigated agriculture yield complex interactions which together with poor hygiene due to knowledge gaps could lead to poor health outcomes.

4.1.1 WATSAN, agriculture, and health linkages

Agriculture and health are linked in many ways. First agriculture is essential for good health and nutrition. Agricultural products are not only sources of energy and nutrients, but also sources of fuel and medicine. It is also a source of livelihood for much of the world's population, especially those living in rural areas. At the same time, agriculture can be linked to poor health and nutrition. Health risks include water-borne diseases due to microbial and other pollutants from irrigation water and livestock-related diseases from exposure to zoonotic pathogens. Besides agriculture is one of the most hazardous occupations worldwide with occupational health hazards from chemicals like pesticides and herbicides, accidents and exposure to extreme weather events (Fan et al., 2012). Health, in turn also affects agriculture: people's health status influences the demand for agricultural outputs, and in agricultural

communities, poor health reduces work performance, reducing income and productivity leading to a downward spiral into poor health.

Fig 4.1 shows the various links between agriculture and health into a single broad framework. The framework comprises the core components of the agricultural supply chain viz. producers, systems, and outputs having implications on health. The key health conditions and diseases associated with agriculture being water-related diseases, undernutrition, foodborne, livestock, chronic diseases and occupational health hazards. The common processes mediating the relationships between the agricultural supply chain and the different health conditions through labor, environment, income, and access to food, water, land and health-related services (Hawkes and Ruel, 2006).

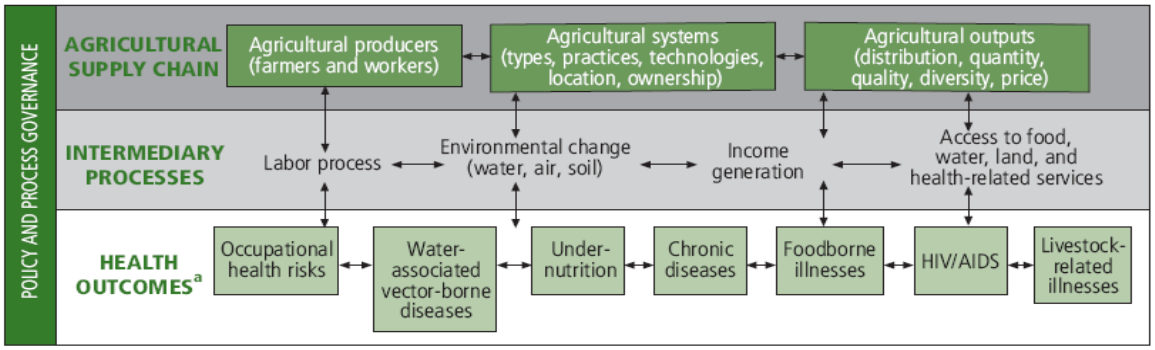

Figure 4-1: Conceptual Framework of links between agriculture and health
Source: Hawkes C, 2006

Further in the rural settings where the WATSAN infrastructure is not well developed. The household gray water generated from the village households drains into the village ponds and is used for activities like washing clothes and at times for irrigation. The on-site sanitation systems designed improperly in the rural areas contaminate the groundwater through seepage. The multi-purpose character of irrigation and drainage infrastructure creates several interlinks between agriculture, water, sanitation (AG-WATSAN), and health.

4.1.2 WATSAN systems and child health

Systemic reviews to assess the impact of inadequate water and sanitation on diarrheal disease in low and middle-income settings have shown that overall improvements in drinking water and sanitation were associated with decreased risks of diarrhea. In their study, Daniels et al. (1990) showed that under-five children residing in households with a toilet experienced 24% fewer episodes of diarrhea than those from households without a toilet. The more

positive impact was experienced in households that practiced better personal hygiene and had a higher water availability. It is further argued that handwashing becomes more frequent when water is freely available and collected with little effort (Cairncross et al., 2010). Kumar and Vollmer (2012) analyzed the national representative data (District Level Household Survey, DLHS-3) for India and found a 2.2 percentage point reduction in diarrhea among under-five children living in households with improved sanitation infrastructure. Fink et al. (2011) found that access to improved sanitation is associated with 13% lower risk of child diarrhea and 27% lower risk of mild or severe stunting. Similarly, a study conducted by Barreto et al. (2007) on the effect of city-wide sanitation program (focusing mainly on the promotion of sewerage connections and conscientious use of the system rather than domestic hygiene promotion) found a 21% reduction in diarrhea.

Other studies, however, show no impact of increasing the number of latrines in a community. For instance, studies by Root (2001), (Baker and Ensink, 2012) concluded that household members with improved sanitation were still exposed to high levels of pathogens from the fecal material if their neighbors have no improved sanitation. Similarly, intervention studies assessing the effectiveness of a rural sanitation intervention within the context of the government of India's total sanitation campaign (TSC) showed no improvement in child health in the intervention villages with latrines (Fan et al., 2012). Diarrhea rates in these TSC studies were virtually the same, so was the prevalence of parasitic worms and child malnutrition (Clasen et al., 2014, Patil et al., 2014). Furthermore, UNICEF (2012) report also notes that diarrhea prevalence drops substantially only if open defecation is eliminated.

4.1.3 Childhood diarrhea, malnourishment -- public health problem

Each year, an estimated 2.5 billion cases of diarrhea occur among children under-five years of age. Poor water quality, sanitation, and hygiene account for 1.7 million deaths worldwide yearly (3.1% of all deaths and 3.7% of all DALY's), mainly through infectious diarrhea. Nine out of 10 such deaths are in children, and virtually all of the deaths are in developing countries(Ashbolt et al., 2001). Diarrhea is the second most common cause of child deaths worldwide with more than 80 percent of child deaths occurring in Africa and South Asia. India ranks top among the 15 countries with three-quarters of the child deaths are due to diarrhea which accounts for a total number of 386,600 annual child deaths (WHO, 2009c). And unsafe

water and poor sanitation results in over 140,000 child deaths from diarrhea every year in India (WaterAid America, 2016).

Repeated enteric infections, usually but not always are linked to attacks of diarrhea and can lead to malnutrition, with long-term adverse effects on development, and can negatively affect all aspects of a child's development: health, nutrition, cognitive development, learning, educational access and achievement (WHO 2002a, Guerrant et al., 2008). Parasitic worm infections is a widespread health issue with over 220 million children in India in need of deworming (WHO, 2014). Up to 10% of the population of the developing world is infected with intestinal worms –a large percentage of which is caused by Ascaris; and worldwide severe Ascaris infections cause approximately 60,000 deaths per year, mainly in children (Kindhauser, 2003). Intestinal worms are largely a disease of people exposed to untreated wastewater or food grown on it. The 85,000 hectares in the Mezquital Valley of central Mexico is one of the classic examples where raw sewage is used to irrigate food crops and causes significant diarrhea and Ascariasis(Cifuentes et al., 1993). The WHO estimates that 50 percent of malnutrition is associated with repeated diarrhea or intestinal worm infections from unsafe water or poor sanitation or hygiene (WHO, 2008).

In India, 48% (62 million children) across all income groups are stunted. The high rate of stunting is surprising given its economic growth, especially in contrast to sub-Saharan Africa where GDP is much lower. And in Gujarat, 52% under-five children are stunted, higher than the country rate (IIPS, 2007). Gujarat's economy has been outperforming the rest of the country with rapid industrial growth and a significant boom in the agricultural growth of 9.6% per year over the past decade – which is faster of the national growth rate of three percent yearly (Shah et al., 2009). Despite the growing economy, the state has not experienced reductions in malnutrition.

Inadequate dietary intake alone does not explain the global burden of stunting, and dietary interventions have not been able to normalize growth (Dewey and Adu-Afarwuah, 2008). In a study by Checkley et al. (2008) found that diarrheal diseases caused by poor sanitation accounted for 25 percent of stunting in children up to 24 months. Diarrhea prevents children from achieving the normal growth, while malnutrition increases the frequency and the duration of diarrheic events, thereby creating a vicious cycle (Preidis et al., 2011). Malnutrition a multidimensional problem requires multi-sectoral interventions from

improving agriculture, health, water, sanitation and household infrastructure to improving care and feeding practices (Gulati et al., 2012).

The current chapter explores the impact of irrigation agriculture, WATSAN infrastructure, and hygiene and sanitation behavior on child health outcomes. The hypothesis is that the communities exposed to different types of water systems for irrigation agriculture are affected differently by the health and nutritional status due to the interaction of irrigation water with sanitation and hygiene. The hygiene and sanitation behavior of the community and their use of information regarding linkages between WATSAN to irrigation would improve household water quality and health outcomes and eventually identify better strategies for linking water uses for 'WATSAN' and irrigation agriculture activities to improve health and nutrition status. We use a more holistic approach including individual as well as community characteristics that can affect or confound the outcome variable. This thesis chapter attempts to identify the linkages between WATSAN and agriculture activities examining the effects of irrigation agriculture on health and nutrition outcomes considering context-specific constraints.

4.2 Theoretical Framework:

We use the household production functions and demand considerations, to link WATSAN, irrigation, and hygiene behavior to identify their impact on health outcomes.

I) Household Production Functions

The proximate determinants of an individual's health usually are decisions made by the individual or the household in which he or she lives- given the assets, cost, time and community endowments. Therefore, the starting point in the determination of individual health should start at the household level.

In a static household production model (Becker, 1965) the households are assumed to maximize their household utility function subject to a budget and a time constraint. According to the theory, households allocate resources to purchase different goods and combine them with time into a household production system to produce various commodities and services. These purchased goods and produced commodities directly enter into the household's utility function.

Consider a one-period household production model with constrained maximization of a joint utility function. Extending the exposition set out in(Behrman and Deolalikar, 1988), the household preferences are represented by the utility function below in equation (WHO. 2014):

$$\boldsymbol{U = U\left(H^{i}, C^{i}_{j,} C^{p}, T^{i}_{l}\right)} \quad \text{(WHO. 2014)}$$

where:

$\boldsymbol{H^{i}}$=Health of Household member i,

$\boldsymbol{C^{i}_{j,}}$=Consumption of *j* different commodities by household member i

$\boldsymbol{C^{p}}$=Consumption of pure public goods

$\boldsymbol{T^{i}_{l}}$= leisure time of household member i

The utility is presumed to depend on the health of each of the household individuals, consumption of pure public and private goods and leisure. The household preference function is maximized to constraints. The first constraint is a health production function. The health of the ith individual is produced by the nutritional intake of the individual, consumption of public and private goods, leisure, the education level of that individual and the principal caregiver of the household, innate health endowment and specific individual characteristics as awareness and health-seeking behavior, and a vector of community characteristics that affect individual's health (access to health-care facility, infrastructure and prices, water and sanitation situation in the area). Therefore the health production function is:

$$\boldsymbol{H^{i} = H\left(N^{i}, C^{i}_{j,} C^{p}, T^{i}_{l}, E^{i}, E^{m}, E_{h}, T_{h}, C_{hc}, W, S, hx, D, K^{i}, \eta^{i}, \Omega\right)}$$

Where:

$\boldsymbol{N^{i}}$= Nutrient intake of the ith individual

$\boldsymbol{E^{i}}$=Education of the ith individual

$\boldsymbol{E^{m}}$=Education of principal caregiver of household

$\boldsymbol{E_{h}}$= Knowledge of good health practices (such as water treatment, washing hands with soap at critical times)

$\boldsymbol{T_{h}}$=Time spent by the household on production of health (taking care of ill family members)

$\boldsymbol{C_{hc}}$=Health- care services from clinic (such as medical treatment and transportation costs)

W= Water quality and infrastructure of household

S=Sanitary infrastructure of household

$\boldsymbol{hx}$**=**Hygiene characteristics of the household

D=Vector of agricultural characteristics (irrigation water used, proximity to the field, hired laborer, self-protection in the field)

$\boldsymbol{K^i}$**=**Child i characteristics as gender, birth weight, order, immunization

$\boldsymbol{\eta^i}$**=**Innate health endowment of the household member i

Ω**=**Vector of community characteristics that include variables that affect an individual's health (such as, access to a health clinic, infrastructure, and prices, water purification systems in place, community hygiene practices).

The second is a drinking water production function. The quality-adjusted production function of drinking water (e.g., potable vs. non-potable) depends upon the water infrastructure and quality at source, treatment process of water at source and household, the time spent by the household member collecting water and is assumed to be a function of distance to the source of water, knowledge of good practices of handwashing with soap and hygiene in the household as they relate to water collection, storage, and use, which impacts the water quality at the storage and use.

Water production function is defined below in equation (3) as:

$$\boldsymbol{W = W(Q_{w\,(W_{c,})}, Q_t, I_{w,} T_w(D_w)\text{„}hx,S,D,}\Omega,) \quad (3)$$

$\boldsymbol{Q_w}$=Quality of storage water used in the household

$\mathbf{W_c}$= Water purification/treatment at household,

$\boldsymbol{Q_t}$**=** Quality of tap water supply to the household

$\boldsymbol{I_w}$= Water Infrastructure access

$\mathbf{T_w}$= time spent by the household in collecting water and assumed to be a function of distance to the source of water (D_w)

S, D,Ω are as defined above.

The third constraint for an agricultural household is a farm production function. The household farm production (equation 4) depends on the agricultural inputs--land, irrigation systems, type of water use, time, hired labor and health of the individuals in the household and a vector of agricultural characteristics.

$$\boldsymbol{F^h = F\left(C^i, A^i, T_{f,}\ L_{k,} H^i, D\right)}$$

Where

$\boldsymbol{F^h}$ is a farm output aggregated overall crops and vegetables production of the household

$\boldsymbol{T_f}$ is the amount of time spent by the household

$\boldsymbol{L_k}$ is the hired labor in agricultural production

$\boldsymbol{A^i}$ is the aggregated capital goods (including fixed amount of land (owned/rented) at the beginning of farming season) and other inputs used in agricultural production.

Finally, there are time and full income constraints. Household's total labor time (T) available allocated to leisure, health-care activities, water collection, and agricultural farm activities given by $T = T_l^i + T_h^i + T_w^i + T_f^i$ (5)

Continuing the model description, it is assumed that households face a monetary budget constraint where income equals expenditure for consumption goods, leisure, health-care services, expenditure for water treatment, hired labor is represented by:

$$I = P_f \boldsymbol{F}^{\boldsymbol{h}} + V = \sum_{j=1}^{J} \sum_{i} P_j C_j^i + \sum_{i} \omega T_l^i + P_{hc} C_{hc} + P_p C^p + P_w W + \omega L_h \quad (6)$$

Where ω is market wage rate; V is non-labor income; I is total household income, and Ps are prices for respective items. Maximizing equation (WHO. 2014) subject to the (WHO. 2014), (3), (WHO. 2014), (5) and (6) constraints yields the following reduced-form demand function for all choice variables in which all exogenous variables appear on the right-hand side of each equation. Therefore, the reduced-form demand functions are given as:

$$Z = f(X) \quad (7)$$

Where ***Z*** is a vector of dependent variables $H^i, W, S, \boldsymbol{F^h}$ and ***X*** is a vector of predetermined variables $(E^i, E^m, E_h, E_w, A_f, I, P_y, P_a, P_{hc}, P_p, P_{cj}, Q_w, D_w, \theta, D, \eta^i, \Omega)$

4.3 Econometric model specification and estimation:

This section outlines the empirical strategy we use to explain the impact of different irrigation water systems, water quality, hygiene, sanitation and behavior on child health outcomes viz. a) Longitudinal prevalence of diarrhea, b) Malnutrition and c) Parasitic Prevalence.

The outcome variable on diarrhea is a longitudinal prevalence of diarrhea among under-five children. Longitudinal prevalence of diarrhea (LPD) is a more appropriate way to measure public health impact(Schmidt et al., 2011). LPD more strongly predicts long-term health outcome (Morris et al., 1996). It is an individual measure of the proportion of time an individual has diarrhea and can be calculated as the number of diarrheal episodes among under-five children divided by the total time period of the year studied, using the following formula (Morris et al., 1996):

LPD=Number of person-year with diarrhea /Number of person-year under observation

Poisson regression analysis for count data is applied for the outcome the longitudinal prevalence of diarrhea (Cameron and Trivedi, 2013, Danjuma and Emmanuel, 2017, Lamberti et al., 2012). Poisson distribution models the probability of y events with the parameter μ interpreted as the risk of a new occurrence of the event during a specified exposure period, t, given by the formula below:

$$Pr(Y = y \mid \mu, t) = \frac{e^{-\mu t}\ \mu t^{y}}{y!} (y = 0,1,2...)$$

In a Poisson regression model, we suppose that the Poisson incidence rate μ is determined by a set of *k* regressor variables (the *X'*s). The expression relating these quantities is

μ= *t* exp (β1*X* 1 + β2 *X* 2 + …. + β*k* *Xk*)

Note that often, *X*1 ≡ 1 and β1 is called the *intercept*. The regression coefficients β1, β2,…,β*k* are unknown parameters that are estimated from a set of data. Their estimates are labeled *b*1,*b*2,…,*bk*. Using the notation, the fundamental Poisson regression model for an observation is written as:

$$Pr(Y_i = y_i \mid \mu_i, t_i) = \frac{e^{-\mu_i t_i}\ \mu_i t_i^{\ y_i}}{y_i!}$$

Where

$$= t_i exp(\beta_{1i} X_{1i} + \beta_2 X_{2i} + ... + \beta_k X_{ki})$$

The rate at which events occur is called the incidence rate, the number of diarrheal events per time period specified in the study. Incidence rate ratio calculated in the Poisson

regression model is a ratio based on the rate or incidence of diarrheal counts having some characteristic or property out of a group consisting of the population of subjects or items from which the counts are a part. While running the Poisson regression model, we specified the IRR option to transform the estimated coefficients into incidence-rate ratios. The analysis was done using Stata 14 software.

The outcomes malnutrition and parasitic prevalence are modeled using the binomial probit model approach. A binomial variable with a value of 1 or 0 based on presence or absence of parasites in the stool is the outcome variable for parasitic prevalence. For the outcome on malnutrition the age and sex-specific z-scores were calculated and categorized into low weight-for-age, low height-for-age and low weight-for-height if the z-score value cut-off of less than -2 SD based on the WHO Global Database on Child Growth and Malnutrition (WHO, 1983).

Probit regression model equation defined below is:

$$Q_{hi} = \alpha_1 X_{hc} + \alpha_2 Z_i + \gamma I_h + \varepsilon_i$$

where the observed variable *Q* is the outcome binomial variable for child I in household h, *X* is a vector of household and community level control variables, Z_i is the child level characteristics, I_h is a categorical treatment variable viz. irrigation water type for a household, α_i is a vector of parameters to be estimated, γ is the parameter of interest associated with the categorical treatment variable, ε_i is a residual term with mean zero and standard deviation of 1.

4.4 Identification Strategy

The use of wastewater for irrigation could be an endogenous regressor because unobservable household heterogeneity may have driven both the treatment (the type of irrigation water) and outcome (child health) variables. Establishing the causal impact of wastewater irrigation on child health outcomes based on cross-sectional data is difficult as it requires a careful investigation of the treatment variable to address the possible endogeneity problem. For instance, endogeneity can arise where there is an unobserved covariate that determines wastewater irrigation water type and health outcomes. In this analysis, irrigation water type is the treatment variable. Moreover, the wastewater irrigation may be an endogenous regressor due to unobservable household's member heterogeneity (variables which cannot be captured in our data) driving both wastewater irrigation water type and health outcomes, omitted

variables correlated with both wastewater irrigation water type and health or measurement errors.

To deal with the probable endogeneity of wastewater irrigation, we used the instrumental variable approach in both the IV poison as well as the IV probit models. We propose two variables as instruments for the treatment variable[5]. The first instrument is the distance to the main city where the farmers travel to sell their vegetables. Although all the survey areas were within good connectivity through major highways the actual distance to travel to the city to sell vegetables was comparatively higher among the wastewater areas. However, the land is inherited from ancestors and migration is not a possibility for the farmers, the wastewater area is an endogenous explanatory variable in our model. The instrument actual distance to the city influences being in wastewater areas but will not influence outcome variable diarrhea and therefore is exogenous. Regarding health care access, all areas including the wastewater areas had similar access to health care with public and private healthcare in almost all areas. Another instrument we considered is land area because per hectare land owned by households in wastewater area was less in comparison to freshwater areas and the land area owned will not affect the outcome variable diarrhea.

Dependent Variables: The dependent variables in the study are longitudinal prevalence of diarrhea, malnutrition and parasitic prevalence

Explanatory Variables: The explanatory variables chapter include; Irrigation water systems, agricultural characteristics, hygiene behavior and WATSAN infrastructure (Table 4.1). The study hypothesizes that the communities exposed to different types of irrigation water systems are affected differently by the health and nutritional status; and the hygiene and sanitation behavior of the community and their use of information regarding linkages

[5] Two instrument variable(IV) stratergy was used for the endogenouse regressor to define the outcome on diarrhoea. Woodridge states that 2 IVs are acceptable, although we can never directly test the hypothesis that the instruments are uncorrelated with the error process u; we can derive indirect evidence on the suitability of the instruments if we have an excess of instruments: that is, if the equation is overidentified, so that we are using 2SLS. The ivregress residuals may be regressed on all exogenous variables (included exogenous variables plus instruments). Under the null hypothesis that all IV's are uncorrelated with u; a Lagrange multiplier statistic of the nR^2 form will not exceed the critical point on X^2 (r) distribution, where r is the number of overidentifying restrictions (i.e. the number of excess instruments). If we reject this hypothesis, then we cast doubt on the suitability of the instruments; at least some of them do not appear to be satisfying the condition of orthogonality with the error process. This is done by using the estat overid command in Stata.

between WATSAN to irrigation reduces any effects on health outcomes arising from specific types of water use in irrigation.

Using irrigation water in agriculture determines household health through interactions with household water, hygiene, and sanitation. Having livestock may increase the risk of childhood diarrhea due to human-animal interaction and exposure to animal excreta. In the study sample, almost 77% of the households own at least one livestock. The livestock kept around the home or away which could affect household contamination through the degree of exposure. Further, the farm laborers have a higher degree of exposure to irrigation water contamination then the households who have hired laborers.

Poor hygiene and sanitation practices increase the risk of childhood diarrhea. The child hand washing (a self-reported answer by child's caretaker) was categorized into hands washed four or more times vs. two or three times. The child hand washing reported at least four times serves as a proxy of the importance of handwashing behavior by the caretaker of the child. To compute a household hygiene score we applied a subjective method (conducting spot checks), following (Webb et al., 2006). The hygiene score computed in this study comprised of five components: environment, sanitation, water, food and personal hygiene. The key components of the environment component include visible fecal contamination, waste piles, flies, roaming animals and stagnant water in the domestic and visible peri-domestic surroundings of a household. The sanitation component primarily considers the availability of toilet facilities, the cleanliness of toilet facilities and the availability of handwashing facilities near to or at the toilet. The water component considers water availability, cleanliness of a household's water source and water storage. The food component assesses the adequacy of food storage in a household. The personal hygiene component covers the visible cleanliness of hands and nails of a household's female head, who also answered the WATSAN module of the questionnaire. The enumerators were provided with a checklist to identify the options based on their observation. Based on the observations from the checklist, a score from one to three was generated for each of the households for every category (environment, sanitation, water, food and personal hygiene). For the final analysis, the household hygiene score was categorized into poor, average and good.

Control variables: Based on existing empirical literature, household socio-economic status, household and child characteristics and community characteristics were included in the analysis to control for observed difference among households.

Studies by Braind *et al.* 2010 and Larson *et al.* 2006, show that socioeconomic factors such as wealth and education influence the types of drinking water sources used by households. In the study, households were divided into five wealth quintiles using factor analysis as employed in the DHS. Asset variables were taken into consideration when computing household wealth quintile, but improved WATSAN infrastructure was not considered to avoid collinearity problems with the WATSAN infrastructure variable used as explanatory variable in the regression model. As the level of education for the household head was either illiterate or primary education with a few having a secondary or tertiary level of education, we categorized the level of education for the household head as illiterate and literate.

Household toilet an infrastructure variable was categorized into an improved versus unimproved toilet as defined by the Joint Monitoring Program (JMP). Our study used the multiple tube fermentation method 'Most Probable Number (MPN) technique, a WHO-recommended technique, to identify thermotolerant fecal coliforms and *E.coli.* in water in the laboratory (WHO, 1993). WHO classifies drinking water into five risk categories for diarrhea according to the *E.coli.* count per 100 ml of water sample: i) 0 (in conformity with WHO guidelines),ii) 1-10 (low risk), iii) 10-100 (intermediate risk), iV) 100-1000 (high risk), v) >1000 (very high risk) (WHO, 1997). Since very high category had very few observations, it was grouped into the 100-1000 category in the analysis.

Community characteristics included open defecation and village household density calculated as the number of households per hectare of land. Open defecation stats in the study area were calculated based on Census 2011 village level data, our sample data as well as the information given by the village head. None of the communities in the survey areas was completely free from open defecation. Moreover, the minimum open defecation prevalence was 25% across the different study areas, a rate which applied to 33% of the survey data. We applied a data-driven observatory approach when defining the open-defecation variable; using a value of 25% as a benchmark to compute a binary variable with more than or less than 25% open defecation in the community.

Child characteristics included in the study are gender, sibling diarrhea and stunting (based on height for age scores). Stunting is an indicator of long-term malnutrition. Diarrhea prevents children from achieving normal growth, while malnutrition increases the frequency and the duration of diarrheic events, thereby creating a vicious cycle. Moreover, children exposed to fecal coliforms suffer from intestinal infections and chronic infections leads to chronic inflammation of the gastrointestinal tract which further prevents absorption of calories and nutrients leading to malnutrition. Studies conducted have revealed that environmental contamination, mediated through environmental enteropathy, is a cause of growth faltering in under-five children in contaminated settings (Lin et al., 2013, Ngure et al., 2014).

Table 4-1: Description of the variables used in the analysis

Variable	Category	N	(%)
Agricultural Characteristics			
Irrigation Water	Surface-Canal	167	25%
	Tube well/Rain	112	16%
	Wastewater	337	50%
	No Farm involvement	45	6%
Livestock	Around Home	125	18%
	Away	122	18%
	Separate Animal Home	261	39%
	No Animals	153	23%
Farm Labourer	No	464	70%
	Yes	197	29%
Household Characteristics			
Wealth Quintile	Poorest	144	21%
	Second	137	20%
	Third	152	22%
	Fourth	135	20%
	Wealthiest	93	14%
Caste	No	623	94%
	Yes	38	5%
Education head of household	Illiterate	285	43%
	Educated P, S or T	375	56%
Improved Toilet	No	428	64%
	Yes	233	35%
Storage water E coli	0 *E.coli*.	107	16%
	1-10 *E.coli*.	181	28%
	11-100 *E.coli*.	257	39%
	101-1000 *E.coli*.	99	15%
Behavior Characteristics			
Hygiene Score	Poor	233	35%
	Average	214	32%
	Good	211	32%
Child Hand Washed	Twice/Thrice	329	50%
	Four/More than Four	317	49%
Community Characteristics			
Open Defecation	<=25%	211	31%
	>25%	450	68%
Private Doctor in Village	No	505	76%
	YES	156	23%
Child Characteristics			
Gender	Male	333	51%
	Female	309	48%
Sibling Diarrhea	No	228	34%
	Yes	433	65%
Height for age	Normal	253	38%
	Stunted	278	42%
	Not Done	130	19%
Total		661	

Source: Own calculation from survey data

4.5 Results

The child health outcomes analyzed in the study include the longitudinal prevalence of diarrhea, malnutrition, and parasitic prevalence among under-five children.

4.5.1 Longitudinal Prevalence of Diarrhea

Overall the mean longitudinal prevalence of diarrhea per person-years is 1.6. Other studies conducted on diarrheal diseases in India have shown that the incidence of diarrheal diseases was as low as 1 episode/child/year (Ramakrishnan et al., 2011) to 2.7 episodes/child/year (Bern C., 2004). The bivariate results as shown in Table 4.2 observes that the households who use wastewater in irrigation, their under-five children had a higher mean LPD of 2 as compared to tube well and surface water irrigators. The unadjusted incidence risk ratios calculated in the Poisson model showed that the under-five children of households using wastewater in irrigation have a statistically significant incidence risk ratio of diarrhea 1.65 times (65% higher, $p<0.01$) as compared to children of households who use surface water for irrigation. The diarrheal incidence is 18% less among under-five children of households who use freshwater from tube wells in irrigation (IRR=0.820, $p<0.1$). Households having no animals or animals kept separately in the animal home had a 20% ($p<0.01$) decrease in diarrheal incidence in comparison to households where animals are kept around the home due to increased chances of eposure to contaminants. The results show that the under-five children of farm laborers had a 35% (IRR=1.35, $p<0.01$) increase in diarrheal incidence. The behavior characteristics as hygiene score and child's hand washed show a significant effect on the longitudinal prevalence of diarrhea. The households with a poor hygiene score had a higher mean LPD of 2.1 in comparison to households with good hygiene score (with a statistically significant decreased incidence risk ratio (IRR=0.578, $p<0.01$) by 42% in comparison to households with a poor hygiene score). Households reporting washing of their children hands two or three times had a higher mean LPD of 1.7 in comparison to households which reported washing hands of children four or more times(LPD=1.5) (with a statistically significant decreased incidence risk ratio (IRR=0.864) by 14%, $p<0.05$). Household characteristics as stored drinking water quality show that as the microbiological storage water quality deteriorates the longitudinal prevalence of diarrhea increases. With a higher storage water contamination with *E.coli.* (101-1000 *E.coli.*), the incidence risk ratio is high (1.348,

p<0.01). The study showed that the households with no improved toilet facility had a higher mean LPD of 1.7 in comparison to households having an improved toilet (LPD=1.4), with a statistically significant 18% less incidence risk ratio (IRR=0.816, p<0.01). Also, the under-five children residing in communities with a higher open defecation have a higher mean LPD of 1.8 as compared to LPD of 1.1 in the less prevalent open defecation community with a statistically significant higher IRR of 1.55, p<0.01 (55% higher) among communities with higher open defecation . The results are shown in table 4.2 below.

Table 4-2: Mean Longitudinal Prevalence of diarrhea (LPD) and unadjusted incidence risk ratio by explanatory variables:

Variable	Category	N	Mean LPD (*PPY*)	Unadjusted IRR	Standard Error
	Surface-Canal (25%)	167	1.2	*Reference*	
	Tube well/Rain (16%)	112	1	0.820*	(0.0973)
	Wastewater (50%)	337	2	1.649***	(0.133)
Irrigation Water	No Farminv (6%)	45	1.4	1.193	(0.171)
	Around Home (18%)	125	1.8	*Reference*	
	Away (18%)	122	1.8	1.005	(0.0948)
	Separate Animal Home (39%)	261	1.4	0.765***	(0.0647)
Livestock	No Animals (23%)	153	1.5	0.817**	(0.0767)
	No	464	1.4	*Reference*	
Labour	Yes	197	1.9	1.356***	(0.087)
	Poor (35%)	233	2.1	*Reference*	
	Average (32%)	214	1.4	0.700***	(0.0511)
Hygiene Score	Good (32%)	211	1.2	0.578***	(0.0450)
	Twice/Thrice (50%)	329	1.7	*Reference*	
Child Hand Washed	Four/More than four (49%)	317	1.5	0.864**	(0.0541)
	0 No (64%)	428	1.7	*Reference*	
Improved Toilet	1 Yes (35%)	233	1.4	0.816***	(0.0549)
	0 <=25% (31%)	211	1.1	*Reference*	
Open Defecation	1 >25% (68%)	450	1.8	1.551***	(0.114)
	0 *E.coli*. (16%)	107	1.3	*Reference*	
	1-10 *E.coli*. (28%)	181	1.5	1.089	(0.113)
	11-100 *E.coli*. (39%)	257	1.7	1.274**	(0.122)
Storage water E coli	101-1000 *E.coli*. (15%)	99	1.8	1.348***	(0.151)
	No	601	1.6	*Reference*	
Waste Disposal	Yes	60	1.2	0.723***	(0.0895)
	No collection	320	1.5	*Reference*	
Garbage collection	Garbage colleted by Town Panchayat	341	1.6	1.077	(0.0669)
	0 <.80 (70%)	463	1.7	*Reference*	
Drainage facility	1 >=.80 (29%)	198	1.2	0.696***	(0.0513)
	Closed Drainage	211	1.8	*Reference*	
Community drainage	3 Open drainage *kutcha*	450	1.2	1.482***	(0.108)
	Total (100%)	661	1.6		

*Robust standard errors in parentheses Significance level *** p<0.01, ** p<0.05, * p<0.1*
Mean LPD (PPY) is Mean Longitudinal Diarrhea Prevalence per Person-Years
Source: Own calculation from survey data

In the adjusted Poisson model (Table 4.3), initially, we ran two models to see the effects of explanatory variables. In the model 1, we included the main explanatory variables namely agricultural, hygiene and sanitation characteristics. Next, in model 2, we controlled for household (wealth, education) and child characteristics as age, gender, and stunting. The results from models 1 and 2 show consistent and significant effect of wastewater irrigation, with under-five children of farmers using wastewater in irrigation having a significantly higher incidence risk ratio of diarrhea 1.43($p<0.01$) and 1.34($p<0.05$) respectively. The model I also shows that the under-five children of farm laborers had a higher incidence risk ratio (1.24, $p<0.05$) for diarrhea as compared to children of households which mainly have hired labor in their farm. However, no significant effect is observed once controlled for household and child characteristics. The significant protective effect of hygiene score as seen in the unadjusted model was not observed in both adjusted models 1 and 2. Diarrhea-causing pathogens are transmitted via the fecal-oral route; with contaminated drinking water and hands being two important environmental transmission routes of diarrhea-causing pathogens to children. A study by Mattioli et al. (2015) has shown that children ingest a significantly greater amount of feces each day from hand-to-mouth contacts than from stored drinking water. In our study, the significant effect of water quality on diarrhea as observed in the unadjusted model was not seen in the adjusted models. While child's hands washed decreased the incidence risk of diarrhea by 15% (IRR= 0.844, $p<0.05$) in the adjusted model 1, but no effect was observed in model 2 when controlled further for household wealth, education, caste and individual characteristics. Having an improved toilet in the household showed no significant effect as seen in the unadjusted model. Open defecation (IRR=1.449, $p<0.1$) and Village household density (IRR=1.008, $p<0.05$) increases the diarrhea incidence as observed in the model I but no significant effect was observed in Model II. Among the control variables for health in model II, we observe stunted children had a higher incidence risk ratio of 1.30 ($p<0.01$).

Table 4-3: Diarrhea incidence risk ratio (adjusted) - Poisson Regression Model

		Model I		Model II	
VARIABLES	Category	Incidence Risk Ratios	Standard Error	Incidence Risk Ratios	Standard Error
Irrigation water	Tube well / Rain	1.002	-0.218	1.108	-0.224
	Wastewater	1.428***	-0.196	1.341**	-0.196
Livestock	No farm involvement	1.307	-0.336	1.302	-0.32
	Away	1.045	-0.136	0.94	-0.116
	Separate animal home	0.958	-0.122	0.899	-0.116
	No animals	1.032	-0.129	0.969	-0.121
Farm Laborer		1.241**	-0.125	1.203	-0.135
Hygiene score	Average	0.908	-0.0983	1.023	-0.114
	Good	0.985	-0.136	1.133	-0.171
Child's hands washed		0.844*	-0.0731	0.973	-0.0845
Improved Toilet		0.87	-0.0869	0.832	-0.0943
Storage water E coli	1-10 *E.coli*.	1.072	-0.151	1.172	-0.159
	11-100 *E.coli*.	1.217	-0.163	1.365**	-0.179
	101-1000 *E.coli*.	1.164	-0.178	1.261	-0.19
Waste disposal-dump area collection done		1.112	-0.185	1.027	-0.171
Open defecation		1.449*	-0.301	1.226	-0.242
Village household density		1.008**	-0.00354	1.005	-0.00385
Scheduled caste and tribe % in village				1.017***	-0.00494
Caste-general				0.803	-0.194
Education of the caregiver				1.012	-0.0931
Wealth Quintile	Second			1.016	-0.132
	Third			0.761**	-0.0992
	Fourth			1.12	-0.188
	Wealthiest			0.965	-0.221
Village Private doctor				0.74	-0.137
Age in months				1.000***	-8.38E-05
Female				0.89	-0.0715
sibling diarrhea				0.923	-0.0766
Stunted				1.305***	-0.114
Constant		0.776	-0.199	1.272	-0.417
Observations		629		612	
Wald chi2		55.25		178.9	
Prob > chi2		0		0	
Pseudo R2		0.0478		0.1109	

Source: Own calculation from survey data

Further to account for the endogeneity of wastewater irrigation, we applied an instrumental variable Poisson regression model (Table 4.4 model 3). The post-estimation test of overidentifying specification with the two instrument variables distance to city and land

area of the farm shows a chi-square value of 0.24368 (p = 0.6216) which is not statistically significant than zero hence instruments can be used, and they are valid instruments. The instrumental variable Poisson regression model results are shown in (Table 4.4 model 3). The results show that the under-five children of farmers using wastewater in irrigation have a significantly higher incidence risk ratio of 2.19 p<0.01, a two times increase in the diarrheal incidence in comparison to 30% increase in model 2 with the inclusion of all control variables. A study by Srinivasan and Reddy (2009) shows higher rates of morbidity in the wastewater irrigated villages in comparision to the control village. Having an improved toilet in the household decreased the diarrhea rates by 22 % (IRR= 0.769, p<0.05). Studies conducted by Kumar and Vollmer (2012) and Fink et al. (2011) in India have also found that in households with improved sanitation infrastructure there is a decrease in diarrhea by 2.2% and 13% respectively. While open defecation had no significant effect on diarrhea, the village household density increases the diarrhea incidence by a marginal effect of (IRR=1.008, p< 0.1). A study by Gasana et al. (2002) has also found that the population density significantly contributes to childhood diarrheal morbidity. Stunted children had an increased diarrheal incidence by (IRR=1.23, p<0.05)[6]. The effect of being a farm laborer or having livestock which was significant in the unadjusted model showed no significant effect in the instrumental variable Poisson regression model (Table 4.4 model 3). Socioeconomic factors including wealth status were important control variables in the adjusted models, the wealth status of households had no significant effect on diarrhea.

A robustness check using endogenous switch Poisson regression model with instrument variables was run to double check the validity of instruments and regression results. The endogenous switch Poisson regression model uses endogenous switching for the count data on longitudinal prevalence by maximum likelihood using adaptive quadrature. It is a multilevel generalized linear model with two sub models. The first level, the switching model, is a probit model that specified the endogenous switching variable and predicted the likelihood of being in the wastewater area. The switch variable was then introduced as a dichotomous covariate in the second level analysis. The second level, the outcome model is a Poisson model used to estimate the effect of wastewater area irrigation to the outcome variable. Being in the wastewater area is an endogenous predictor with σ being positive and

[6] The effects of stunting and diarrhea may be biased because of reverse causality

significantly different from zero (σ =.5746, p-value=0.000). The switching model reports the likelihood ratio test to determine if rho=0. The rho in our model was not zero and the likelihood ratio statistics 57.02, p value=0.000). Hence the adequacy of the endogenous switching specification is supported by the rejection of the null hypothesis ρ = 0. The results of the Endogenous switch regression model were similar to the instrumental variable Poisson model. The results are mentioned in the appendix (Table 4.4 model 4). Wastewater irrigation, improved toilet, village household density and being stunted had a significant effect across both models while the effect of water quality was not significant.

Table 4-4: Diarrheal incidence risk ratio- Instrumental Variable Poisson Regression Model

Wastewater area: First Stage Regression (Poisson)

Wastewater area	1	2
Distance to the city	2.445*** (.171775)	1.964*** (.308)
Land Area	.0131** (.005)	.0223** (.006)
Observation	661	612
Stage 2 controls	No	Yes
Model Wald Chi2	226.83	35306
Model p- value	0.0000	0.0000

		Model 3		Model 4	
VARIABLES	CATEGORY	Incidence Risk Ratios	Standard Error	Incidence Risk Ratios	Standard Error
	Tube well / Rain	1.272	(0.274)	1.000	(0.191)
Irrigation water	Wastewater	2.185***	(0.526)	1.785***	(0.335)
	No farm involvement	1.288	(0.303)	1.067	(0.241)
	Away	1.033	(0.169)	0.974	(0.130)
Livestock	Separate animal home	0.989	(0.168)	0.947	(0.124)
	No animals	1.018	(0.186)	1.020	(0.150)
Farm Laborer		1.176	(0.149)	1.184	(0.130)
Hygiene score	Average	1.128	(0.176)	1.101	(0.141)
	Good	1.434*	(0.304)	1.246	(0.211)
Child's hands washed		1.002	(0.107)	0.989	(0.0884)
Improved Toilet		0.769**	(0.0980)	0.792**	(0.0858)
	1-10 *E.coli*.	1.112	(0.183)	1.208	(0.170)
Storage water E coli	11-100 *E.coli*.	1.364**	(0.215)	1.417***	(0.190)
	101-1000 *E.coli*.	1.250	(0.226)	1.331*	(0.215)
Waste disposal-dump area collection done		1.134	(0.250)	1.080	(0.198)
Open defecation		1.210	(0.348)	1.131	(0.224)
Village household density		1.009*	(0.00535)	1.008**	(0.00401)
Scheduled caste and tribe % in village		1.017***	(0.00608)	1.015***	(0.00539)
Caste-general		0.671	(0.172)	0.780	(0.195)
Education of the caregiver		0.999	(0.121)	1.025	(0.0975)
	Second	1.006	(0.152)	1.015	(0.134)
Wealth Quintile	Third	0.692**	(0.107)	0.760**	(0.105)
	Fourth	1.037	(0.186)	1.118	(0.170)
	Wealthiest	0.939	(0.254)	0.967	(0.209)
Village Private doctor		0.761	(0.185)	0.795	(0.139)
Age in months		0.999***	(0.000100)	0.999***	(8.46e-05)
Female		0.887	(0.0866)	0.896	(0.0756)
sibling diarrhea		0.866	(0.0888)	0.909	(0.0836)
Stunted		1.233**	(0.127)	1.301***	(0.120)
Constant		0.978	(0.459)	0.870	(0.310)
Observations		612		661	
Hansen's J chi2		0.24368			
p-value		0.6216			
Likelihood ratio test for rho=0: chi2(1)				57.61	
Prob > chi2				0	
Model Wald chi2(32)				539.63	
Prob > chi2				0	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: Own calculation from survey data

In the previous multivariate models ran we did not include all the community variables such as garbage collection, drainage system variables due to collinearity problems. because the drainage system variables and open defecation are synergetic with communities having higher open defecation also had poor drainage systems. In the bivariate analysis, we see that communities with poor drainage facilities had a significantly higher incidence of diarrhea and policy implications for proper drainage systems and garbage collection are equally important along with improving open defecation situation in the community. Therefore, in the secondary analysis shown in the appendix (Table A-3 model 5), we ran the instrumental variable Poisson regression with the inclusion of all community variables. However, we do not see any significant effect of added community variables in the model. We also applied the instrumental variable Poisson regression with the village level fixed effect to account for the village level fixed effects however the model was misspecified with very low values of Hansen's J chi-square statistic. The reason for the village level fixed effect model to be misspecified could be that in most villages there is a segregation of richer and poor income groups into different areas, the richer groups being educated tend to make private arrangements for garbage collection in their area and have better cleanliness and drainage facilities while among the poor income groups there is absence of sanitation services. And depending on the village size this stratification ranged from five to eight or nine areas based on our observation in the survey villages.

4.5.2 Malnutrition

The z scores for the commonly used nutrition indicators weight-for-age (underweight), height-for-age(stunting), and weight-for-height(wasting) were calculated based on the WHO child growth standards using stata igrowup_package(WHO, 2009a). Age and sex-specific z scores of less than -2 standard deviation were followed to define the underweight, stunting and wasting. The study results showed that 42 percent of the under-five children were undernourished, 52 percent were stunted, and 22 percent wasted. The study results were similar to the National Family Health survey round 3 (NFHS-3) conducted in 2005-2006, with 41% undernourished, 49% stunted and 20% wasted under 3 children in Gujarat (IIPS, 2007). While the 2015 global nutrition report, depicting the Nutrition Country Profile of India showed a drop in stunting to 39% from 48% in 2014 (IFPRI, 2015).

The multivariate regression results showed that stunting a preferred indicator of chronic malnutrition was affected by the household improved toilet (29%) and open defecation (40%) in the community. Also, a higher longitudinal prevalence of diarrhea resulted in increased stunting by a marginal effect of 8%.

Below we describe in detail the predictors of stunting and wasting in the adjusted as well as unadjusted probit model. In the unadjusted model (Table 4.5), we see that the main predictors affecting stunting in under-five children are improved toilet, good hygiene score, and community sanitation variables namely open defecation, village household density, garbage collection, and drainage systems. In the agricultural characteristics, there is no effect of type of irrigation water on stunting. While under-five children of farm laborers are significantly more stunted in comparison to households which mainly have hired laborers. In addition, the households keeping animals in a separate animal home have less stunted kids, (marginal effect of 11.9) that is the probability of stunting was 12 percentage points lower, in comparison to households who keep animals in the home. A household improved toilet decreases stunting by 16.8% while it has no significant effect on wasting. Good hygiene score of the household resulted in 18% reduction in stunting and 7% in wasting. Among the community sanitation variables, we observe that increased open defecation of more than 25% leads to an increase in stunting and wasting with a marginal effect of 13% and 8% respectively. Garbage collection by the town panchayat in a community leads to a decrease in stunting and wasting by a marginal effect of 16.3%, and 8.7% respectively. While coverage of drainage facility of more than 80% decreases stunting by a marginal effect of 9% but has no impact on wasting. And if the community has open *Kutcha* drainage in comparison to closed drainage systems there is an increase in stunting by a marginal effect of 4% but does not significantly affect wasting. Among the child characteristic variables, we see that with a unit increase in longitudinal diarrhea prevalence the stunting increases by a marginal effect of 3%.

Table 4-5: Predictors of Malnutrition in the unadjusted Probit Model

Variable	Category	height for age		weight for height	
		Marginal Effects	se	Marginal Effects	se
Irrigation water	Tube well / Rain	-0.0573	(0.0669)	-0.000469	(0.0549)
	Wastewater	0.0567	(0.0527)	0.0339	(0.0442)
Hired Labor	No farm involvement	-0.110	(0.0870)	-0.0466	(0.0674)
	Some Hired	0.115*	(0.0630)	0.0137	(0.0529)
	Farm Laborer	0.159**	(0.0677)	0.0173	(0.0573)
Livestock kept	No Farm Involvement	-0.0405	(0.0915)	-0.0604	(0.0716)
	Away	-0.0294	(0.0690)	0.0686	(0.0604)
	Animal home	-0.119**	(0.0592)	0.0147	(0.0498)
	No animals	-0.0980	(0.0680)	-0.0430	(0.0544)
Improved Toilet		-0.168***	(0.0419)	-0.0334	(0.0381)
Waste Disposal safe		-0.0387	(0.0810)	-0.0351	(0.0714)
Hygiene score	Average	-0.00239	(0.0522)	-0.00987	(0.0458)
	Good	-0.181***	(0.0519)	-0.0759*	(0.0432)
Open Defecation >=25%		0.132***	(0.0455)	0.0797**	(0.0366)
Garbage collection		-0.163***	(0.0404)	-0.0869**	(0.0358)
Drainage facility >=.80		-0.0907**	(0.0460)	-0.0479	(0.0403)
Community drainage	Open Kuccha/No drainage	0.0421***	(0.0147)	0.0205	(0.0131)
Village household density		-0.00217*	(0.0012)	-0.000227	(0.0012)
Longitudinal Diarrhea		0.0273**	(0.0118)	-0.00499	(0.0100)
Observations		531		531	

*Standard errors in parenthesis *** p<0.01, ** p<0.05, * p<0.1*
Source: Own calculation from survey data

In an adjusted probit model with and without instrumental variable regression, we controlled for household and community variables along with individual child characteristics. The results from the simple probit regression (Table 4.6) show that stunting an indicator of chronic malnutrition was significantly affected by improved toilet, open defecation and higher longitudinal prevalence of diarrhea

To address the possible endogeneity of wastewater irrigation, we used an instrument, distance to the main city where the farmers travel to sell their vegetables. Since the Wald test of exogeneity of the instrumented variables test statistic is not significant, there is not sufficient information in the sample to reject the null hypothesis of no endogeneity, so a regular probit regression may be appropriate. The point estimates from IV probit are still consistent as reported in Table 4.7 below.

We observe that the effect of household improved toilet in decreasing stunting (marginal effect of -0.29, p<.05). Also, the communities with open defecation of more than 25%, their under-five children were malnourished with a probability of 39 % and 55% for stunting and wasting respectively. Increased toilet coverage is believed to be effective for reducing exposure to fecal pathogens and preventing disease. Studies have shown that high population density and open defecation are perhaps the keys to explaining the unresolved puzzles of the high prevalence of stunting among children in India (Chambers and Von Medeazza, 2013). Our study, however, did not see any impact of village household density on stunting.

The longitudinal prevalence of diarrhea increases stunting by 8% (marginal effect of 0.082, p<0.05). Vice versa is true, stunted children had a higher incidence risk ratio of diarrhea[7]. Studies have also shown that diarrhea prevents children from achieving normal growth, while malnutrition increases the frequency and the duration of diarrheic events, thereby creating a vicious cycle as also shown in the clinical data from long-term cohort studies(Guerrant et al., 2008).

Having good household hygiene had no effect on stunting and wasting. The other control variables as higher birth weight and household female density decrease the malnutrition rates among under-five children in our study. Some community and irrigation variables as garbage collection and drainage variables which showed impact in the unadjusted model had a collinear effect and were dropped due to multicollinearity effect.

[7] The marginal effects of diarrhea and stunting may be biased because of reverse causality

Table 4-6: Predictors of Malnutrition in the adjusted Probit Model

Variables	Category	height for age		weight for length	
		Marginal Effects	se	Marginal Effects	se
Irrigation water	Tube well / Rain	0.0927	(0.0772)	0.104	(0.0740)
	Wastewater	-0.0271	(0.0676)	0.00793	(0.0525)
	No farm	-0.0204	(0.0960)	0.0191	(0.0892)
Livestock	Away	-0.0276	(0.0675)	0.0759	(0.0553)
	Separate shed	-0.0640	(0.0646)	0.0487	(0.0503)
	No animals	0.0542	(0.0727)	0.0302	(0.0598)
Farm Laborer		0.0414	(0.0565)	0.00792	(0.0481)
Hygiene score	Average	0.0282	(0.0619)	-0.0355	(0.0525)
	Good	-0.0825	(0.0800)	-0.0557	(0.0652)
Improved Toilet		-0.104**	(0.0509)	0.000635	(0.0435)
Waste disposal-dump area collection done		0.104	(0.0797)	-0.0112	(0.0681)
Open defecation		0.143*	(0.0755)	0.144**	(0.0634)
Village household density		0.000232	(0.0015)	0.00159	(0.0013)
Scheduled caste and tribe % in village		-0.00640**	(0.0026)	-0.00647***	(0.0022)
Caste-general		-0.0810	(0.121)	-0.0270	(0.0981)
Education of the caregiver		-0.0170	(0.0481)	-0.0202	(0.0413)
Wealth Quintile	Second	-0.0003	(0.0696)	-0.0764	(0.0611)
	Third	0.0926	(0.0689)	-0.00185	(0.0630)
	Fourth	0.00109	(0.0799)	-0.0638	(0.0690)
	Wealthiest	-0.0730	(0.109)	-0.0315	(0.0927)
Longitudinal Prevalence of Diarrhea		0.0296**	(0.0120)	-0.00122	(0.0102)
Age in months		0.000103**	(4.2e-05)	6.7e-05*	(3.6e-05)
Female		-0.0186	(0.0413)	-0.0904**	(0.0356)
Total under-five children		0.0619**	(0.0283)	0.00277	(0.0244)
Birth weight		-0.0909**	(0.0391)	-0.0794**	(0.0326)
Observations		531		531	
Wald chi2		60,96		37,88	
Prob > chi2		0,0001		0,0475	
Pseudo R2		0,0886		0,0691	
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1					

Source: Own calculation from survey data

Table 4-7: Predictors of Malnutrition in the Instrumental Variable Probit Model

Wastewater area, First stage Regression

Wastewater area	Probit	
	1	2
Distance to the city	3.314*** (.177)	5.037*** (0.726)
Observation	661	638
Stage 2 controls	No	Yes
Model Wald Chi2	347,36	303,81
Model p- value	0.0000	0.0000
Pseudo R2	0,6959	0,7997

Robust standard errors; Significance *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	Category	height for age		weight for height	
		Marginal Effects	se	Marginal Effects	se
Irrigation water	Wastewater	-0.0759	(0.251)	0.0430	(0.273)
	Tube well / Rain	0.257	(0.229)	0.376	(0.264)
	No farm involvement	-0.056	(0.273)	0.0708	(0.325)
Livestock	Away	-0.076	(0.191)	-0.119	(0.194)
	Separate animal home	-0.178	(0.180)	-0.191	(0.251)
	No animals	0.153	(0.205)	0.274	(0.208)
Farm Laborer		0.115	(0.156)	0.184	(0.204)
Hygiene score	Average	0.077	(0.175)	0.115	(0.230)
	Good	-0.225	(0.222)	0.0278	(0.170)
Improved Toilet		-0.290**	(0.144)	0.0007	(0.163)
Waste disposal-dump area collection		0.289	(0.239)	-0.0375	(0.279)
Open defecation		0.392*	(0.229)	0.548**	(0.261)
Village household density		0.0006	(0.004)	0.005	(0.004)
Scheduled caste and tribe % in village		-0.0178**	(0.007)	-0.004	(0.038)
Caste-general		-0.225	(0.335)	-0.277	(0.215)
Education of the caregiver		-0.0470	(0.133)	-0.00628	(0.210)
Wealth Quintile	Second	-0.0008	(0.192)	-0.227	(0.242)
	Third	0.255	(0.196)	-0.107	(0.327)
	Fourth	0.00297	(0.220)	-0.023***	(0.008)
	Wealthiest	-0.199	(0.296)	-0.0992	(0.387)
Longitudinal Prevalence of Diarrhea		0.0823**	(0.034)	-0.0718	(0.147)
Age in months		0.0002**	(0.000)	-0.322**	(0.130)
Female		-0.0518	(0.117)	0.00928	(0.087)
Total under-five children		0.172**	(0.079)	0.000239*	(0.000)
Birth weight		-0.252**	(0.110)	-0.284**	(0.122)
Observations		531		531	
Wald chi2		59.59		36.13	
Prob > chi2		0.0001		0.0696	
Wald test of exogeneity Prob > chi2		0.9963		0.9342	

*Standard errors in parenthesis *** p<0.01, ** p<0.05, * p<0.1*
Source: Own calculation from survey data

Due to collinearity problems variables as garbage collection, drainage system variables were dropped because variables as open defecation and drainage system are

synergetic as communities with higher open defecation also have poor drainage systems. However, in the bivariate analysis, we do observe that community variables as garbage collection and drainage systems a significantly effect on stunting and policy implications for proper drainage systems and garbage collection are important. Hence in the secondary analysis presented in (Table 4.8), we ran the instrumental variable Poisson regression with the inclusion of all community variables. The instrumental variable Poisson regression model results showed no significant effect of added community variables in the model. To account for the village level fixed effects in the model, we apply the instrumental variable probit regression with the village level fixed effect, however the model was not implementable.

Table 4-8: Predictors of Malnutrition in the Instrumental Variable Probit Model

VARIABLES	Category	weight for age Marginal Effects	se	weight for age Marginal Effects	se
Irrigation water	Wastewater	-0.105	(0.274)	0.0645	(0.298)
	Tube well	0.177	(0.262)	0.550*	(0.312)
	No farm	-0.0967	(0.289)	0.183	(0.355)
Livestock	Away	-0.0445	(0.193)	-0.133	(0.197)
	Seperate shed	-0.185	(0.184)	-0.253	(0.254)
	No animals	0.159	(0.206)	0.240	(0.210)
Farm Labourer		0.109	(0.158)	0.194	(0.209)
Hygiene score	Average	0.0839	(0.177)	0.109	(0.233)
	Good	-0.191	(0.223)	0.0429	(0.173)
Improved Toilet		-0.298**	(0.144)	0.00707	(0.165)
Waste disposal-dump area collection		0.393	(0.243)	-0.137	(0.284)
Open defecation		0.0696	(0.432)	1.004**	(0.504)
Village household density		-0.00103	(0.005)	0.00772	(0.005)
Scheduled caste and tribe % in village		0.00681	(0.0154)	-0.0108	(0.039)
Caste-general		-0.329	(0.346)	-0.299	(0.217)
Education of the caregiver		-0.0566	(0.134)	-0.0280	(0.210)
Wealth Quintile	Second	0.00874	(0.193)	-0.248	(0.243)
	Third	0.269	(0.197)	-0.121	(0.330)
	Fourth	0.00851	(0.221)	-0.0534***	(0.019)
	Wealthiest	-0.203	(0.297)	0.0158	(0.408)
Longitudinal Prevalence of Diarrhea		0.0843**	(0.0352)	-0.0588	(0.149)
Age in months		0.00029**	(0.0001)	-0.323**	(0.131)
Female		-0.0574	(0.117)	0.00609	(0.088)
Total under-five children		0.180**	(0.0809)	0.000237*	(0.000)
Birth weight		-0.262**	(0.110)	-0.274**	(0.122)
Garbage collection		-0.617*	(0.358)	0.759	(0.472)
Drainage facility >=.80		0.486	(0.356)	-0.691	(0.424)
Community drainage Open Kuccha		0.222	(0.615)	-0.331	(0.726)
Observations		531		531	
Wald chi2		59.59		40.49	
Prob > chi2		0.0001		0.0598	
Wald test of exogeneity Prob > chi2		0.8468		0.9126	

Source: Own calculation from survey data

4.5.3 Parasitic Prevalence

Total 498 stool samples were tested for parasites in the stool of under-five children in the study. Out of which 130 (26%) tested positive for Protozoal or Helminthic infections. Other studies conducted in the urban slums of Gujarat found a 15% prevalence of intestinal parasitic infections among individuals with age group less than 25(Shobha et al., 2013). In other studies conducted in India, the prevalence ranged from 21% among all age groups in rural Lucknow, North India (Nitin et al., 2007) to 47 % among school children in Kashmir in a prospective study (Singh et al., 2010). In the present study from 130 positive samples protozoan infection is found in 85 (17%) cases which included Giardia, E Histolytica, E Coli, Giardia lambia, while Helminthic infection found in 45 (9%) cases which included ascariasis, hookworm, Entrobiusvermicularis, Trichuris Trichuria and H. nana Strongyloidesstercoralis (helminths). The three soil-transmitted helminth infections, ascariasis (roundworm), trichuriasis (whipworm), and hookworm, are the main intestinal helminth infections in humans (Bethony et al., 2006).

The bivariate results suggest that irrigation, hygiene personal as well as community sanitation have a significant effect on the parasitic prevalence among the under-five children. A study by Bethony et al. (2006) shows soil-transmitted helminth infections particularly affecting children living in poverty, where inadequate sanitation, overcrowding, low levels of education, and lack of access to health care make them particularly susceptible. In Table 4.9 we show the parasitic prevalence by various categories in the bivariate analysis. Overall parasitic prevalence in the sample studied is very high. The children of wastewater farmers have significantly higher parasitic prevalence (30.7%) in comparison to children of freshwater Tube well irrigators (23.5%). Household hygiene score significantly affected the parasitic prevalence with children of poor hygiene households had a higher parasitic prevalence (33.2%) as compared to good hygiene households (20%). Using soap in a household affected the parasitic prevalence with soap users having a parasitic prevalence of 20.8 % in comparison to under-five children of non-soap using households (28.6%). None of the other individual household characteristics significantly impacted the parasitic prevalence. Community characteristics impacted the parasitic prevalence with children in communities residing in areas with open defecation of greater than 25% had a significantly higher parasitic prevalence of 28.9% in comparison to children in communities with less open defecation (19.9%). In

communities with better drainage coverage (>= 80%) the parasitic prevalence was significantly less (18.1%) as compared to (29.5%) when the drainage coverage was < 80%. Similarly under-five children residing in closed drainage communities had a lower parasitic prevalence (19.6%) in comparison to communities with open Kucha drainage systems (29%).

Table 4-9: Parasitic Prevalence (PP) by explanatory variables:

Variable	N	Category	PP %	chi-P value
Irrigation water	111	Surface-Canal	20.7	0.051
	81	Tube well/Rain	23.5	
	270	Wastewater	30.7	
	36	No Farming	13.9	
Hygiene score	196	Poor	33.2	0.012
	145	Average	22.8	
	155	Good	20	
Wealth quintile	120	Poorest	28.3	0.397
	89	Second	30.3	
	120	Third	23.3	
	107	Fourth	28	
	62	Wealthiest	17.7	
Caste	475	ST/SC/SEBC	26.3	0.626
	23	Other general	21.7	
Education of Head of Household	211	Illiterate	23.7	0.294
	287	Educated P, S or T	27.9	
RO water plant	473	NO	26.2	0.806
	25	YES	24	
Improved Toilet	316	NO	26.9	0.595
	182	YES	24.7	
Use soap	339	NO	28.6	0.063
	159	YES	20.8	
Clean hands post defecation	29	Unchecked	13.8	0.12
	469	Checked	26.9	
Livestock	137	NO	24.8	0.687
	361	YES	26.6	
Waste Disposal safe	459	NO	26.4	0.654
	39	YES	23.1	
Garbage collected by Town Panchayat	239	0 No collection	29.3	0.12
	259	1 Garbage collected by Town Panchayat	23.2	
Households with drain	349	0 <.80	29.5	0.008
	149	1 >=.80	18.1	
Open Defecation	156	0 <=25%	19.9	0.032
	342	1 >25%	28.9	
Community drainage	158	CLOSED DRAINAGE	19.6	0.025
	340	OPEN DRAINAGE KUCHA	29.1	
Water Quality (Storage)	83	0 *E.coli*.	20.5	0.066
	149	1-10 *E.coli*.	23.5	
	180	11-100 *E.coli*.	26.7	
	77	101-1000 *E.coli*.	37.7	
Livestock	105	Around home	29.5	0.709
	100	Away	28	
	179	Separate animal home	24.6	
	114	No animals	23.7	
Total	498		26.1	

Source: Own calculation from survey data

Table 4-10: Parasitic Prevalence in the Probit Model

		Model I		Model II	
Variables	Category	Marginal Effects	se	Marginal Effects	se
Irrigation water	Tube well / Rain	0.0515	(0.0802)	0.132	(0.0907)
	Wastewater	0.00427	(0.0667)	0.00384	(0.0719)
	No farm	0.00885	(0.104)	0.0702	(0.107)
Livestock	Away	0.0218	(0.0605)	0.0247	(0.0598)
	Separate shed	0.0311	(0.0580)	0.0407	(0.0578)
	No animals	0.0118	(0.0632)	0.0213	(0.0629)
Farm Laborer		0.0863	(0.0533)	0.0949*	(0.0536)
Hygiene score	Average	-0.0921	(0.0581)	-0.101*	(0.0590)
	Good	-0.137*	(0.0718)	-0.158**	(0.0717)
Child's hands washed		0.00431	(0.0419)	0.000456	(0.0417)
Improved Toilet		0.00906	(0.0477)	0.00927	(0.0473)
Storage water E coli	1-10 *E.coli*.	0.0319	(0.0594)	0.0397	(0.0591)
	11-100 *E.coli*.	0.0514	(0.0585)	0.0477	(0.0587)
	101-1000 *E.coli*.	0.124*	(0.0744)	0.133*	(0.0749)
Waste disposal-dump area collection		0.0346	(0.0805)	0.0185	(0.0790)
Open defecation		0.0146	(0.0804)	0.126	(0.131)
Village household density		-0.00274	(0.001)	-0.00155	(0.0019)
Scheduled caste and tribe % in village		-0.00115	(0.002)	-0.00300	(0.0052)
Caste-general		0.0103	(0.113)	0.0503	(0.115)
Education of the caregiver		0.0340	(0.0445)	0.0301	(0.0444)
Wealth Quintile	Second	0.0285	(0.0648)	0.0189	(0.0645)
	Third	-0.0123	(0.0608)	-0.0140	(0.0606)
	Fourth	0.0562	(0.0728)	0.0514	(0.0724)
	Wealthiest	-0.0285	(0.0947)	-0.0116	(0.0964)
Longitudinal Prevalence of Diarrhea		-0.00718	(0.0110)	-0.00727	(0.0110)
Age in months		-2.26e-05	(3.62e-05)	-2.73e-05	(3.62e-05)
Female		-0.0477	(0.0396)	-0.0437	(0.0395)
Total under-five children		-0.0456*	(0.0267)	-0.0418	(0.0269)
Garbage collection				0.0279	(0.117)
Drainage facility >=.80				-0.218**	(0.0963)
Community drainage Open Kuccha/No drainage				-0.242	(0.189)
Observations		483		483	
Wald chi2		34.57		39.16	
Prob > chi2		0.1826		0.149	
Pseudo R2		0.0561		0.0619	

Robust seeform in parentheses

Source: Own calculation from survey data

Table 4-11: Parasitic Prevalence in the Instrumental Variable Probit Model

		Model III		Model IV	
Variables	Category	Marginal Effects	se	Marginal Effects	se
Irrigation water	Wastewater	-0.0534	(0.284)	-0.118	(0.303)
	Tube well / Rain	0.156	(0.279)	0.430	(0.327)
Livestock	No farm involvement	0.0154	(0.351)	0.227	(0.376)
	Away	0.0735	(0.201)	0.0900	(0.202)
	Separate animal home	0.0928	(0.195)	0.116	(0.197)
	No animals	0.0403	(0.220)	0.0725	(0.221)
Farm Laborer		0.276*	(0.163)	0.308*	(0.166)
Hygiene score	Average	-0.302	(0.192)	-0.342*	(0.195)
	Good	-0.470*	(0.255)	-0.565**	(0.260)
Child's hands washed		0.0169	(0.139)	0.008	(0.141)
Improved Toilet		0.0361	(0.161)	0.040	(0.162)
Storage water E coli	1-10 *E.coli*.	0.113	(0.209)	0.143	(0.210)
	11-100 *E.coli*.	0.180	(0.207)	0.171	(0.209)
	101-1000 *E.coli*.	0.397*	(0.241)	0.427*	(0.244)
Waste disposal-dump area collection done		0.102	(0.280)	0.0434	(0.289)
Open defecation		0.0765	(0.285)	0.411	(0.625)
Village household density		-0.008	(0.005)	-0.0051	(0.006)
Scheduled caste and tribe % in village		-0.003	(0.008)	-0.0094	(0.018)
Caste-general		0.043	(0.374)	0.177	(0.385)
Education of the caregiver		0.116	(0.150)	0.104	(0.151)
Wealth Quintile	Second	0.095	(0.211)	0.065	(0.212)
	Third	-0.039	(0.212)	-0.046	(0.213)
	Fourth	0.180	(0.235)	0.164	(0.237)
	Wealthiest	-0.101	(0.329)	-0.0384	(0.331)
Longitudinal Prevalence of Diarrhea		-0.0226	(0.037)	-0.0217	(0.038)
Age in months		-7.00e-05	(0.000)	-8.29e-05	(0.000)
Female		-0.159	(0.131)	-0.148	(0.132)
Total under-five children		-0.149*	(0.088)	-0.135	(0.089)
Garbage collection				0.0900	(0.435)
Drainage facility >=.80				-0.841*	(0.461)
Community drainage Open Kuccha/No drainag				-0.723	(0.841)
Observations		483		483	
Wald chi2		29.49		32.03	
Prob > chi2		0.3881		0.4154	
Wald test of exogeneity	Prob > chi2	0.6795		0.4622	

*Robust seeform in parentheses *** p<0.01, ** p<0.05, * p<0.1*
Source: Own calculation from survey data

Next, to study the impact of the variables after controlling for household, individual and community characteristics, we applied the probit regression model. The adjusted probit model (Table 4-10 Model I) with robust standard errors shows that only good hygiene (marginal effect of -13.7, p<0.1) and storage water quality of 101-1000 *E.coli*. (marginal effect of 12.4, p<0.1) had a significant effect on parasitic prevalence after controlling for individual and community characteristics. With the addition of

community characteristics, hygiene and poor water quality variables still showed a significant effect (Table 4-10 Model II).

To address the possible endogeneity of wastewater irrigation, we used an instrument, distance to the main city where the farmers travel to sell their vegetables. In the adjusted IV probit model the Wald test of exogeneity of the instrumented variables test statistic is not significant; hence, there is not sufficient information in the sample to reject the null hypothesis of no endogeneity, so a regular probit regression may be appropriate. The point estimates from iv probit are still consistent, reported in table 4.11. Hygiene and water quality had a significant effect on parasitic prevalence. Having a good hygiene score resulted in a decrease in parasitic prevalence with a marginal effect of 0.47 at $p<0.1$ significance levels. The households having poorer water quality with E Coli more than 100 had a higher parasitic prevalence (marginal effect of 0.39, at $p<0.1$ significance levels). Also, the under-five kids of farm laborers had a higher parasitic prevalence (0.27, at $p<0.1$). None of the other variables had a significant effect on parasitic prevalence in the multivariate regression model. The wastewater irrigation did not have any significant effect on parasitic prevalence in the adjusted model. A study conducted by Ensink et al. (2005) found the high risk of parasitic prevalence among wastewater farmers and their kids, however, the study does not control for wealth, individual or community characteristics. In our study, we do observe a higher parasitic prevalence among the under-five children of wastewater farmers (30%) in the bivariate analysis however when we control for socioeconomic, household as well as community characteristics we do not see a significant effect.

In another IV probit model (Table 4.11 model 4) we also added the additional community variables and observed similar effects as seen in model 3. Additionally, we observe that communities with better drainage connections greater than 80% had a lower parasitic prevalence (marginal effect of -0.841 at $p<0.1$). In a study conducted by Barreto et al. (2007) to evaluate the impact of largescale community sewer construction in Brazil, showed the intervention to be effective in reducing the high parasitic prevalence in the community. To account for the village level fixed effects in the model, we apply the instrumental variable probit regression with the village level fixed effect,

however, the model was not implementable. Socioeconomic factors including wealth status were important control variables in the adjusted models, and the wealth status of households had no significant effect on health outcomes in the study.

4.6 Robustness

A range of estimation strategies were applied to identify a robust relationship between irrigation water and child health outcomes. The impacts of wastewater irrigation, improved toilet, and stunting on child diarrhea incidence are robust to different model specifications. The results from Poisson, instrumental variable Poisson regression (model 3) and endogenous switch regression model (model 4) show that stunted children and residing in wastewater area had a significantly higher incidence of diarrhea (presented in Table 4.4). The additional community variables as garbage collection and drainage systems showed collinearity with the main community variables on open defecation and village household density, and hence they were not included in the main model. In another model, we included garbage collection and drainage systems, and we still see the significant effect of wastewater and stunting. Poor water quality (11-100 *E.coli*.) significantly increased the diarrhea prevalence statistically across different models however no statistical significance was observed with higher *E.coli*. (101-1000 *E.coli*.) in water which could be due to smaller sample size in the higher *E.coli*. (101-1000 *E.coli*.) category and water quality measured only once in the study. Previous studies show that using larger sample sizes(Wu et al., 2011) and study designs that include the appropriate temporal relationship between exposure and outcome measurements within the disease incubation period shall better link water quality to diarrhea (Levy, 2015). In a study conducted by Luby et al. (2015) where repeated measurements of water quality were conducted with a follow up of diarrheal symptoms after a few days of water testing for 2 years showed an increased risk of diarrhea with higher contamination.

The irrigation water use had no significant impact on malnutrition and parasitic prevalence in the study. The impact of improved toilet, open defecation and longitudinal prevalence of diarrhea on stunting was robust across the main models (Table 4.6, Table

4.7). However, the effect of open defecation on stunting was at a significance level of p<0.1. Also in the additional analysis including community variables viz. garbage collection and drainage we observe that garbage collection showed a significant effect while the effect of open defecation is not observed probably due to the collinear effect of these variables. Moreover, communities with less open defecation also tend to have better garbage collection and drainage systems. The effect of hygiene score and water quality with high *E.coli.* (101-1000 *E.coli*.) on parasite prevalence was significant across all models. The village level fixed effects model was not implementable probably because each village has a further segregation by richer and poor income groups residing into different areas, the richer groups had privatized solid waste collection with better cleanliness in comparision to the poor income groups where there is absence of sanitation services. Depending on the village size this stratification ranged from five to eight or nine areas based on our observation in the survey villages.

4.7 Conclusions

Overall, the mean longitudinal prevalence of diarrhea per person-years is 1.6. The instrumental variable poisson regression results reveal that the main factors affecting the longitudinal prevalence of diarrhea were the use of wastewater for irrigation, sanitation infrastructure and being stunted (Table 4.4). Use of wastewater for irrigation increases exposure to contaminants and risk of diarrheal diseases among those exposed due to probable contamination from exposure to contaminants through irrigation water from direct and indirect child exposure. The study showed that under-five children of farmers using wastewater in irrigation have a significantly higher incidence risk ratio of 2.19, two times increase in the diarrheal incidence in comparison to canal water irrigators (Table 4.4). None of the other agricultural characteristics had a significant effect on diarrhea. Increased toilet coverage is believed to be effective for reducing exposure to fecal pathogens and preventing disease. The study observes that having a household toilet decreases the diarrhea incidence by 20%. The study also revealed that increased open defecation in a community increases the diarrheal incidence however once controlled for wealth, education, and child stunting there is no significant effect.

Stunted under-five children had an increased diarrheal incidence of (IRR=1.23, $p<0.05$). Vice versa being true, the longitudinal prevalence of diarrhea increases stunting by 8% (marginal effect of 0.082, $p<0.05$).

Stunting a preferred indicator of chronic malnutrition was very high (52%) and was affected by the household improved toilet (29% decrease) and open defecation (39% increase) in the community (Table 4.7). The study did not observe any effect of village household density on stunting. Improved sanitation infrastructure decreases the diarrhea risk as evidenced in this study. Community variables like garbage collection and drainage facility had a significant impact on malnutrition in the unadjusted model, but in the adjusted model no significant effect is observed which could be due to multicollinearity effect with other variables as open defecation. Parasitic prevalence in the study was very high (26%). Hygiene, water quality, and drainage were the main factors affecting the parasitic prevalence in the study (table 4.10). The significant impact of wastewater irrigation and open defecation was observed in the bivariate analysis when not controlled for other variables.

5 SUMMARIZED FINDINGS, DISCUSSION OF OPPORTUNITIES FOR ACTIONS, AND CONCLUSIONS

The study identified the linkages between WATSAN and agricultural activities by examining the effects of irrigated agriculture on water quality, WATSAN and health outcomes. The main factors affecting water quality and diarrheal diseases include irrigation water type, hygiene practices, water treatment technology, sanitation infrastructure and community variables viz. open defecation, village household density. Based on these results we analyze the economic trade-offs and discuss the opportunities of actions between enhancing health outcomes through facilitating behavioral change by providing information to communities versus changing WATSAN-infrastructure services and wastewater treatment interventions or combining the three intervention options.

5.1 Main Study Outcomes

Irrigation water plays an important role in transmitting microbial contamination to domestic drinking water through human and animal interaction with irrigation water. And the communities exposed to different types of water systems for irrigation are affected differently by their health and nutritional status. Overall the study observed poor microbiological water quality at both POU (80%) and POS (73%) of the households surveyed. The health outcomes were poor with high rates of stunting (52%), parasitic prevalence (26%) and the longitudinal prevalence of diarrhea of 1.6 persons per year.

The drinking water at storage was potable (no *E.coli.*) only among 16%, 14% and 28% households in wastewater, surface canal water, and tube well irrigated communities respectively. The tube well irrigators had significantly better water quality in comparison to canal water irrigators both in portability (11 % less likely to have non-potable drinking water ($p<0.1$) and a decrease in the level of the log of *E.coli.* content, with robust result across different models. We found that the wastewater irrigating households had no significant effect regarding potable drinking water (logit regression results); however, there is a significant decrease in the levels of the natural log of *E.coli.* In comparison to canal irrigators (table 3.5). The probable explanation to poor water

quality among canal water irrigators in comparison to wastewater areas as per our observation of the study areas is regular chlorination of water tanks managed in the wastewater areas and the presence of more open drainage areas in many surface water irrigated communities. Due to collinearity issues between variables, chlorination variable and community variables as open drainage were dropped from the regression model. Though the different irrigation water types affect the drinking water quality, the confounding effect of community open drainage and chlorination of water tanks cannot be ignored. The effect of irrigation water type on health outcomes was observed on the longitudinal prevalence of diarrhea with a significantly higher incidence risk ratio of 2.19, $p<0.01$ among under-five children of farmers using wastewater in irrigation in comparison to canal water irrigators (Table 4.4). Malnutrition and parasitic prevalence were not significantly affected by irrigation water type.

Increased toilet coverage is believed to be effective in reducing exposure to fecal pathogens and preventing disease. The study results show that having an improved toilet did not have any significant impact on household drinking water quality. However, the households in areas with higher open defecation prevalence had poor drinking water quality (76% increases in the log of *E.coli*. (Table 3.5). Having an improved toilet significantly decreased the diarrhea incidence by 20 %, $p<0.05$. The study also revealed an increase in the diarrheal incidence with increased open defecation, but, the significant effect was not observed once controlled for wealth, education, and child characteristics (Table 4.4). Open defecation was high in the study areas, but the FGDs reveal that villagers are now becoming aware of the importance of having a household toilet due to its growing social impact and subsidy schemes nevertheless small households continue to practice open defecation. Stunting, which is an important indicator of chronic malnutrition was also affected by the household improved toilet and open defecation in the community. The stunted children had a higher incidence risk ratio of diarrhea, and vice versa is true, the increased longitudinal prevalence of diarrhea increased stunting in under-five children. As also shown by Guerrant et al. (2008), diarrhea prevents children from achieving normal growth, while malnutrition increases the frequency and the duration of diarrheic events, thereby creating a vicious cycle.

The hygiene and sanitation behavior of the individual household and community with their use of information regarding linkages between WATSAN and irrigation can overcome the adverse health effects of irrigation. The study observes that the households with poor hygiene score were worse off (35% increase) than those with good hygiene score in terms of household drinking water quality (Table 3.5). Diarrhea-causing pathogens are transmitted via the fecal-oral route; contaminated drinking water and hands being two important environmental transmission routes of diarrhea-causing pathogens to children. The present study observed that hygiene and water quality were the main factors affecting the parasitic prevalence. As the water quality deteriorated (101-1000 *E.coli*.) the parasitic prevalence among under-five children increased by 39% ($p<0.1$).

Having a good hygiene score resulted in a decrease in parasitic prevalence by 47% at $p<0.1$ significance levels. Malnutrition and diarrhea were not significantly affected by the household hygiene score. While child's hands washed decreased the incidence risk of diarrhea by 15% (IRR= 0.844, $p<0.05$) in the adjusted model but the results were not robust across all models. The effect of poor water quality on diarrhea was observed in the unadjusted model while no significant effect was observed in the adjusted models. Children ingest a significantly greater amount of feces each day from hand-to-mouth contacts than from stored drinking water (Mattioli et al., 2015).

The survey showed that the households considered their water quality good and mainly used the conventional sieve/ mesh filter for water treatment before storage. The water treatment methods are rarely carried out properly. For example, although almost 90% of the households reported using the simple straining method of filtration to treat their water before storage, most households were observed to use old and unhygienic strainers. In the study sample, 5% of the households using Reverse Osmosis (RO) water treatment had better drinking water quality (71% decrease in *E.coli.* and 15 % less likely to have non-potable drinking water). The effect was consistent even after controlling for other hygiene, behavioral and community variables (Table 3.5). The study showed that microbiological contamination increased with the use of larger sized storage containers. As the size of the water storage container increases the water quality

deteriorates with significant effect across all models however the effect size is very small (5% increase in the log of *E.coli.*). The probable explanation for higher contamination in larger size container could be the tendency to refill the container without emptying and cleaning the larger containers in comparisons to a smaller container.

The study observed that the households located closer to an area with open drains were more likely to have poorer water quality, although the estimated effects were very small. Also, the household's drinking water quality is negatively correlated with the distance of a household to their main water supply tank (Table 3.5), which perhaps is because with the increase in distance the chances of breaches in the pipe integrity increases.

The qualitative FGDs conducted revealed that the villagers were more concerned with the drainage problems as compared to open defecation because open defecation areas were usually away while the poor drainage in the community is more evident as one enters into the community. There were no drainage systems, or if present they were *kutcha* (no cemented pipes) drainage, and all the drainage eventually finds its way to the village pond which becomes breeding sites for mosquitos. The communities with poor drainage facilities had a significantly higher incidence of diarrhea in the bivariate analysis. However, these variables were collinear with important explanatory variables as open defecation and multivariate analysis did not show any significant effect. Solid waste management was poor and in the absence of regular sanitation services upper-income groups installed privatized services, but there was complete absence of these services among the areas populated by poor income groups which resulted in increasing levels of local inequities and fights among the residents. The rapid growth of population in peri-urban areas has led to an increase in the volume of solid and liquid wastes but the institutional capacities to handle them, remain largely absent. With no municipal services, solid wastes lie uncollected along roadsides, or if collected, are dumped in any low-lying lands where stray animals further scatter the wastes. The solid and liquid wastes have destroyed the local landscape and are a huge health hazard to the residing communities. The study shows the importance of community

characteristics as garbage collection, drainage facility, and village household density on water quality and health outcomes, however, the results are not robust across models.

5.2 Opportunities of Action

Based on the quantitative and qualitative assessments of the study the main factors affecting poor health and nutrition outcomes were wastewater use in irrigation, poor WATSAN infrastructure, and poor hygiene behavior. Cheaper ways of wastewater treatment as riverbed filtration (RBF) to deal with the increasing wastewater generated beyond the capacity of STPs.; WATSAN infrastructure with scaling of household toilets and community drainage & sanitation infrastructure; behavioral interventions with knowledge of availability, cost, and advantages of different water treatment methods, hygiene, and sanitation when all applied simultaneously will improve the overall health situation in the community (Figure 5.1). We discuss elaborately these three opportunities for action that is wastewater treatment, WATSAN infrastructure and behavioral interventions in this section as they pertain to our study findings.

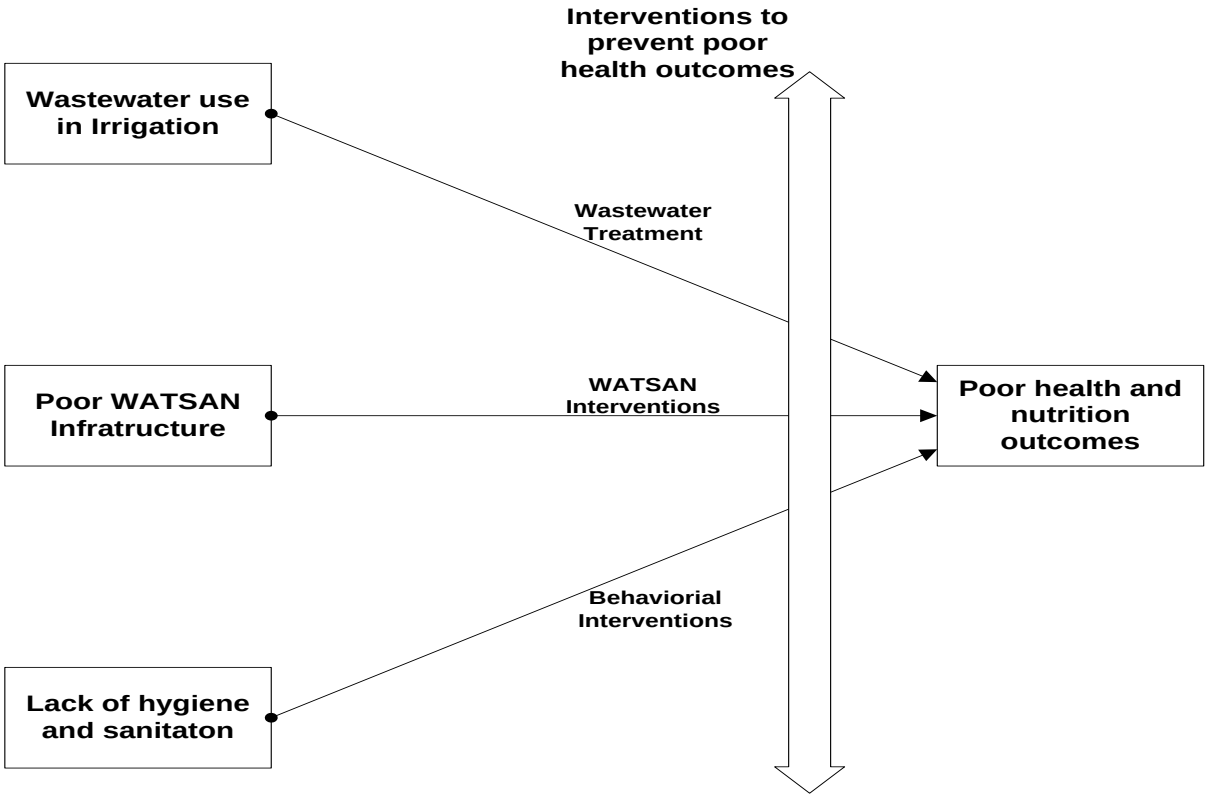

Figure 5-1: Main interventions to prevent poor health and nutrition outcomes
Source: Own Illustration

5.2.1 Wastewater Treatment

The highly contaminated wastewater from urban areas after secondary treatment is being released into the river and used for irrigation directly. While wastewater irrigation is a good alternative for irrigation water in water-scarce regions, the contaminants present in it pose environmental and health risks to the exposed population. The analysis revealed higher levels of diarrheal diseases (2 times increase) in the villages irrigated with wastewater in comparison to tube well/Narmada canal water irrigation, with under-five children of farm laborers being at risk (Table 4.3).

The sewage water generated due to the rapid population growth is beyond the capacity of existent sewage treatment plants in Ahmedabad, and the sewage water after secondary treatment drained into the river. In 2011, the Comptroller and Auditor

General (CAG) conducted random checks of pollution indicators of the Sabarmati river. The CAG declared that the fecal coliform and total coliform bacteria in the river were beyond permissible limit (increase in Fecal Coli by 860%; and Total Coliforms by 480%) set by the WHO guideline for the microbiological quality of treated wastewater used in agriculture for restricted irrigation.

Policies should be implemented to prevent any unplanned use of untreated wastewater, executed through laws and economic measures suitable to the local conditions and aimed at protecting both the health and environment. At present, there are a total of 9 STPs in Ahmedabad with a total capacity of 1075 MLD (million liters per day) (AMC, 2013). There are plans to set up five sewage treatment plants (STP) and add a tertiary treating facility. The proposal is to utilize 150 MLD tertiary treated water for Sabarmati river which will keep the river flowing full the entire year (DNA, 2013). Remaining treated water will provide water for industrial and green belts. However, the remaining secondary treated water with the industrial effluent will eventually find its way into the downstream river and will be utilized for irrigation purposes and continue to pose a threat to the population exposed.

Alternative and sustainable technologies as River Bank Filtration (RBF) can fill in the gaps due to poor STP capacity and provide safe water in the long term. RBF technique is an effective and well-accepted technique for the treatment of surface water procedure for removal of turbidity and bacterial contamination. The concept of RBF was developed in Germany and has widely been used in Europe for public and industrial water supply along the rivers over 100 years (Tyagi et al., 2013). In India, the RBF technique is applied on the surface water of four rivers of Uttarakhand. It is an efficient and well-accepted technique for the treatment of surface water. The technique has many benefits; easy to operate, requires little maintenance, keeps water free of chemicals, kills germs and do not require obstructing the river flow by building barrages. Though RBF cannot apply to every river and every season in India as in the lean season, water may percolate towards the river and is most suited to rivers having deep alluvium aquifers formed by deposition of sand and silt and have a hydraulic conductivity suitable

for cleaning water. A proper assessment of the Sabarmati riverbed is required to determine the needed criteria area for RBF wells.

The rapid growth of population in peri-urban areas in the last decade has meant that the volume of solid and liquid wastes has increased, but the institutional capacities to handle them, remain largely absent. To minimize the discrepancy between the rapid growth and provision of the treatment infrastructure decentralized wastewater treatment system is an alternate solution in rural and peri-urban areas. Wastewater treatment in ponds is a well-known technology used widely in rural areas in the European nations for wastewater treatment. (Wendland and Albold, 2010). Pond systems are a high-performance, low-cost, low-energy and low-maintenance treatment processes, especially suitable in warm climates. Most of the rural areas have a village pond where household sewage drainage water from households gets collected. The sewage drainage in the rural and peri-urban household is essentially the water from household cleaning and drainage activities (also termed as the greywater) as the household toilet' waste is drained into the on-site sanitation system viz. pit latrines/septic tanks. Channeling the greywater through *pucca* drainage systems from all households to the village pond along with simple measures of basic pond cleaning of solid wastes/aquatic plants and mosquito control measures on a regular basis will help to maintain a low-cost, sustainable means of greywater cleaning in the community.

5.2.2 WATSAN Infrastructure

The study observed that improved sanitation infrastructure decreases diarrhea risk by 8% (Table 4.3) which in turn also had a protective effect on stunting; therefore an emphasis on sanitation interventions is recommended. The villagers estimated that building a household toilet in a rural area costs 10,000-15,000 Rs. while the subsidy received by a household is 4,500-6000 Rs. and the remaining is out of the pocket expenditure. The initial amount received is only 2,000 Rs. and the remaining amount received is after the household toilet construction completes along with a picture of the built toilet. Some of the poor households start the construction and have to stop in between as they cannot afford an out of pocket amount. These issues have led to many

partly constructed toilets which are being used as storehouses, while the household members continue to go for open defecation. It was also observed that though the scheme does exist at the village level, many households were not even aware of the scheme and its benefits. Less awareness about the subsidy schemes could be due to the political will of the community leaders in publicizing about it. Besides the community leaders also face an increased workload and administrative issues from the long waiting process in getting the subsidy approval and receiving funds for the households. Perseverance and willingness on the part of community leaders are very important to expedite the entire process facilitating the toilet construction in their community. Due to gaps and delays in the process of receiving funds for toilet construction, there were many partly constructed toilets in the villages. Efforts should be made to evaluate the partly constructed toilets in the community and measures taken to facilitate the process of subsidy grant so that the construction gets completed. Besides those below poverty line (BPL) families who cannot afford any out of pocket expenses, the gram panchayat can find ways to help them complete the toilet construction.

Community toilets could be a cheaper option however from the focus group discussions we found that the residing villagers did not use the community toilets as were not clean and created more nuisance due to the intermittent water supply and regular cleaning is not carried out.

Access to improved water source has increased considerably across the country. One of the ways a household benefit from the improved water supply is that it reduces the distance they have to travel for cleaning and washing. Also, this increases the household's washing and cleaning activities, which improves the overall household hygiene. However, increased household drainage also generates a larger amount of sewage. The rural and peri-urban areas have poor drainage infrastructure, with sewage often being released into the open or Kucha drainage systems. Human and animal feces further contaminate the sewage released into the open Kucha drainage systems. Through cross-contamination from various activities as children playing around and personal hygiene of household members this sewage can contaminate household drinking water. Besides, open contaminated drainage water also contaminates the

drinking water directly or indirectly through sewage seeping into cracked water pipelines. In the present study, the communities which had *pucca* drainage systems in the study had a lower prevalence of diarrhea. *Pucca* drainage prevents exposure to contaminants and decreases the water-borne diseases through the microbial transmission. Hence investments in community *pucca* drainage infrastructure are important to prevent contamination. Rural and peri-urban areas often lack proper planning on laying a drainage infrastructure covering certain areas while missing others. The unprecedented population growth with the changing landscape in the peri-urban areas poses a challenge and requires a complete drainage infrastructure development for liquid waste management. Putting a drainage infrastructure is resource intensive hence systematic and sustainable investments should be employed after proper assessment of the area taking into consideration elevated areas, on-site sanitation, and drinking water pipelines.

5.2.3 Behavioral Interventions

The study revealed that household members are aware of the harmful effects of wastewater but are reluctant to adopt proper precautionary and defensive measures very regularly. The farmers perceived that the main health issues with the use of wastewater irrigation were foul smell and skin diseases. While they do not perceive that intestinal infections/diarrhea in kids is related to wastewater use in irrigation and are in general are unaware of the infectious pathways such as the contamination of drinking water or food items. Behavioral interventions with information, education and communication (IEC) on proper protective measures as wearing shoes regularly by farmers, washing hands and feet with soap after exposure to wastewater irrigation, not taking children to wastewater irrigation areas will decrease exposure to microbiological contaminants and hence intestinal infections. To change behavior, the IEC should regularly be conducted until the behavior becomes a norm among the farming community. IEC conducted by village health workers along with self-explanatory posters on regular meetings in the community could be cost-effective ways of improving the behavior of community members.

Good hygiene and improved water quality had a significant effect on parasitic prevalence in the study. Information on improving personal and domestic hygiene will improve the household water quality. From the FGDs it was observed that households kept their households clean but do not care about the peri-domestic or community cleanliness and dumped the garbage outside without any consideration. The villagers perceived that the village leaders must take care of the garbage situation in the community. Awareness on maintaining peri-domestic hygiene and measures for garbage disposal with sanitation services along with community involvement shall improve the overall sanitation situation in the community.

In spite of good coverage of improved water source, the study observes poor drinking water quality at both POU and POS. Hence action is needed at both the ends viz. POS and POU. The high microbiological contamination at source mandates strict monitoring of water samples and regular cleaning and chlorination of water in tanks. At the point of use, the households continue to use the conventional method of water filtration as a custom and are not aware of its drawbacks and alternative affordable treatment options. Behavior change through awareness and availability of different water filters along with good hygiene practices shall ensure safe drinking water quality.

Almost 90% households in the study use the more conventional straining method of water treatment with particle filters, such as sieve or cloth. Using cloth filters is an age-old practice in India since the 5th century BC when Buddhist monks and nuns were allowed eight requisites as their personal property, the eighth of which was “a water strainer for removing impurities from drinking water”(Bhikkhu, 1999). Straining is a very simple method of filtration in which water is poured through a piece of cloth, which removes some of the suspended silt and solids and destroys some pathogens. After straining, water may not be perfectly safe for drinking, but it can be a drinking water improvement step for people with no other treatment options. These filters are low cost (Rs. 60 average) and have a widespread acceptance but are not very effective in removing harmful elements such as *E.coli.* and total coliform. Also from our observation, we see that households did not change these filters regularly and had organic matter deposits on it. In such circumstances these filters are not effective, rather

contaminate the water samples. It is very important to use a clean cloth, as a dirty cloth may introduce additional pollutants into the water. The households should be educated to change the cloth strainers on a regular basis to improve the effect of filters. Colwell et al. (2003) conducted a study in Bangladesh which showed that cloth filters from sari folded at least four times decreasing the mesh size to 20 microns, could effectively remove more than 99% of V. cholera(the bacteria that cause cholera) if those bacteria were attached to plankton. Cloth filters could be redesigned having more folds and tighter weave to filter out harmful contaminants in water. And importantly made available to the households with the awareness of its advantages.

This study showed that 5% of the households using RO water treatment had statistically significant drinking water quality (*E.coli.* being 71% lower than the households without RO treatment facilities) (Table 3.5). Filters using the RO technique are very effective in reducing the protozoa, bacteria, viruses, chemical contamination and total dissolved solids (TDS) from water (Centers for Disease Control and Prevention). However, a household RO filter costs around 5000 Rs. and also requires electricity and regular filter cleaning which may not be affordable to all households. Alternatively, a village level RO filter of 250 Litres per hour capacity costs a family on an average 5 Rs. Per day at the rate of (0.10/ liter) and is sufficient for a village with 400 families (Government of India, 2015). The flipside of all RO filters is that they produce three times wastewater (high in TDS) for every liter of clean water which makes the RO filters not very environmentally sustainable. Therefore systems could be designed in a way that the hard wastewater from the RO filter utilized for washing and cleaning purposes.

Another variety of filters are the gravity non-electric filters. The relatively more affordable (Rs. 1500 on an average) gravity non-electric filters were not seen in the households surveyed. CITE'S research, conducted on the use of water filters in Ahmedabad, found that the overall performance of these non-electric filters far surpasses that of cloth/mesh filters though it varied widely by the model when measuring *E.coli*. removal, turbidity removal, flow rate, and filter lifetime(MIT Team, 2015). Their research shows that these filters may not be reaching remote areas because

market penetration in these areas takes time and companies are either unwilling or unable to invest.

Household water filters if used correctly, consistently, and continuously could serve as a useful tool in ensuring safe drinking water. One type of water filter cannot be designated to all households, and hence awareness and availability of the different water filters should be encouraged so that households can pick a water filter that meets their needs while keeping in mind the limited resources. Since each village is different regarding population, village size, groundwater quality, drainage and sanitation systems; a proper assessment of each area should be carried by the water and sanitation committee and can decide if a village level RO filter can be installed based on the affordability.

5.3 Conclusions and Main Policy Implications

The water quality, health and nutritional outcomes in the community are affected differently due to linkages between irrigation, WATSAN systems, and hygiene behavior. The study observed poor drinking water quality, health and nutrition outcomes in the communities surveyed. Drinking water quality was positively impacted by water treatment practice such as reverse osmosis resulting in 71% decrease in the log of E. coliform and proper storage with larger containers resulting in 5% increase in *E. coli* (Table 3.5). Hygiene and sanitation indicators had mixed impacts on the quality of drinking water, and the impact was largely driven by hygiene behavior rather than sanitation infrastructures. Community open defecation and high village-household density deteriorate household stored water quality with 76% and 150% increase in the log of *E.coli.* respectively (Table 3.5). The study observed that as the stored water quality deteriorated, the diarrheal incidence risk ratio increased significantly. Good hygiene and water quality positively impacted the parasitic prevalence.

In spite of having an improved water source, poor storage drinking water quality illustrates that an enhanced monitoring strategy should combine indicators of sanitary protection along with measures of water quality testing. At source /water tank chlorination is an important step, however, there is a general dislike of the taste of

chlorinated water and hence not done regularly. Experimental research in the field should be conducted to find the dose of chlorine that can be optimal when due to the increased water supply water for drinking purposes is not stored for a longer duration. Smaller doses may not affect the taste, and residual chlorine can just be sufficient for keeping the water safe for a shorter duration. Behavior change with safe water storage and point-of-use water treatment should be the focus of intervention to ensure the quality of water consumed.

The study observed poor health outcomes with mean longitudinal diarrheal prevalence per person-year of 1.6, stunting rates of 52% and parasitic prevalence 26%. Wastewater irrigation, household stored water quality, and sanitation infrastructure had a significant effect on diarrhea. Wastewater irrigation increases the risk of diarrheal diseases among those exposed due to probable contamination from exposure to contaminants. The under-five children of farmers using wastewater in irrigation had a two times higher diarrheal incidence in comparison to canal water irrigators (Table 4.4). The farmers perceived that wastewater irrigation causes skin diseases and foul smell which were more obvious to the farmers while intestinal infections/diarrhea were not considered to be due to wastewater irrigation but from the food habits. While wastewater irrigation in water-scarce regions is beneficial, the contaminants present in it pose several environmental and health problems. Regulations to prevent any unplanned use of untreated wastewater should be implemented after a comprehensive assessment taking into account the local conditions. The increased sewage generation due to population growth requires scaling of the existing STPs for wastewater treatment which however is costly, and with the increasing population and sewage production, it may still not be sufficient. Alternatively, cheaper methods as riverbed filtration (RBF) wells along the Sabarmati River should be considered for wastewater treatment.

Household improved toilet lead to a 20% reduction in diarrheal incidence while open defecation had no significant effect on diarrhea (Table 4.4). Stunting was also affected by the household improved toilet (decreased stunting by a marginal effect of -0.29, $p<.05$) and open defecation (increased stunting by a marginal effect of 0.39, $p<.05$) in the community (Table 4.7). The study observed that stunted kids had a significantly

higher incidence of diarrhea and vice versa, increased the longitudinal prevalence of diarrhea increased stunting by a marginal effect of 7 %, $p<0.05$. Proper measures should be taken to fill in the gaps to scale up the household toilets in the community. And the efforts to improve sanitation should not only meet coverage targets but should also be implemented in a way that accomplishes uptake and delivers genuine health gains. There is an increased awareness among households to build a household toilet mainly because of its social impact. The household perceptions revealed concerns over poor drainage systems and solid waste management than open defecation and policy implications for proper drainage systems and garbage collection are equally important along with improving open defecation situation in the community.

Agriculture, WATSAN, and health are closely interlinked, and the AG-WATSAN nexus requires a holistic approach to design interventions for improving the health and nutrition outcomes. For instance, access to improved water source without assuring that water is free from fecal contamination will continue to pose a threat from water-borne diseases. Likewise dietary interventions alone without WATSAN improvements and hygiene behavior will undo much of the good gained from dietary interventions. A holistic approach with household water treatment, hygiene behavior, proper wastewater management, improvements in household sanitation infrastructure, as well as community sanitation and sewerage connections is needed to improve child health and nutrition outcomes in rural and peri-urban settings of India. Since the problem is complex and interlinked across sectors, there is no one solution to the problem and a cross-sectoral approach with the engagement of various sectors viz. agriculture, WASH, health, nutrition, at different levels is necessary.

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7 APPENDICES

Appendix 1

Hygiene score:

The hygiene score consisted of five components: environment, sanitation, water, food and personal hygiene score. In the environment category, a household was given a score of three if the enumerator found an insignificant number of flies and no sign of contamination in the household's peridomestic environment; a score of two if the enumerator found a significant number of flies, some waste, or restrained animals; and a score of one if the enumerator found a significant number of flies, fecal contamination, waste piles, stagnant water or free-roaming animals.

In the sanitation category, a household is given a score of three if the household has an improved sanitation facility with water access at home, a score of two if the household has an unimproved sanitation facility without water access for washing at home, and a score of one if the household had no sanitation facilities and practices open defecation.

In the water category, a household was given a score of three if they have access to improved water source and adequate water storage; a score of two if the water storage container had no cover or if the water withdrawal method was inadequate; and a score of one if the household uses an unimproved source for drinking water, if the water source or water storage container appeared visibly contaminated, or if no water was available from the source.

In the food category, a household was given a score of three if the household covered stored food and kept the food above ground, and if their dishes were clean; a score of two if they left stored food uncovered or on the ground, or if their dishes were dirty; a score of one if stored food was kept improperly, if there were a significant number of flies, or if their kitchen area was contaminated.

In the personal hygiene category, a household was given a score of three if the female head of a household had clean hands, clothes, and teeth and if she wore shoes; a score of two if her clothes were dirty or if she did not wear shoes; and a score of one if there were visible signs of dirt under her finger nail, if her hands were dirty, or if her teeth were severely discolored (black or red).

The final score of a household was obtained by summing the scores of all five categories and ranged from 5 to 13. The sample households were divided into quintiles based on their final score.

Water Testing Procedure

MPN Analysis Procedure

Step 1: Presumptive positive cases

For each drinking water sample 15 tubes are prepared, five with 10mL double strength Mac Conkey Bile Broth (MCBB), five with 10mL of single strength MCBB and five with 10mL of single strength MCBB. Durhams tube will be placed in each of the tubes. Each tube is labeled with the appropriate Unique ID number of the sample which is provided on the water sample given to the lab for testing. The 5 DS, 10mL tube is then inoculated with 10ml of the original sample; each of the 5 SS,10mLtubes is inoculated with 1 mL of the original sample and each of the 5 SS,10 mL tubes with1mL of the diluted(1:10 dilution) sample (prepared by adding 1 ml to the 9 ml of the sterile water).

The tubes are then placed in the incubator at 44°C for 24h. All positive tubes are then noted as presumptive positive cases in the laboratory register. The negative tubes are placed back into the incubator for an additional 24h period at 44°C. Presumptive positive cases are noted in the laboratory register. All tubes that show no gas production or color change are then noted as negative cases. All presumptive positive tubes need to be confirmed as described in step 2.

Step 2: Confirmation of Presumptive Positive Cases

The confirmation procedure included two steps:

1) Each presumptive positive case are inoculated onto a selective medium 'Mac Conkey Agar' & on differential medium EMB Agar (Eosin Methylene Blue Agar) and incubated at 37±1°C for 24 hours.

2) Colonies that appear like *E.coli.* was inoculated in 2.0 mL Typtone tryptophan broth and incubated at 37±1°C for 24 hours.

3) A loop full of TTB suspension inoculated on Simmons Citrate Agar slant at 37±1°C for 24 hours for Citrate test and observed for change in color.

4) Kovac's reagent was added into Typtone tryptophane broth for Indole test. Red coloured ring on the upper level of suspension was visualized & considered Indole Positive.

The Mackie and Mccartney table in the Appendix (p914-918) was used for reading the MPN counts for fecal coliforms and *E. coli.* count per 100 ml(Collee et al., 1996)

Focus Group Discussions: Summary

A total of 13 focus group discussions were conducted with the villagers to know the perception of the villagers on the water and sanitation situation in their community. The FGDs themes were water and sanitation situation including any subsidy schemes which had benefited them related to toilet construction; perception about the clean environment and its effect on their lives, system response and improvement needed. We also asked about their perception about water quantity vs. water quality interventions, sanitation vs. hygiene interventions, and multiple vs. single-use of water interventions. We conducted two focus group discussions with the village women to know the perception of villagers residing in different areas as there was a segregation of poorer and richer communities in one village. The summary of each FGDs conducted is mentioned below and we try to summarize them in the villager's phrases as much as possible. The villagers would mention the name of communities and areas which are named as vaas by the villagers. We conducted 7 in-depth interviews with the sanitation community which in most cases comprised of the *Sarpanch* who is the head of the village.

VILLAGE WOMEN

1. **MIROLI—Village Women (Area 1)**

a. **Water Situation**

Water is not a problem; it comes two times till 2 to 3 pm. The water is clean but it has high total dissolved solids (TDS). Due to high TDS, all households are having kidney stone issue. We had complained and the laboratory testing was done 2-3 yrs before and the results were good so people say it's good. Sometimes there are motor problems and water does not come but this happens rarely. On these days go to farm about 1 km away to fetch water.

One of the health workers residing in the village who participated in the FGD said that we put chlorine tablets every day in the tank so chlorinated water comes from taps. If there is diarrhea or vomiting case in the village we inform Panchayat to check the linkage if any.

There is no water meter and many people keep their tap open so a lot of water is wasted. The tap is at the one end of house and people are sitting at other end and when someone complains, *Sarpanch* would instruct them to keep their taps closed if they are not using the water, but after few days it would become the same.

b. **Sanitation**

Fifty percent of the households have toilet while the rest go for open defecation. The school has a toilet facility built but not used yet.

Schemes for Toilet: BPL families were informed and forms were filled, and a subsidy of RS. 4,500 is given after they built toilets. The scheme started two years before and many households have built toilet under the scheme. When we asked if this has reduced the illness in the community, the answer was 'Yes'.

c. **Drainage**

The village has gutter lines, all water goes to pond and there is no waterlogging issue

d. **Solid waste, Cleanliness, and Maintenance**

Solid waste is disposed of on-road where there is a garbage dump. Before bins were placed but people were misusing it as animal excreta were being filled into the bins which started smelling bad so they were removed.

Our area is clean as we keep it clean. The dirty area in our village is – Bharvadvas. They have cattle so it's dirty.

Yearly we pay RS. 300 or 200 as per the house size which includes everything wealth tax, water tariff, cleanliness expenses etc.; RS. 20 for cleaning and RS. 100 for checking. The cleaners come once in a month and if there is anything they just sweep the road.

e. Perception

When the villagers were asked about any issues related to open defecation they answered that no. it is in open and far from the housing so there is no issue. The people who do not have a toilet what would they do, they go to farms and in the daytime, they also have to go in harsh sunlight.

A bad environment is when there is littering, open defecation etc. If the environment is clean there will be no illness and we will have cleanliness all around. Village cleanliness is a must.

Quality of water has to be good. Good water has to be good for the body. If it's not good then it may result in illnesses. If it's less its ok, but it has to be quality.

Good quality and time management are important. If it's timely than work can be finished on time and there is less waste.

f. Improvement needed

On questioned about any improvement needed in the village they answered that waste shall be disposed of properly. Those who don't have toilets shall be given some help.

g. Multiuse or Single use water systems

Multiuse

2. MIROLI—Village Women (Area 2)

a. Water Situation

Water is good (clean and sweet water), there is no problem. The water comes from two parts, the one that comes in the hilly area is good and the other part is not good. It smells and there is a pond next to it so illness happens. In school if you drink water you will do vomiting, it is that bad so our children take water from home. Sometimes when there is a motor issue we have to travel 2 km to fetch water, however in two years it has hardly happened.

People waste water and so sometimes we don't get water at my place, how many times I go and fight with them. We treated few leakages so now I got supply in my tap.

Once in a week, Asha worker visits our house for giving chlorine tablets. She puts in the tank for domestic use like washing, as there is no issue in drinking water.

b. Sanitation

Two out of hundred households have toilet and bathroom while rest all go for open defecation, half a km away. There is no community toilet in the village. The school has a toilet but there is no toilet in Anganwadi, *Sarpanch* has said that from 5 months it had been told but no one is creating a toilet in Anganwadi. The area near Anganwadi is dirty so children get impacted. They cleaned once or twice but then never came, how much *Sarpanch* can also do.

On asking if any toilet scheme exists in their village, villagers answered- It is present since last 2-3 years, the gram sevak has said that Rs. 6,000 would be given for toilet and bathroom constriction. They wrote our number and then gram Sevak ate the money. We spent 40,000 to build a toilet in our house, now I am going to ask for money. Another person mentioned that we got money, Rs. 700 when Maheshbhai was *Sarpanch*. Before 4 months all were given form and from those who filled the form only 5% got it. Some others mentioned that those who have money have already built it and we have given form to get Rs. 4,000. One person mentioned that they used to put stones and do it in such small toilet how would people go.

c. Drainage

Now we have a gutter line in the whole village.

d. Solid waste, Cleanliness, and Maintenance

Sweeping is a problem in our village. Waste is dumped, if there is a wedding or something in the village then someone may sweep the village. We don't know why this person has become *Sarpanch* when she doesn't look at us. While another person said that the new *Sarpanch* has improved the village. The village is clean but all the boundary areas are dirty. When you enter the village you will see dirty

and it stinks. People throw waste in the pond; they used to wash cloths and utensils also and used to defecate too. From here to Baliadev the village is clean, Bharvad's area is bad but now it is also better.

We pay Rs. 500 per annum as tariff which includes the light bill, house bill and we also pay for cleaning in the village but nobody does any cleaning. When asked on how the complaints are registered the villagers mentioned that the *Sarpanch* and family are not free all the time. We villagers among ourselves had met and decided if there is an issue we would collectively go to *Sarpanch* and complain but it doesn't happen.

e. Perception

When we asked about their perception about open defecation villagers answered -- Malaria, cholera all that happens in our village and children frequently get diarrhea, malaria and viral illness is also very common. There are no toilets so what to do. Overall people have stomach issues also. It is not only due to open defecation as people eat outside food, ice-cream, ice cream slush so it happens.

Perception of villagers on cleanliness--We keep our houses clean for our family and health otherwise illnesses will happen. We have a clean environment and as we have cattle we have some dirt issue that creates illness. We cannot tell that to *Sarpanch*, we only have to keep it clean. Village cleanliness is the joint responsibility of the whole village. We tell people and then also they don't do it Benefits of the clean village are people would be healthy, children would be healthy too. Perception of villagers on water quality is the preference of water quality over quantity.

f. Improvements needed

Those who don't have toilet shall have it, and waste dump on the street shall be removed. All four sides out of the village need cleaning as there is dirt all around, even on the way to school. They sweep and create a dump in our gate only. They shall do it further and there has to be a vehicle to take it. *Sarpanch* had put up big bins and it used to get emptied after 4 days. People use to come and throw garbage in it but if they don't do it what *Sarpanch* can do.

g. Multiuse or Single use water systems

Single use

3. UNALI – Village women (Area 1)

a. Water Situation

All households have a tap connection and water comes twice. When there is a motor problem people have to fetch water from well. There is usually no queue to get water from the well however it is an open well in the village and the water quality in the open well has deteriorated. There is no scheme where chlorine tablets are given to households.

b. Sanitation

25% households have a toilet facility while 75% go out for open defecation. Some of the households may have a toilet but still go for open defecation as they are habitual. They don't understand and when we try to convince them to use their toilet they will tell that we shall not interfere.

There are no community toilets in the village. The school has toilets which are clean, the girls clean their toilet and boys clean their toilet. Anganwadi has a toilet but there is no water so no one uses it.

Toilet scheme— there were toilets approved before some time. They help the BPL families if they have to build a toilet, govt. deposits money in bank directly.

c. Drainage

The gutter line is under construction, half of the village has started using it and work is under process for rest.

d. Solid waste disposal, Cleanliness, and maintenance

Waste is an issue, sometimes sweeper comes after 3 days or more. Only school is being cleaned not the village.

Good areas are the chowk and Sakhiman chowkdi. Some areas of the village are dirty as 'Ganpati Vaas', People have cattle on their premises so you will find that areas dirty, that areas are very dirty. After the water timing, the village becomes messy.

When asked 'if you want some changes in the village, do you go to *Sarpanch*', they replied who would tell? There was water in our house, so everything was under water and spoiled. We went to complain but *Sarpanch* was not home so we talked to his wife and come back. Other things we have complained is about the road but that's done now.

e. Perception

The dirty area is where there is litter and people are doing open defecation. Illnesses are being spread if the area is not clean. Not any specific kind of illness but people feel unwell frequently and kids face diarrhea and vomiting frequently. The benefits of the clean village are that the people would appreciate it. There will be no illnesses and village would have a good impression, 'Swachhata tya prabhuta' meaning that where there is cleanliness there is God. Village cleanliness is the responsibility of *Sarpanch*. We are of the perception that clean water quality is more important than quantity.

f. Improvement needed

To make the village clean all have to spread awareness and do collective efforts. We have to come together collectively and complain so that message goes in the village. Alone nobody can do it.

g. Multiuse or Single use water systems

Single use

4. UNALI-Village Women (Area-2)

a. Water Situation

We drink from well and bore. Borewell water is clean but it doesn't suit all due to salinity (We filter it and drink due to salinity and we make vessel empty by night).so few go to well but the water in well is dirty. It is not suitable for drinking but what people would do. They are not comfortable with the water that comes in tap and when there is a problem with electricity or some repair work we have to go to well only of nearby farms and sometimes it takes 8-10 days.

Washing is a problem as there are no dhobi ghat(the place where villagers come to wash clothes). We also don't have a bathroom in all houses so where to wash clothes. In monsoon, there is so much mud and dirt that you cannot stand in the village. Water in tap comes thrice daily, they waste a lot but if there is a dhobi ghat and gutter it would be better.

The pond was used for bathing before but people threw so much dirt, so where to go now.

Chlorination is done by the health worker in tank, in well all places including households every 15 days

b. Sanitation

There are no toilets in our area, only 3-4 houses have toilets. No public, school or Anganwadi toilets are there in our village. For open defecation we have to walk 1 hour, women have to go far off as there are people around.

Toilet scheme- Yes, they wrote our names three months before but it is not approved yet. The subsidy is given but you have to give photos then only you get it. We borrowed money to build the toilet and its half done now. Now nobody comes to even see it. Some BPL families have received a subsidy amount to build a house and a toilet so only 2-3 with govt. support.

c. Drainage

No gutter lines, water goes to sand pits. If people use tap for washing water comes on the road.

d. Solid waste, Cleanliness, and Maintenance

Everywhere there is dirty on road and all sides. There is no bin in the village so where to throw garbage is an issue. We throw solid waste next to the pond, the whole pond is dirty now. We don't take pond water as there is dirt around and people tie their cattle there also.

Nobody comes for cleaning and we don't have anyone in the village to do the cleaning. Before 6 months there was a lady whom I used to give wheat, rice and Rs. 10 to clean. When we asked the village women if they complain about issues in their village as dirt around the well they answered that no men complain, we do not.

e. Perception

Due to open defecation, people fall ill. In monsoon it's very dirty now we have a road. Our figures get a fungal infection in monsoon, cholera would happen, but what to do.

Cleanliness of the village is not in our hand. Yes, it is a responsibility of the entire village but if we will tell people there would be fights in the village as no one wants to take responsibility.

Benefits of a clean village are that there are no illnesses and we are healthy.

Perception about water-Water quality should be good, less and need-based use is better

f. Improvement needed

We want a dhobi ghat so that there is less water in the village is wasted. We need a better gutter line, and school in the center of the village. The situation in our village shall be improved. When asked about having a toilet in each household the village women answered-- yes it would be better.

g. Multiuse or Single use water systems

Single use

5. RANCHARDA --Village women (Area-1)

a. Water Situation

Water supply is good and clean, we get water two times in a day. Water that comes from Panchayat has salinity so it tastes different; when we cook pulses and beans they don't come out good with it. Narmada water is good in taste and clean filtered water, so we bring that water for drinking and cooking purpose daily. It is available 24 hours and there is no queue. Those who can afford use aqua guard (RO) instead.

The houses at a higher level don't get water and lower level gets water so there is a fight on this. There are days when the motor is not working; on those days we get the Narmada canal water. We feel some water shortage in the summer time. If any problems in water all women go together to the panchayat office to register the complaint.

b. Sanitation

Most of the houses in the village are having toilet facilities only a few families from lower strata of the village are not having it. As Vaghris, the lower strata live in slums of the village they do not have toilets otherwise people have toilets. Most of the Thakor families are having it. Otherwise, Thakor, Harijan all go out. The impact of open defecation is on people who are on the long road, on our side there is no issue. The village has no issue with open defecation.

In school, the toilet is not good there is no cleanliness. Anganwadi has a toilet facility and it is good. The Nirmal gram scheme is at Vatika tekra as of now. Here Government collected Rs. 600-700 and has built toilets for all. We are rich Patel community and we are all having toilets.

c. Drainage

There are drainage lines in the village

d. Solid waste disposal, Cleanliness, and Maintenance

For solid waste disposal, we have waste bins at each home and there is a collection of waste every second day through private waste collectors we have kept and pay Rs. 10 per month. There is no government sweeper and the Gram Panchayat sweeper never comes. The one that comes from Gram Panchayat only do road sweeping and don't take the solid waste.

Our village is cleaner than most of the other villages as you can see around the village. The cleanest is our Patel vaas while the dirtiest areas are Vaghri, Harijan vaas, Bhangi vaas.

e. Perception

Perception about the clean environment is clean in all ways. No littering and waste, no faeces. The village also has to be clean. If houses are clean and outside is dirty then mosquitos would come in. Benefits of a clean village are no illness, no epidemics. Village cleanliness is the responsibility of all villagers.

Quality of water has to be good. If there is a lot of water but not potable, what would we do with it?

f. Improvement needed

We need more cleanliness. At household level we do clean but if there is waste outside, boys would collect and burn it.

g. Multi or single-use water systems

Single-use is preferred

6. RANCHARDA- Village Women (Area-2)

a. Water Situation

Water is available for 2 hours twice daily. Water is clean; we drink what others drink in the village. There is salinity, we can see on the vessels, so don't know what happens to our stomach. Narmada water is clean and has no salinity; we have to take water from there which is 15 min walk from home. Tap water is not that good, but who would go to collect Narmada water every day.

When there is a motor problem we do not get water ten we fetch water from a bore well 15 minutes away and there is no queue, it takes a total of an hour to get water at home. There everyone goes (Patel, Thakor) and the water is clean.

If the tap is broken we would complain in Panchayat otherwise water would get wasted.

b. Sanitation

All households do not have toilets; we don't have it in our vaas only 2-3 houses have it, we all go for open defecation. Patel vaas and Thakor vaas have it as they have a khalkuvo (pit). But from bus stand to Bhangi vaas and Vaaghri vaas the households do not have a toilet. We constructed toilets so made Khalkuvo (septic tank) now it is full of water and there can be a problem of contamination in the pond and thus illnesses. We spent Rs. 20,000 for toilet and khalkuva and we also pay tax.

There is no scheme where we received a subsidy for toilet construction in our houses. There are even no public toilets in this village why would anybody make toilets in our houses.

c. Drainage

We have a gutter line which eventually ends in the village pond. So we get mosquitos, and people throw excreta also in the pond. It also stinks and we have mosquitos in summer. It's because of dirty stagnant pond water; if this water goes away then it's good for us. There is no illness as of now, as we take good care of kids.

d. Solid waste disposal, Cleanliness, and Maintenance

Solid waste is an issue; it lies near the pond if the bins are there we can put our waste in it. Our street is clean; we don't have much plastic waste. The village is overall clean, we don't have many cattle and even those who have, keep them in the proper animal house so not dirty. Vaaghrivaas, Datanvaas communities in this village are dirty. We and Kumbharvaas are good. Sanitation Committee of the village does arrange for cleanliness in the village.

e. Perception

Our village is clean. We keep it clean. Generally, it is good and there is no illness in the village. Village cleanliness is our responsibility. At home, I tell my daughters to keep clean. It used to be dirty before but now the time has changed and there are facilities. The benefit of the clean village is that we live in a clean environment. There are no mosquitos, no illness so people are healthy.

Their perception about open defecation is that all sit together; even the lady who is just married sits with the other man of the village, what is the choice that we have. However, they perceive that it does not leads to any illnesses.

f. Improvements needed

Yes, one thing is about toilets. We keep our houses and surroundings clean but we cannot tell others.

g. Multiuse or Single use water systems

We don't have any complaint about water so we don't feel like changing it. We have good bore water.

7. GANPATPURA – Village Women

a. Water Situation

Water facility is good; all households have a tap connection. We get clean water from the bore at a fixed time every morning till 12 noon so most of the work is finished. We get bore water directly, the water is less but it's clean. We have no tank so water is not dirty, it is clean.

Motor issues are repaired fast, but if water is not coming due to motor issues there is another bore of *Sarpanch* and we take water from there. We never have to go to fetch water far away. If there are any issues in the pipeline, we complain to *Sarpanch* and it gets repaired.

The health workers come door to door to give chlorine tablets.

b. Sanitation

It is a small community with 45 households and from 45 only 15 houses have toilets others go for open defecation half a km. away. No subsidy was given to build toilets and people have built on own. Nothing not a single paisa was given by the government. Only those three tires were put where you can't even go to the bathroom. Schemes had come and gone we registered our names too but nothing has happened. We do not have any Nirmal Gram scheme.

c. Drainage

The gutter line was laid 2 years back and all water gets drained to pond due to which some mosquitoes happen. There is no water logging in the village and the excess water in monsoon finds its way to farms.

d. Cleanliness

We have a clean environment, there is no dirt. There is no issue as we have everything clean, there is nothing dirty not even in monsoon. There are no diseases just some viral illnesses. This is Thakor's area which is clean as you can see and that side is Vaghri's area, their area is going to be dirty only and it will not change.

Sweeping is happening so all places are in the village are clean. We keep our area clean and Bhangi (sweeper) also comes and cleans every Saturday and burns the trash. *Sarpanch* has arranged for the sweeper.

e. Perception

Impact of a clean environment is that we do not get sick. Benefits of a clean village-- Anyone who comes from outside like our village, they feel like a picnic. Village cleanliness is a joint responsibility of all *Sarpanch* and the village people.

When the villagers were asked about what difficulties do people face with open defecation -they said that we have to go with an umbrella in monsoon.

Villager's perception of water quality is that it is more important than water quantity.

f. Improvement needed

Sanitation (toilet) facilities to households that do not have it

g. Multiuse or Single use water systems

Separate for bathing and washing and drinking as well as farming.

8. SABASPUR – Village Women (Area-1)

a. Water Situation

We get good water, there is no water issue, we get water two to three times a day and if there is any problem the bore operator starts again in the day. There is a new line set up so there are a total of four lines. If the motor is not working we go to the nearby bore well in the farm (about a km) away

and there is no queue there. We do not need to complain as the *Sarpanch* would know the problem and it will take 2-3 days to repair. Water is clean, no problem with taste or smell.

We do not have any scheme like chlorination tablets provided at door step by the health workers.

b. Sanitation

50% households have a toilet and 50% don't have a toilet in our village. There are no public toilets and no toilet in the Anganwadi. The school has a toilet but it is not for the kids. There are no toilet subsidy schemes in the village, our names were taken two months before but there is no progress. All households have constructed toilets with their own money.

c. Drainage

There are no gutter lines so disposal is an issue. We don't waste water but a gutter line would be better, especially in monsoon. Bathing and washing water goes to khalkuvo (sandpit). If there is water logging we break something in the monsoon season to drain the water away.

d. Solid waste disposal, Cleanliness, and Maintenance

There is no waste disposal, no gutter line. We need dustbins, as all villagers throw outside otherwise where we would go for disposal. We face problem in waste disposal and water disposal too. Mosquitos are there in big numbers everywhere. Cleanliness is not up to the mark. Our area is clean as nobody litters here but all other areas in the village are dirty. There is heaps of waste here and there. After 6 or 12 months *Sarpanch* calls JCB (dump truck) and removes it.

There is no information given on cleanliness by village authority and children get sick frequently.

When we asked why you don't keep your village clean collectively, they would '*say that only 2-3 women like us cannot do, we told the other villagers but it's not effective. This Thakorbhai (Sarpanch) would not understand this. They will eat, drink and go out and defecate. They will not cooperate ever, Rabari community is also like that. However the village was worse than this before 10 years, we used to go to well for water fetching and houses were kaccha*'.

e. Perception

The clean place would not have mosquitos and there will be no illnesses. The clean village is the responsibility of *Sarpanch* and all villagers. Village cleanliness is important so that dirt doesn't spread and there will be no illness. If houses are clean and outside it dirty we would still fall sick.

Less but good water quality is better, but there is no water issue in the community.

f. Improvement needed

If there is a collection vehicle which comes daily there will be no waste. Gutter lines should be there so that there is no littering. We need toilets so people don't have to go for open defecation. We, villagers, want to do all good but who would come to support us.

g. Multi-use or single-use water systems

Single use

9. Sabraspur - Village Women (Area-2)

a. Water Situation

Water facility is perfect with no issue, we get bore well water and it is clean. When there is a motor problem we do not get water and we have to go to farms 1—2 km away but we have to stand in line for an hour as there is a single tap from the bore well. But mostly we don't have to do that as the repair would be done by the evening or next day. There is no problem in summer either.

b. Sanitation

Only a few (50%) have toilets at home, rests go out for open defecation only. We fall sick and it smells bad, it has an adverse effect, especially in monsoon. And in the last days of gestation, pregnant females face more trouble due to walking long. There are no community toilets in the village. Anganwadi has a toilet but the door is broken and there is no water facility so it is not in use. The kids finish toilet at

home and then come to Anganwadi. If they do it in Anganwadi, they call his/her mother and she cleans it. The school has a toilet which is clean and has water facility but children will not use it.

There is a scheme for toilets but they don't approve it. They say that it gets approved from Gandhinagar; we are living for 21 years and have election card then also we don't get it. Other women said that the scheme is there we have to fill the form in Panchayat and we get Rs. 1,200.

There is no Nirmal Gram scheme is present in our village.

c. Drainage

We don't have a gutter line that is the reason we have dirt as an issue. Water from household activities goes into a sandpit.

d. Cleanliness

The village doesn't have cleanliness activity as there is no sweeper so people throw here and there. There is no door-to-door collection of waste. No daily sweeping or disposal of waste. There is so much dirt around but whom to tell. Nobody cleans it and the dirt is next to Anganwadi. We can clean our premises but can't force others. Thakor and Rabari communities throw anywhere if we would tell them they will come to fight. How would we feel when it's unclean around us. Our area is clean, the other side is dirty with uneven road and people, Here we all are educated so we don't litter, there they do and also throw water and waste on road.

We don't have waste bins. *Sarpanch* brought and placed the bin but how many times *Sarpanch* can do cleanliness if all are littering? Who would go far off to throw it? So people litter around their premises. If *Sarpanch* would tell there will be a fight. *Sarpanch* tells people to go and dump near pond wall but people would argue that why we would go there.

e. Perception

Where there are littering and waterlogging its dirty environment. It leads to Malaria, fever, and mosquitos. Village cleanliness is our responsibility. If there is littering, surrounding is not clean then it smells bad and could lead to illness. The benefits of a clean village are that there is no illness and children would be healthy. The whole village has to be clean but who would do it. All people clean their places and some stay at farms also so their houses are dirty. Village cleanliness is the responsibility of *Sarpanch*.

Those who have toilets, illnesses have reduced at those houses. Water quality is more important than quality.

f. Improvement needed

Cleanliness efforts and the gutter line would make village better place.

g. Multi or Single use water systems

Single use

10. Juna – Navapura- Village Women (Area-1)

a. Water Situation

There is only one bore in the whole village; we have water problems every day. Water timing is not decided, it comes for two days and then for next three days it doesn't come. Some days before, the water supply was not available for about 2 months so people had to fetch water for washing and drinking and we used to wash our clothes with used water. We would bring it from the bore in farms 1km away from our house.

Panchayat just comes and goes; can't they see villagers going to fetch water far off? Who would listen to us is the main question.

Water that is coming as of now is good. Village health workers give chlorine tablets and sometimes they put in the tank, the last time they came was 6 months before.

There is no drinking water in Anganwadi, the woman goes and brings it from somewhere.

b. Sanitation

Only 10-15 households have a toilet otherwise all go for open defecation. There are no community toilets; school has a toilet with water facility but there is no toilet in Anganwadi

When asked about any scheme for toilets in the community they answered that no we are tired of writing to them. It's been 12 months but there is no action. They have created few stones but how to use it? It takes Rs. 20,000-25,000 to build toilet which we cannot afford.

c. Drainage

There are no gutters in the village. Another person mentioned that it is there in half of the households in the village.

d. Solid Waste disposal, Cleanliness, and Maintenance

Our village is dirty. It's not clean. There is mud, water everywhere. There is no sweeper in the village. No, not even in the entire year any cleaning is done; in school also children clean it. There are illnesses in the village as malaria, cholera, fever, diarrhea and we all suffer. In monsoon, children cannot go out as the road is always with water.

e. Perception

When asked that who is responsible for village cleanliness the villagers answered--None all shall keep their houses and premises clean. Some others said that--*Sarpanch* is the one who has to take an interest, here we have to tell and then also nothing would happen. Some others said that villagers also don't allow *Sarpanch* to work, they have to understand first how one man would do everything.

When we asked the villagers about the benefits of the clean village they said 'None'. When asked if the whole village sweeping is better they answered 'yes it would look clean'. When probed if this will decrease the illness they said yes of course.

When we asked the villagers about the benefits of toilets at home, they said that if we will have toilets at home we don't have to go out far off. Going out is a problem, in monsoon, it's a big problem, where to go.

Perception on water quality—water quality is more important than quantity.

f. Improvement needed

We need cleaning; RCC road and all water logging sites shall be checked. Only half of the village is getting water, everyone must get it. We have informed to the *Sarpanch* but he doesn't do anything.

g. Multiuse or Single use water systems

Single use; village water shall be in the village for use while in farming we have bores.

11. JUNA NAVAPURA— Village Women (Area-2)

a. Water Situation

All houses in the village have a tap connection for water. Water comes once and there is no fixed time; sometimes it goes on until 2-3 pm. Water quality used to be clean but now it's bad, we have to go to fetch water and women are having back pain. They have laid a new line but then also there is no water to few houses. Sometimes for 2 months, we do not get water and we have to go to fetch water from a bore well 2-3 km away, these small girls also go to get water.

b. Sanitation

Twenty-five percentage of the households have toilets rest go for open defecation. There are no community toilets; the school has a toilet with water facility.

Toilet scheme came 2 years before but then don't know. They were paying for the toilet so we had to build first and then they would pay with photo proof of construction. Five to ten households have built but no compensation is given yet, they took photos too.

We do not have any Nirmal gram scheme, nobody has told us about it as no one comes here.

c. Drainage

Now there is a gutter line in the village so little better. Gutters are half open, so it is dirty. RCC roads were done till outskirt areas. *Sarpanch* stays in outskirt but our inside areas are yet to be connected otherwise waterlogging would happen. Whole village water logging happens in our area.

d. Solid Waste, Cleanliness, and Maintenance

We have dirt issue in the village everywhere, only a few households keep the surroundings clean. We clean our houses, where else we shall work. Bad areas in the village are Baliyadev where there is water logging so the even vehicle cannot pass by. The village entrance is filled with waste. We have a dumping area but there is no waste bin. No sweeping is done.

Whom to tell, it can cost us if we complain. Here nobody comes; the water in tap is also pale yellow. It's not waste but gutter water. If we women go and tell then our men would tell us not to do, so we feel the need to tell but we don't.

We complain to *Sarpanch* in case of pipeline/tap damage but they don't come on time and it takes 3-4 days, there is no immediate work done.

e. Perception

Illness happens from open defecation. Due to dirtiness in the village, we have Malaria, Cholera and all that. In cholera, there is diarrhea, vomiting, and fever due to mosquito bites. Though I am not educated but I know it as I am at the hospital only and I brought up all these kids.

Benefits of a clean village are that if someone like you comes to our village, the village would look clean and there are no illnesses.

Village cleanliness is the responsibility of *Sarpanch*, we don't have any responsibility it's all *Sarpanch*'s.

Perception on water--Water quality should be good.

f. Improvement needed

If there is space for dump by govt. we can keep our village clean. Dirty and waste dumps need removal. There shall be no dirt around and no waterlogging. We need good roads, cleanliness, and toilets.

g. Multiuse or Single use water systems

Single use

12. NAVA-- NAVAPURA- Village Women (Area-2)

a. Water Situation

All houses are having a tap connection and we get clean drinking water from the bore. Water comes till 12 noon but if there is electricity issue it won't come. In the evening when people return from the farm we get water for an hour or two. Water pressure doesn't come in higher areas so we have to keep our taps open.

In monsoon even if it is little less supply we can manage with rainwater that is being stored on farms and in vessels which is sufficient for washing clothes.

People from the Malaria and Health Department come to put chlorination tablets; they put them in the cement tanks every 10-15 days.

b. Sanitation

Half of the population goes for open defecation. There is no community toilet; the school has a toilet with water facility for children but there is no toilet in Anganwadi.

The toilet Scheme started 2-3 years before in which the Govt. gives money up to Rs. 8,000-9,000 for toilet construction but the cost of constructing a toilet comes around 25,000 so how to finish the construction. How can a farm laborer meet this expenditure? And what else govt. can also do. Another person mentioned that we have made a toilet and spent a total of RS. 26,000 while they give only Rs. 2,000; how to match this? Now, most households have toilets so there is no dirt. And those who don't have they have to go out and especially monsoon are bad for open defecation.

c. Drainage

Before two years gutter lines were built and from the gutter lines of the entire village, all the water drains into the river. When there were no gutter lines there was more illness in the village, after the gutter line, it is better. We had cholera, diarrhea, fever etc. and skin diseases and the monsoon was bad. There was water logging near Panchayat which is removed now.

d. Solid waste disposal, Cleanliness, and Maintenance

There is litter in the village, there are cattle so it will be there. However, the dirt due to cattle is different as it's not harmful. But we clean their excreta twice in a day.

We dispose of the solid waste on the road where there is a dump. We burn the plastic bags, rest we throw in the dump. Few households also create dump beside their house. It is not dirty it is compost; if we don't keep it then we may have to buy fertilizers from outside.

No one comes for sweeping; we do it on our own. Sometimes someone would come to clean; NSS cleaned the village during their training

We cannot say whether the entire village is clean but our surrounding is clean. Yes, all households clean their premises every day so it's clean. Our Talati used to tell those who were keeping their surrounding dirty so now all is clean. All villagers clean it and they have built toilets plus now we have a gutter line so it's all clean. We have some dirty area next to our place as there is a road and it has dog's excreta etc.

When the villagers were asked where do they complain if it's dirty they said that No, to whom we can tell, nobody does it so we have an illness.

e. Perception

We have Thakor population and our *Sarpanch* is also Thakor so we don't waste. We are well aware and we don't waste water. We clean our houses what else we would do. We all keep our premises clean but if the village is clean it is a better situation. If the environment is clean there is no illness and children would be healthy. Even if we clean our houses they may fall ill as children go out and play in the village. So if the village is clean there will be no illness.

Village cleanliness is the responsibility of village women and Gram Sabha members, all are responsible.

Perception on Water quality—Water quality should be better than water quantity. It's like eat less but eat well.

f. Improvements needed

It is good if good work happens in the village. We don't have stand post and cattle trough in our village. We don't have washing area and crematorium.

The water from the river is used for washing of color bags so that water is blue and red and created a loss in farms. There is foam being generated in farms due to it, it is bad water. Basically, this is river water used for irrigation from the river.

g. Multiuse or Single use water systems

Single

13. **Palodiya- Village Women (Area-2)**

a. Water Situation

Water is not a problem in our village, we get two times water in tap but timing is not fixed. Sometimes on occasions, we get it for the whole day but it has never happened that we don't get water in a day. Mr. Hari Iyer (a philanthropist) has put RO plant at two places. There are punching cards where we enter and 15-liter water comes. People used to waste it so instead of 20 now they are giving 15 liters. Water is available 24 hrs and there is no queue.

We pay a water tariff of Rs. 150 yearly.

b. Sanitation

In this village 100% households have toilets. Only 2-4 households do not have toilets. Poor households may not have it or households where there is not enough space to build may not have it. Schools have a toilet facility and water connection. Haribhai (a philanthropist) has made community toilets with water facilities which are cleaned regularly.

There is a scheme for toilet construction by the government which started 2 years before where Govt. supports BPL families giving Rs. 2600 and APL Rs.600 for toilet construction. On particular days there are training sessions a taluka office for it.

After the scheme started there is a difference in the illness in the community. When there were no such schemes people did not know about it. Now sanitation committee is active so people know the importance of cleanliness. There were teams visiting from Delhi and Hyderabad and they used to take photos of the dirty place and clean place; in the meeting, they showed it to *Sarpanch* and Talati and gave suggestions. Now it is a different situation, Narendrabhai CM has given the award to our village. Our village is now a nirmal gram awarded village.

c. Drainage

There is no water logging, we have drainage lines.

d. Solid waste disposal, Cleanliness, and Maintenance

There are these drums and bins in all Vaas (areas) of the village. There is designated person who takes all waste in collection vehicle and buries it outside the village daily. This is a private arrangement done by Panchayat. AUDA has put up bins but they don't come to empty it.

All areas are clean, this Patel vaas, and the area where *Sarpanch* stays are clean. Thakor vaas has animal husbandry and it gets dirty in monsoon. There is no waste dump in the village. Our area is clean but all are not same; people don't use bins and throw here and there which leads to mosquitoes.

There are no serious illnesses in our community.

e. Perception

A clean environment is where there is no water logging, where there is no dirt, where there is no waste dump in the clean area. If it's dirty there will be insects and the result would be illnesses like diarrhea, vomiting, malaria, typhoid. All households should have a toilet and Anganwadi should have a too. Village cleanliness is everyone's responsibility.

Good quality water is more important than quantity. If we have lots of water but not potable what would we do with it?

f. Improvement needed

There are mosquitoes and I have told to Panchayat 2-3 times. Racharada PHC is spraying medicines. If things are being supplied from govt. we use it but as people are littering so there is an issue and it gets worse in monsoon.

Sweeper comes after one or two days, there has to be someone for daily disposal as people would litter something or the other. The outside streets are sometimes cleaned and sometimes not

g. Multi-use or single-use water systems

Single-use systems are preferred

VILLAGE SANITATION COMMITTEE/*SARPANCH*

1. MIROLI VILLAGE

a. Water Situation

We have a population of 5,000 people here with all houses having a tap connection and there is no issue of drinking water in the village. Water is coming regularly but TDS is an issue. Here in Patel vaas, we all have ROs but otherwise, people cannot afford it. So when I became *Sarpanch* we bought RO in 3 months' time we installed a machine worth 2 lacs Rs. installed for no cost for villagers. The machine

gives 20 liters of water per household for just RS. 5 which covers only the electricity bill. It worked for 2 months but then this was not sustainable basically due to people from the opposition(doing politics) so we had to send that RO machine back.

Water supply is on from morning 5 am to 1 pm. Our Patel vaas is in lower area so we get very good force but in Bhoi vaas, Rabari vaas there is a low-pressure issue so we give water from 11 am to 2 pm to them.

b. Sanitation

Only 20% households are left without toilets, basically, households with huts (*kutcha* houses) are not having toilets. We built fifty toilets in 2 years, forms were filled and report sent to 20-30 households last year. And this year few private toilets were built, as now people have at least understood the importance of a household toilet.

When Nirmal Gram scheme started there was no training given from the Nirmal gram team to build toilets and their benefits, only forms were distributed. We called people in the gram sabha meeting and told them about the scheme and its benefits and filled the forms for subsidy under the Nirmal Gram scheme. We also explained to them that we shall not spread dirt and keep our village clean otherwise we will get ill. I explain them in a simpler way like now your girl is 10 years and it's not good if she goes for open defecation. Once she has an illness in her body she would suffer a lot. If you don't want to spend in lacs for the treatment you should spend RS. 10,000-15,000 to build a toilet. And it's good for old people too. If the government is giving you everything it's going to be yours and you are the only one who would be using it then what is the problem.

We fill the forms and we supervise when the toilet construction starts. We also take a photo of the built toilet and give a report to block office to receive money. The money comes after 6 months and villagers get restless until they receive the money. Besides we have the MNREGA scheme in which APL and BPL families get RS. 4,500 for digging the pit latrine. Before Nirmal Gram, there were 25 toilets built and there was less monetary support from the block level, also people used to say that it would be better if the support from government is RS. 10,000-15,000. But now the amount has been increased so people are ready. Just it takes 6 months for payment that becomes too much for the households.

I as a *Sarpanch* wish that my village remains Nirmal (clean) and we get the second award for under the Nirmal Gram Scheme. With that award, I can work to improve for my village. I want to make Kutir so that those passers get some rest. I want to create a Dhobi Ghat of RCC so in the afternoon when the water supply is not available at 1 pm, people who leave for work early in the morning can take bath and wash their clothes etc. when they come back.

c. Drainage

We don't have water logging situation even in high rain days. We have laid gutter lines in all areas of the village so now wastewater disposal is automatic. It directly goes to the pond. It has been 10 years but still, gutter water goes to the pond. The problem is that how to empty that pond. We have talked with the irrigation cooperative to use the machine to extract water that can be used for irrigating farms. And under the MNREGA scheme, the pond deepening can be undertaken but don't know how to do?

d. Cleanliness and maintenance

For waste collection in our Patel vaas we have bins and sweeping is done with a monthly charge of Rs.20. For the whole village cleaning, I arrange every month 10 laborers who would clean the whole village. We have removed the drum we had placed before as people were throwing liquid waste in it. Now we have created a pit and have informed people to throw their trash in it and then after two months, we clean it. We pay RS. 2,250 for tractor rent which collects the trash from the pit. Most areas in the village are clean; In Chunara vaas main road is dirty as they throw on the road.

The villagers pay a tariff and we take care of the maintenance work for pipelines and gutter lines in the village.

The problem in this village is that opposition people play politics. They spread dirt in the village; they break the gutter line and block it so village becomes dirty. They do this to show the villagers that I am not doing anything.

e. Multi-use or Single use water systems

The single-use water system is preferred.

2. UNALI - VILLAGE

a. Water Situation

There are 250 houses in the village so only one bore is enough to get water for all, however, the bore well water is saline but there is no problem. There is no area in our village where there is a water-related issue. 100% households have a tap connection and water comes for 1 to 1.5 hrs and people can take as much as they want during that time. Chlorine tablets are distributed through some programme by health officials who come to school and village to distribute chlorine tablets. They come once or twice and give to the women in the village. The *Sarpanch* also mentioned that the water quality needs improvement.

b. Sanitation

Almost 70% of the households in the village have toilets. Now 30% are left without toilets and their forms are being filled up (40 forms are filled recently) so that 100% households will have toilets. The toilets are made by the household on their own, Govt. only makes RS. 4,500 subsidy available to motivate households who want to construct a toilet. Toilet construction normally costs 15,000 to 20,000. When we asked if the money is sufficient for BPL families the *Sarpanch* said that it's ok for them. We have all BPL families where they get RS. 9200 under the NREGA scheme and they have to work as labor. So minimum wage is RS. 300 per day. The village also has another scheme called 'Mukhya Mantri Gruh Yojna' where all the *Kutcha* households are being built to pukka (cemented) and a subsidy of 75,000 is given for the same. Four houses in our village are being built at present. These houses will have a toilet and a gutter line.

Nirmal Gram scheme is there which includes first toilets construction, then gutter line, waste disposal. After this, a government employee monitors if we have achieved 100% coverage on these components then the village is declared a Nirmal Gram Village. It takes 10 years to achieve it. I am here since 2 years and the drainage line has been laid.

When we asked if there are changes in the village after the scheme, the *Sarpanch* answered that it was all muddy and dirty before but now with the toilets and gutter line the situation has changed. When we asked about the level of illnesses after the scheme he answered that there is not much change. When we asked that their neighborhood village is declared a Nirmal Gram Village the *Sarpanch* answered that in that village the *Sarpanch* is since last 20 years and here I became the *Sarpanch* since last 2 years only. Someone is needed for longer to get the work done. Here there was no training and we have to go from home to home to make people understand the need to build a household toilet.

c. Drainage, Cleanliness, and Maintenance

For the solid waste management, we have bins that were placed by the Ahmedabad urban development association since last 6 months. Only bins are kept but tractors are not there so where to dispose when bins are full, hence we are not using bins either. When it was asked what they used to do before 6 months when there were no bins then the *Sarpanch* said 'There was nothing, it was littering all the way, everyone used to dump waste here and there'.

In 15 days or a month sweeping is done. Otherwise, village people were sweeping their premises. We don't get laborers in our village for cleaning work, so that is the first problem we have. In the village, if villagers themselves get involved in sanitation campaign it works, people from outside cannot come. People have to create a clean environment in the village where they reside.

When there is a problem in the motor and water is not available to villagers we call for a water tanker and we also have another well in the village. The water in the well is clean. Before when the village was not having a bore well, the villagers used this well only. If sometimes there is a pipeline issue or water quality issue, a person would call and we take the plumber and kit to check. The person comes from outside from Ahmedabad and usually, we don't get someone in time. When we asked if the water, sanitation and waste management is in your hand how do you monitor if something goes wrong and what do you do in such situations? Here there is nothing to change; we hardly manage repairers and sweepers. We do not have them here and it is a problem as it is difficult to have people from Ahmedabad.

For the water logging issues, we have built a gutter line after I became *Sarpanch* in this community. Before you cannot go to the road or pass through school, we have created it now. I had to start from stage zero in this village as there were so many priorities, how can one reach all of them together. I have completed 1.5 years and now in the 5th month, I will complete 2 years. The road behind was constructed; two bores and street light all that I have done. If people were so concerned and the village is next to Ahmedabad, it would not have been so backward. We wish that 100% households have a toilet. The government. subsidy of Rs. 4,500 is there so we have started filling forms and rest of the money villagers shall pay to build a household toilet. The government has also given a cleanliness grant of RS.5, 000 for village cleaning.

Minimum maintenance cost is Rs. 1,500 and then there is a repairing cost of RS. 4,000 to 5,000 if the pipeline breaks. Households pay a tariff of Rs. 250 yearly which includes all taxes for light, water etc. It is difficult to collect tariffs as people do not want to pay taxes.

d. <u>Multi-use or single-use water systems</u>

Single-use is preferred

3. RANCHARDA--VILLAGE

a. <u>Water Situation</u>

Water is continuously available from 5.30-8.30 am. There are 6-7 bores so water is available for 2 to 2.30 hours daily. We have plenty of water and water is being wasted everywhere. All houses have a tap connection except the Vatika tekra area which is at an elevation so Narmada water comes there. We are building a new bore in Vatika tekra area and the work is about to begin. On the tekra area, the BPL families have got subsidies to build houses but there is no change even after the subsidy in that area.

Chlorination of water tank is done by Primary Health Centre. We have good quality as well as the quantity of water. For a new tap connection to the household, the charges are Rs. 1,000 and then a water tariff of RS. 100 per year which households pay to the panchayat.

b. <u>Sanitation</u>

In the newly built houses, we provided toilet and bathroom facility. Vaghrivaas, Chunarvaas have bad hygiene standards and do not have toilets. The government has run sanitation campaign but the idea of having a toilet could not work at Rs. 9,000. One brick costs Rs. 5, a khalkuan (pit) will cost RS. 5,000 - 6,000 so this scheme of Government is wrong. The subsidy schemes for toilet becomes nil by the time it reaches here. The subsidy money is sent from Delhi but by the time it reaches here it is all eaten by the officers, besides staff also keep asking for numerous papers. Hence toilets we made in this village are private and others go out for defecation.

c. <u>Drainage</u>

We have proper gutter lines laid by the government in the entire village and the polluted water gathers in the village pond as there is no other disposal. Also, there is a small pond near the Indus village and there is stagnant polluted water there because of which there are large numbers of mosquitoes around in the area. Before the gutter lines were laid there was no dirt since less water was being used

so there was less dirt. Now what happens is we have more water available, more wash areas, and it is all joined with the gutter line. Because wastewater is not being disposed completely to the ponds and get stagnant there so it is dirty and has many mosquitos. The disposal has become unsuccessful with gutter line planning. From my viewpoint in village areas, there should be no gutter line.

When we (interviewer) said that if there is no gutter line all street would have waste. Water would come on the street if there is no gutter line. To that, the committee member answered that because there is a tap system in the community, if it would not have been the case, this would not happen. If people would have been going out for defecation it would not have been the case. Less water use and less waste lead to automatic control on cleanliness.

d. Cleanliness

The village is mainly clean except certain areas as Vagri vaas, Chunara vaas, Harijans vaas. People have to change their behavior. They litter here and there and eat gutka (betel quid with tobacco) throwing the cover everywhere. We have stopped people going for open defecation along the road. The village cleaning is done by Bhangis every day. There are 4 laborers for it but from last 15 days they have not done the cleaning and that is why the area looks dirty today.

4. GANPATPURA – Village

a. Water Situation

We have a bore well for a total population of 300 people in the village with all houses having a tap connection. The water quality is good and water testing is being done regularly and there are no issues or illnesses in the community. A lady from the Malaria department comes every 15 days with chlorine tablets supply which keeps our water quality good. It's a small village so water comes morning, evening and sometimes on special occasions like wedding, we keep the water supply on the entire day.

b. Sanitation

This village is declared as a Nirmal Gram village and we received an award which we have to collect from Delhi. The Nirmal gram scheme was introduced around one year before when there was a team from Delhi. In this scheme, the toilets were built where RS. 2,500 were given per household and the contractor had built them. Before the scheme 80% had toilets and after the scheme rest 20% toilet construction was done and now all households in the village have toilets.

After the scheme, the situation in the village has changed as nobody goes to the farm for open defecation now. When we asked if it changed the illness situation in the community they answered that 'there was no illness before and after the scheme, in our community'.

c. Drainage, Cleanliness, and Maintenance

We all are Thakor community and the village is very clean. The solid waste disposal is collected and put into bins. When it gets full then a man from Jaspur (a nearby village) would come and burn it. He comes once in a week on Saturdays. This is a private service and we pay them.

There are no water logging issues in the village as we are at the height and always there is cleanliness in our village. It is a small village and we are always clean. We are satisfied with the village situation and no improvement is needed.

Money for maintenance comes from tariff the households would pay but if the households are not paying then we manage the repair at our own expenditure. If things are broken we immediately repair it.

d. Multi-use or single-use water systems

The preference is separate water for drinking and washing using bore well in the community for household purpose and for irrigation purposes Narmada Canal water which the farmers receive in their farms.

5. **SABASPUR VILLAGE**

a. Water Situation

The water facility in the village is good and water is supplied 2-3 times in a day. The village population is 4000 and there is one tube well, also we have made one new tube well with a water tank. The water tank was broken so now we are taking permission to work on it again. There is some water scarcity so we have put the resolution for one more bore and tank. We also get Narmada Canal water but people have found dead bodies in the canal so nobody in the village drinks water from Narmada Canal, it is used for irrigation purposes. We take care that there is no leakage and if there is any we work on it fast.

b. Sanitation

The village comprises of Thakor community so we have toilets. Open defecation is 20%, as now people are more aware and have built 30 ft. toilets. The village is backward as we have 40% BPL families. Those who have a BPL card get everything, they got puccka houses built but toilets are not built. Even if they have a household toilet they go for open defecation. We are now tired of giving them advice, as they are the same after few days. In the village, toilets are not being used mostly.

We do not have any toilets under the government scheme, no Nirmal Gram scheme in this village. There are no community toilets as it is not practical because if 50 people use a community toilet it gets filled in 10 days and then there are water logging issues and no space for final disposal.

c. Drainage

We have gutter lines which drain outside village in farms but the village is at a low level so in monsoon water gets accumulated which is then pumped into farms

d. Cleanliness and Maintenance

We clean houses and collect our waste and go and throw out at the dump. The dustbins are kept near the school near water tank but it gets filled soon. There is no daily door-to-door collection as we do not have Bhangi or Vaghri community in our village. We don't have a sweeper in the village; we are Darbar so we don't do sweeping. We call Bhangi from Usmanabaad after 4-5 weeks but he sweeps and puts the trash in the bin. We don't have any space in the village and we dispose our waste outside so inside is all clean. We spray medicines in monsoon. All areas are clean, but where Thakor stays it always has to be clean. Some of them are educated so they spread awareness of cleanliness etc. too.

We have low tariffs in our village as 40% of the population is poor but if the motor is burnt then it may cost us 25,000 Rs. and the expenses are borne by the *Sarpanch*. When we come to know that the pipeline is broken we would immediately do the needed work and we would also pay from our pocket at that time. The idea is that we don't want villagers to be an inconvenient situation.

Improvements needed– All I want to do is get one tube well in the village so that water is made available in the exterior areas where water is not reaching. The government has given one new water tank and bore so now we are working for it. We need one tube well now so there will be cleanliness and no mud around. Gutter water is not being disposed of as we are a lower level and if it goes back into the land there will be serious issues. So we want to create kuvo (pit) where we can open up all our gutter lines.

e. Multi-use or single use

Single use

6. NAVAPURA- VILLAGE

a. Water Situation

We have laid pipeline for water connection in each house and given connection. But we have one water tank in our village and we don't have enough water to meet our needs. We have to fetch water sometimes from farms 2-4 km away. If the bore functions all day, it doesn't meet the summer needs or special needs like a wedding in the village. We have to call a water tanker in such situations. We tried it but there was no process in the direction of having the second bore for quality water. We had been told to pay 10% community contribution for water tank but in our village people are not ready

as they are poor and laborers. So the work for another bore has not started. Chlorination is not done we just empty the tank and clean it at regular intervals.

b. Sanitation

We have 40-50% households having a household toilet facility and rest 60% go for open defecation. They have to go in open; men can go but it is a big trouble for women as they have to go on roads. There are vehicles coming and going and they can go only in dark.

Under the toilet scheme, we have to build first. A toilet costs around RS. 25,000-30,000 and after that we have to send a photo and they approve 4,600 RS. as support and 1,000 RS. is received from PMC that comes around a total of RS. 7,000. A total of 25-30 toilets are made under the scheme, photos have been taken and money has been given to households. Now the scheme is not working since last 6 months.

c. Drainage

We have gutter lines. In monsoon, there is water logging as there is no outlet so it is problematic.

d. Cleanliness and Maintenance

The area near river bank is clean as it has a gutter line made through WASMO project, which is good. Navanagar area is not clean, where there is no facility for water or toilets. We had Nirmal Gram scheme when we did the cleaning of the roads and dirt, school advertisements but now we have dirty and water logging every day. We don't have enough gutter lines so we have to go outside. Nirmal Gram is not successful in this village.

There is no facility for dump collection and we dump the trash outside towards the farm. There is no government land to dump it.

Water tariff is around 100-150 RS. but we are in the loss as we have gutter line problems bore and motor issues so what we spend is more than what we get as the villagers do not pay on time.

We also do the repair in case of damage and we do pipeline puncture checks and repair at the timely basis.

Benefits of village cleanliness are that we will have clean roads and there will be no illness. For the betterment of the village we need better gutter line facility and then we will have cleanliness. Toilet coverage should be 100% then we will not need to go out for defecating in open. Drinking water has to be good quality. Village cleanliness is a joint responsibility of all villagers and the *Sarpanch*.

e. Multi-use or Single-use systems

Single-use preferred

7. PALODIYA- VILLAGE

a. Water Situation

All households in the community have a tap connection. Even the huts/*kutcha* households have been given connections and water is available for 24 hrs. However, the bore well is old and the water content is not sufficient and it may stop working in a few months. It's almost 14-15 years old bore well and we spend very less for repair while in other villages the monthly expenditure is around RS.10,000. We need one more bore now and we have given an application and paid for another bore but nothing has been done yet. There is no one to push, the *Sarpanch* is new and he is little weak. . We have two tanks and a population of 1200, we have created the second tank with our contacts. We have RO water plant worth RS.10 lac (installed by a charitable organization) from which clean water is available to all villagers free of cost and they can extract 20 liters of water per day per household.

If there are any complaints about water-related issues we send a plumber. We have a plumber employed in the village at a monthly wage of RS. 1700 so there is no other labor expenditure. The maintenance cost for a tap connection is RS. 100 per household and if there is no tap connection it is RS. 50. Also, we have a factory here so a professional tax has been collected of Rs. 1.5 lac every month and other expenditures are also be covered. Hence water tariff collected is enough to meet

the expenses. We also received an award of RS. 10 lac from District and Block as our village is good in cleanliness.

b. Sanitation

Most households in the village have a household toilet, only 1-2% may not have toilets, like 5-10 houses, and work for that is also under process. Very rarely (2-4 households) people would go for open defecation. The government gives Rs. 5,000 once the toilet is constructed by the household. An officer would come to check and then only will give the amount to the household. Besides this Haribhai (charitable organization) has helped households to build toilets if they cannot afford. The raw material for the toilet construction is available through a contractor who works for the village.

We also have 4 community toilets separate for men and women with light and water which are cleaned weekly. The villagers rarely use them as they have a household toilet.

- **Drainage and Maintenance**

We have a gutter (drainage lines) for drainage of household sewage (kitchen) water. And the drain water goes to a pit situated 1 km outside of the village. The drainage lines were laid 2 years before. For the toilets, we have pit latrines.

The door to door collection of waste is done. There are dustbins and sweepers come to sweep every day. After sweeping they dump the waste in a pit (4ft deep) and burn it and we pay for it. Villagers pay tax for it and in our village, the tax collection is 100%. The whole village is clean but the boundary areas are dirty, few places would remain like that only. Littering would happen, near the village pond.

Nirmal gram scheme in the village included cleanliness, sanitation, water facility, education, and good health of villagers, and we have received the Nirmal gram award now. After the Nirmal gram scheme, there is a huge change in the situation of the village as people are now aware and they have built toilets. We have Monthly Gram Sabha meetings, people pay taxes and ask for services. When asked about the illnesses in their village the committee answered that we have an Anganwadi Centre where children get vaccinated, a Primary Health Centre within 2 km, and for emergency services, Bopal area hospitals are nearby (around 6-7kms).

In our village, everyone including the panchayat and the sanitation committee all work together so that the village doesn't get affected in any case. We have a meeting where we address all the issues. We also have gram Sabha meetings 3-4 times in a year where all villagers, teachers, health workers would meet. All the complaints are written and resolved and a report is sent to the block level. There is much coordination in our village and no legal fights or biases.

d. Multi-use or Single-use water system

On the multi-use or single-use water systems, they preferred a separate water supply which is usually borewell in the farms and a separate drinking water supply in the village residential areas as farmers reside in the village and go to their farms in the village vicinity for farming.

Additional Tables

Table A1: Correlation Matrix between hygiene and behavior variables

	Use soap	Clean hands post def.	Waste Disposal safe	No Toilet	Clean Toilet-Poor	Clean Toilet-Good	Hygiene Score-Poor	Average	Good
Use soap	1								
Clean hands post def.	-0.0328	1							
Waste Disposal safe	0.3492	-0.0781	1						
No Toilet	-0.2591	0.0887	-0.1833	1					
Clean Toilet-Poor	-0.169	0.0345	-0.112	-0.3378	1				
Clean Toilet-Good	0.3726	-0.112	0.2586	-0.7802	-0.3253	1			
Hygiene Score- Poor	-0.3785	0.1193	-0.2009	0.3677	0.2354	-0.5259	1		
Average	0.0709	-0.0298	-0.055	-0.0603	-0.1248	0.1436	-0.5855	1	
Good	0.3443	-0.1004	0.2831	-0.3438	-0.1268	0.4296	-0.4785	-0.4317	1

Source: Own calculation from survey data

Table A2 : Caste Category by wealth quintile

	SEBC/ST/SC		General		Total
Caste Category	N	%	N	%	
Poorest	127	97.69	3	2.31	130
Second	131	99.24	1	0.76	132
Third	131	99.24	1	0.76	132
Fourth	128	96.97	4	3.03	132
Wealthiest	75	57.25	56	42.75	131
Total	592	90.11	65	9.89	657

Source: Own calculation from survey data

Table A 3: Outcome Longitudinal prevalence of diarrhea

VARIABLES	Category	Model 5 Incidence Risk Ratios	Standard Error
	Tube well / Rain	1.149	(0.267)
Irrigation water	Wastewater	2.483***	(0.759)
	No farm involvement	1.130	(0.281)
	Away	0.953	(0.164)
Livestock	Seperate animal home	0.967	(0.175)
	No animals	0.994	(0.186)
Farm Labourer		1.151	(0.157)
Hygiene score	Average	1.162	(0.191)
	Good	1.504*	(0.329)
Child's hands washed		1.023	(0.122)
Improved Toilet		0.817	(0.106)
	1-10 Ecoli	1.062	(0.181)
Storage water E coli	11-100 Ecoli	1.365*	(0.218)
	101-1000 Ecoli	1.232	(0.225)
Waste disposal-dump area collection done		1.095	(0.250)
Open defecation		2.172	(1.214)
Village household density		1.009	(0.00696)
Scheduled caste and tribe % in village		1.041***	(0.0154)
Caste-general		0.615*	(0.162)
Education of the caregiver		0.998	(0.124)
	Second	1.019	(0.156)
Wealth Quintile	Third	0.692**	(0.110)
	Fourth	0.996	(0.183)
	Wealthiest	0.777	(0.212)
Village Private doctor		0.577	(0.207)
Age in months		0.999***	(0.000103)
Female		0.884	(0.0896)
sibling diarrhoea		0.795**	(0.0855)
Stunted		1.210*	(0.129)
		0.719*	(0.139)
Garbage collection		0.610	(0.196)
Drainage facility >=.80		2.113	(0.993)
Community drainage Open Kuccha/No drainag		0.471	(0.280)
Village level controls		No	
Constant		1.096	(0.580)
Observations		612	
Hansen's J chi2		6.0499	
p-value		0.0139	

Robust seeform in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix 2

Consent Form

Participation Information Sheet and Informed Consent Form

Name of Project: Exploring the links and dynamics therein for WATSAN and irrigation agriculture (AG-WATSAN Nexus) for a better nutrition and health outcome Gujarat, India

Part I: Information Sheet
Introduction

My name is _____ and in collaboration with the Indian Institute of Public Health, Gandhinagar (IIPHG) and Center for Development Research (ZEF), University of Bonn we are conducting a study that will examine the impact of wastewater irrigation on water sanitation and health. We would like to invite you to be part of this research. We have sampled certain households randomly to collect information on the wastewater irrigation, water, sanitation and health issues. You are one of them and invited to take part in this research and we would appreciate your contribution to our understanding on water sanitation and health in your area.

This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take the time to explain. If you have questions later, you can ask them from me or of another researcher.

Purpose of the research: To analyze the social, environmental, health and economic tradeoffs of the type of water use in agriculture; and eventually identify better strategies of linking water uses for 'WATSAN' and irrigation agriculture activities to improve health and nutrition status.

Type of Research Intervention: This survey will involve your participation as a participant that will take about 45 minutes to complete the information. After this initial questionnaire which will include your demographic, socioeconomic and water quality information we will come to visit on a biweekly basis for 7 months to collect information if you got sick. For the under-five children the mother/caretaker will be asked to give information. The height and weight of under-five kids will be measured as per the WHO anthropometric guidelines.

Voluntary Participation: Your participation in this research is entirely voluntary. It is your choice whether to participate or not. The choice that you make will have no bearing on your job or on any work-related evaluations or reports. You may change your mind later and stop participating even if you agreed earlier.

Benefits of Participation: There will be no direct benefit to you, but your participation is likely to help us find out more about the present burden of water, sanitation and health diseases and eventually identify better strategies of linking water uses for 'WATSAN' and irrigation agriculture activities to improve health and nutrition status in your area.

Reimbursements: You will not be provided any incentive to take part in the research as a compensation for loss of your time. We will acknowledge your contribution in sparing time for us in answering the questions.

Confidentiality: We will not be sharing information about you to anyone outside of the research team. The information that we collect from this research project will be kept private. Any information about you

will have a number on it instead of your name. Only the researchers will know what your number is and we will lock that information up with a lock and key. It will not be shared with or given to anyone.

Right to Refuse or Withdraw: You do not have to take part in this research if you do not wish to do so, and choosing to participate will not affect your job or job-related evaluations in any way. You may stop participating in the interview at any time that you wish without your job being affected. I will give you an opportunity at the end of the interview/discussion to review your remarks, and you can ask to modify or remove portions of those, if you do not agree with my notes or if I did not understand you correctly.

Whom to Contact

If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact Dr. Ruchi Vangani, Indian Institute of Public Health, Gandhinagar, Contact Number: 9898073709; e-mail: vangani.ruchi@gmail.com

You can ask me any more questions about any part of the research study, if you wish to. Before you decide to participate, you can talk to anyone you feel comfortable with about the research.

Do you have any questions?

Part II: Certificate of Consent

Participant Statement:

I have read (or have had read to me) this consent form. I have discussed with the research staff the information in this consent form. I have been given the opportunity to ask questions, and my questions were answered to my satisfaction.

I understand that I may refuse to participate in this study and that if I refuse to participate, this will not result in negative personal repercussions. I agree to participate in this study. I also understand that if, for any reason, I wish to stop participating, I will be free to do so. I have understood the purpose of the study and I am willing to participate in the interview.

Print Name of Participant_____

Signature of Participant _____ Date _____

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands. I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been forced into giving consent, and the consent has been given freely and voluntarily.

Signature of Researcher /person taking the consent_____
Date _____

Focus Group Discussions (FGDs): Themes

WATSAN Qualitative Study: Villagers

1. <u>WATSAN (water and sanitation) situation in the village?</u>

- Your perception about your village in terms of water and sanitation situation?
- From your perspective what areas in the WATSAN in your village are perceived good?
- From your perspective what areas in the WATSAN in your village are perceived bad
- Is open defecation a problem in your village?
- What are the issues related to open defecation in your village?
    - **a.** Effect on Girls and pregnant women
    - **b.** Elderly people
- Is waste a problem in your village? Describe the garbage collection and disposal and preventing water-logging in your village
- Describe the situation of community sanitary complex, school toilets, and anganwadi toilets.
- What is your perception regarding the drinking water?
    - **a.** Multiuse vs. single use water systems and their effect on their lives?
- Is drinking water good and how does it compare between different communities in the village?
- Do you have any complaints about taste, colour or odour
- Do villagers have to stand in line for hours for water collection at the water point
- Is water point at home or 200 m from the house, in this village?
  Water stagnation around the Public Stand Post
    - **a.** Does excess water flows freely in rainy season? Describe situation
    - **b.** Does excess water flows freely in summer season also? Describe situation
    - **c.** Are you happy with surroundings of water point? Describe situation
    - **d.** Have you tried to improve the cleanliness around water point? Describe situation

2. <u>Perception of villagers about the clean environment and its effect on their lives and improvement needed?</u>

- What does a clean and dirty village environment mean to you? Do you consider your village clean? Why yes /why not?
- Do you have any concerns about the environment in which you live, its impact on you and your family?
- Common diseases in the village cholera, diarrhea, diphtheria, dysentery, eye infections, skin rashes, or typhoid, malaria, dengue, chikungunya?
    - What are the most frequent diseases in general and their intensity?
    - Who are the greatest victims of these diseases?
- In your perception is it important to keep the village clean?
- What are the benefits of a clean village?
- Why or why don't you think it's important that your village should be hygienic and clean?
    - System response to combat the WATSAN situation in the village?
    - Whose responsibility is it to keep the village clean?
- Whom do you complain about non-functional/break down of a hand pump?
- Does GP respond to your complaint? How?
- Is there any policy and system for addressing complaint at GP?

- Is the system functioning as per policy?
- What is your perception on the level of cleanliness maintained by the sanitation committee of your village?
- WASH interventions that exist in this village
    - Does Nirmal Gram Scheme exist in the village?
    - When did the scheme start?
    - What did the scheme include:--probe on IEC activities (awareness campaigns, meetings, training, wall posters), infrastructure building (latrines in HH), and subsidies to HH particularly the BPL families, drainage line construction in the village.
    - Was subsidy provided to build WASH infrastructure (latrines) to BPL families?
    - Change in the situation (diseases) before and after the scheme started?
    - Is your village an NG awarded village?
    - Change in the situation before and after the award? ---Probe on % of HH with latrines, garbage removal regularization, their perception on decrease incidence of diseases.
    - Any other WASH interventions (as soap for handwashing, chlorine tablets provided) that exist in your village?

3. <u>What do you think needs improvement in your village</u>

- What could have been improved in your village (specific to WATSAN) so that you are satisfied with the WATSAN situation in your village?

4. <u>In your perception what is more effective in your village: water quantity vs water quality interventions, sanitation vs hygiene interventions, multiple vs single interventions</u>

WATSAN Qualitative Study: Village Sanitation Committee

1. Describe the water and sanitation situation in your village?

- From your perspective what areas in the WATSAN in your village are perceived good?
- From your perspective what areas in the WATSAN in your village are perceived bad
- Population with access to sanitation (latrine) facilities
- Population using open defecation in your village?
- Percentage of household in the village with year-round access to improved water source (Home connected to the pipe system, or home 200 m from water point).
- Quantity of water available per capita per day by villagers (drinking, washing, bathing, cleaning)
- Ask if this village has multi-use water systems or single use water systems in place (explain what is multi-use and what is single use water systems with pictures)
- What is the garbage collection and disposal mechanism in your village?
- What mechanism exists to clear the water logging in the village?

2. System response to combat the WATSAN situation in the village
   - *Planning and design of WASH interventions*
     - What factors do you consider are important when planning and designing WASH interventions to make them sustainable
     - How do you promote or support village level operations and maintenance?
     - How are the complaints related to WATSAN from the villagers processed?
     - How do you plan for maintenance after a system is constructed?
     - How much is the maintenance cost of water and how much is collected as a water bill paid by the community? *(Percentage of recurrent costs for water supply services provided by community)*
       What is your level of (financial) commitment towards post-construction support?

   - *WASH Interventions in existence*
     - WASH interventions that exist in this village
     - Does Nirmal Gram(NG) Scheme exist in the village?
     - When did the scheme start?
     - What did the scheme include:--probe on IEC activities, collaboration with the private sector for infrastructure building (latrines in HH), and subsidies to HH particularly the BPL families, drainage line construction in the village.
     - Was subsidy provided to build WASH infrastructure (latrines) in BPL families?
     - Change in the situation (diseases) before and after the scheme started?
     - Is your village an NG awarded village?
     - Change in the situation before and after the award? ---Probe on % of HH with latrines, garbage removal regularization, their perception on decrease incidence of diseases. Also gently ask the award amount and its utilization in improving the village further.
     - Any other WASH interventions (as soap for handwashing, chlorine tablets provided) that work well in your village?

   - *Monitoring and measures of success*

- What aspects of the WASH intervention do you measure and how does this help improve sustainability?
- When your monitoring results show you that something is not working, how do you correct this?

3. In your perception what is more important water quantity vs water quality interventions, sanitation vs hygiene interventions, multiple vs single interventions

Unique Identification Number_____

HOUSEHOLD QUESTIONNAIRE

IDENTIFICATION

VILLAGE _____

HOUSEHOLD NUMBER . . . . . .

URBAN=1; PERI-URBAN=2;RURAL=3

NAME OF HOUSEHOLD HEAD _____

RELIGION (HINDU=1,MUSLIM=2,CHRISTIAN=3,OTHER=4)

CASTE(SC=1, ST=2, SEBC=3, OTHERS=4)

BPL CARD(YES, CARD SEEN=1, YES CARD NOT SEEN=2, NO=3, D0NT KNOW=4)

DATE Of VISIT — DAY / MONTH / YEAR (2 0)

INTERVIEWER'S NAME _____ — TIME

RESULT* _____ — FINAL RESULT

*RESULT CODES:
1 COMPLETED
2 NOT COMPLETED
(Modules to complete)
3 OTHERS _____
(SPECIFY)

REVISIT DATE — DAY / MONTH / YEAR (2 0)

TOTAL PERSONS IN HOUSEHOLD

TOTAL UNDER 5 CHILDREN

PERSONS HAD FEVER/DIARHEA IN LAST 15 DAYS

Total Number of pregnet women

GPS
N E

SUPERVISOR	OFFICE EDITOR	DATA ENTRY
NAME _____	NAME _____	NAME _____
DATE _____	DATE _____	DATE _____

Now we would like some information about the people who usually live in your household or who are staying with you now.

LINE NO.	RESIDENTS	RELATION-SHIP	SEX	AGE	ELIGIBILITY		EDUCATION		OCCUPATION
	Please give me the names of the persons who usually live in your household starting with the head of the household.	What is the relationship of (NAME) to the head of the household? SEE CODES BELOW.	Is (NAME) male or female?	How old is (NAME)?	CIRCLE LINE NUM-BER OF ALL GIRLS AGE 6 to 59 monts	CIRCLE LINE NUM-BER OF ALL Children AGE 6 to 59 monts	IF AGE 7 YEARS OR OLDER		IF 15 YEARS OR OLDER
							Has (NAME) ever attended school?	What is the highest level of school (NAME) has attended? What is the highest grade (NAME) completed at that level?	What is the occupation of the (NAME)
(1)	(2)	(3)	(4)	(5)	(8)	(6)	(7)	(8)	(9)
			M F	IN YEARS			YES NO	LEVEL	
01			1 2		01	01	1 2 NEXT LINE		
02			1 2		02	02	1 2 NEXT LINE		
03			1 2		03	03	1 2 NEXT LINE		
04			1 2		04	04	1 2 NEXT LINE		
05			1 2		05	05	1 2 NEXT LINE		
06			1 2		06	06	1 2 NEXT LINE		

Q. 3: RELATIONSHIP TO HEAD OF HOUSEHOLD

01 = HEAD
02 = WIFE OR HUSBAND
03 = SON OR DAUGHTER
04 = SON-IN-LAW OR DAUGHTER-IN-LAW
05 = GRANDCHILD
06 = PARENT
07 = PARENT-IN-LAW
08 = BROTHER OR LEVEL:
09 = NIECE/NEPHEW BY BLOOD
10 = NIECE/NEPHEW BY MARRIAGE
11 = OTHER RELATIVE
12 = ADOPTED/FOSTER/ STEPCHILD
13 = NOT RELATED GRADE:
98 = DON'T KNOW

Q. 8: EDUCATIO Q.9 OCCUPATION

EDUCATION LE\
1 = PRIMARY
2 = SECONDAR\
3 = HIGHER
8 = DON'T KNO\

01= FARMER
02=LABOURER
03=BUISNESS
04= SHOPKEPPER
05=OFFICE WORK
06=STUDENT
07=HOUSEWIFE
08=Animal Rearing
09=Retired
10=Unemployed

Unique Identification Number_____

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(1)	(2)	(3)	(4)	(5)	(8)	(6)	(7)	(8)	(9)
07			1 2		07	07	1 2 NEXT LINE		
08			1 2		08	08	1 2 NEXT LINE		
09			1 2		09	09	1 2 NEXT LINE		
10			1 2		10	10	1 2 NEXT LINE		
11			1 2		11	11	1 2 NEXT LINE		
12			1 2		12	12	1 2 NEXT LINE		
13			1 2		13	13	1 2 NEXT LINE		
14			1 2		14	14	1 2 NEXT LINE		

TICK HERE IF CONTINUATION SHEET USED ☐

(2A) To make sure that I have a complete listing: Are there any other persons such as small children or infants that we have not listed? YES ☐ ADD TO TABLE →

2B) Are there any other people who may not be members of your family, like domestic servants, lodgers, or friends who usually live here? YES ☐ ADD TO TABLE →

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HOUSEHOLD CHARACTERISTICS

NO.	QUESTIONS AND FILTERS	Coding Categories	SKIP
104	What is the main source of drinking water for members of your household?	PIPED WATER PIPED INTO DWELLING ..... 1 PIPED TO YARD/PLOT/ ..... 2 PUBLIC TAP/STANDPIPE ..... 3 HAND PUMP ..... 4 TUBE WELL/BORE WELL ..... 5 DUG WELL PROTECTED WELL ..... 6 UNPROTECTED WELL ..... 7 WATER FROM SPRING PROTECTED SPRING ..... 8 UNPROTECTED SPRING ..... 9 RAINWATER ..... 10 TANKER TRUCK ..... 11 CART WITH SMALL TANK ..... 12 SURFACE WATER(RIVER/DAM/ LAKE/POND/STREAM/CANAL/ IRRIGATION CHANNEL ..... 13 BOTTLED WATER..... 14 OTHERS 15 SPECIFY _____	
105	Do you do anything to the water to make it safer to drink?	YES ..... 1 NO ..... 2 DON'T KNOW 8	2→107 8→107
106	What do you usually do to make the water safer to drink? IF MORE THAN ONE METHOD IS MENTIONED, ASK WHICH IS USED MOST OFTEN.	BOIL ..... 01 ADD BLEACH/CHLORINE ..... 02 STRAIN THROUGH A CLOTH ..... 03 USE WATER FILTER (CERAMIC/SAND, ETC) 04 RO (AQUAGUARD ETC) ..... 05 LET IT STAND AND SETTLE ..... 06 OTHER _____ 96 (SPECIFY) DON'T KNOW 98	
107	What kind of toilet facility do members of your household usually use?	FLUSH OR POUR FLUSH TOILET FLUSH TO PIPED SEWER SYSTEM 11 FLUSH TO SEPTIC TANK ..... 12 FLUSH TO PIT LATRINE ..... 13 FLUSH TO SOMEWHERE ELSE ..... 14 FLUSH, DON'T KNOW WHERE ..... 15 PIT LATRINE VENTILATED IMPROVED PIT LATRINE 21 PIT LATRINE WITH SLAB ..... 22 PIT LATRINE WITHOUT SLAB/OPEN PIT 23 COMPOSTING TOILET ..... 31 BUCKET TOILET ..... 41 HANGING TOILET / HANGING LATRINE ..... 51 NO FACILITY/BUSH/FIELD ..... 61 OTHER _____ 96 (SPECIFY)	

NO.	QUESTIONS AND FILTERS	Coding Categories	SKIP
108	The toilet used by your household members is a privately owned or a shared facility?	Privately owned ..... 1 Shared 2	To 110
108a	How many households share the toilet facility used by your family members?	Specify ☐☐ DK 8	
109	How far is the toilet facility from your residence?	NEAR (Between 0-1 km) ..... 1 FAR (1-3km) ..... 2 TOO FAR (>3 km) ..... 3 DK 4	
110	What type of fuel does your household use for cooking?	Main / Secondary ELECTRICITY ..... 1 / 1 LPG/NATURAL GAS ..... 2 / 2 BIOGAS ..... 3 / 3 KEROSENE ..... 4 / 4 COAL/LIGNITE ..... 5 / 5 WOOD ..... 6 / 6 STRAW/SHRUBS/GRASS ..... 7 / 7 AGRICULTURAL CROP WASTE ..... 8 / 8 DUNG CAKES ..... 9 / 9 OTHER ..... 10 / 10	
111	Do you own this house?	YES ..... 1 NO 2	
112	Type of House	KACHHA ..... 1 SEMI-PUCCA ..... 2 PUCCA 3	
113	How many rooms are there in your household including kitchen?	MORE THAN ONE ..... 1 ONLY ONE ROOM 2	2→116
114	How many rooms in this household are used for sleeping?	NUMBER OF ROOMS ☐☐	
115	Do you have a separate room, which is used, as kitchen?	YES ..... 1 NO 2	
116	Do you own any other house anywhere?	YES ..... 1 NO 2	

NO.	QUESTIONS AND FILTERS	Coding Categories	YES	NO	SKIP
117	Does your household have: (NAME)	ELECTRICITY	1	2	
		MATTRESS	1	2	
		PRESSURE COOKER	1	2	
		CHAIR	1	2	
		SOFA SET	1	2	
		COT OR BED	1	2	
		TABLE	1	2	
		ELECTRIC FAN	1	2	
		RADIO OR TRANSISTOR	1	2	
		COLOUR TELEVISION	1	2	
		SEWING MACHINE	1	2	
		MOBILE TELEPHONE	1	2	
		ANY OTHER TYPE OF TELEPHONE	1	2	
		COMPUTER	1	2	
		REFRIGERATOR	1	2	
		WASHING MACHINE	1	2	
		WATCH OR CLOCK	1	2	
		BICYCLE	1	2	
		MOTORCYCLE OR SCOOTER	1	2	
		AN ANIMAL-DRAWN CART	1	2	
		CAR	1	2	
		TRACTOR	1	2	
		WATER PUMP	1	2	
118	Does your household own any of the following?	A.COWS/BULLS/BUFFALOES	1	2	
		B. CAMELS	1	2	
		C. HORSES/DONKEYS/MULES	1	2	
		D. GOATS	1	2	
		E. SHEEP	1	2	
		F. CHICKENS/DUCKS	1	2	
		G. PIGGERY	1	2	
119	Are you and your family covered by a health scheme or health insurance?	YES	1		
		NO	2		2→201
		DK	8		8→201
120	What type of health cover/ health scheme/ health insurance?		**YES**	**NO**	
		EMPLOYEES STATE INSURANCE SCHEME (ESIS)	1	2	
		CENTRAL/STATE GOVERNMENT HEALTH SCHEME	1	2	
		MEDICAL REIMBURSEMENT FROM EMPLOYER	1	2	
		COMMUNITY HEALTH INSURANCE PROGRAMME	1	2	
		MEDICLAIM	1	2	
		OTHER PRIVATELY PURCHASED	1	2	
		OTHER (If Yes Specify)	1	2	

Agricultural Characecteristics

NO.	QUESTIONS AND FILTERS	Coding Categories		Skip
201	What is the main source of earning for the household? (More than one can be encircled)	FARMING	1	
		BUISNESS (SELF)	2	
		OFFICE WORK.....	3	
		DAILY WAGE EARNER	4	
		MILKING ANIMALS	5	
		OTHERS (SPECIFY)	8	
202	Are you or any member of the family engaged in farming?	YES	1	
		NO	2	2->202b
202a	Specify the relationship of the family members going to the farm? (Tick all that apply)	SELF	1	
		FATHER.....	2	
		GRANDFATHER.....	3	
		SONS.....	4	
		BROTHERS.....	5	
		WIFE.....	6	
		DAUGHTERS.....	7	
		OTHERS(SPECIFY).....	8	
202b	The land where the farming is done by you and your family members is?	Own Land	1	
		Rented	2	
		Care taker of land from landlord	3	
		Farm Labourer	4	2->205
204	How much agriculture land does this household own?	UNITS [ ][ ]		
204a	Out of this land, how much is irrigated?	UNITS [ ][ ]		
205	Have you hired labours to work in your farms?	YES (mainly hired workers)	1	
		YES (some hired workers)	2	
		NO	3	
206	How far is the farm from home? Kms	[ ][ ][ ]		
207	What is the main source of water supply for the crops in the farms you irrigate?	CANAL.....	1	
		TUBE WELL.....	2	
		BORE WELL.....	3	
		WASTEWATER.....	4	
		RIVER WATER(UPSTREAM).....	5	
		RIVER WATER(DOWNSTREAM).....	6	
		POND.....	7	
		RAIN WATER	8	
		COLLECTED RAIN WATER.....	9	
		OTHERS (Specify).....	10	

NO.	QUESTIONS AND FILTERS	Coding Categories	Skip
207i	What is the main source of irrigation water between (Use codes from the above qs) Feb to May…… June to Oct…… Nov-Feb……	☐ ☐ ☐	
207a	How much money is spent for the main water source Rs.	☐☐☐☐☐ Yearly Monthly	
208	What is the alternative source of water supply for the crops in the farms you irrigate?	NONE 0 CANAL 1 TUBE WELL 2 BORE WELL 3 WASTEWATER 4 RIVER WATER(UPSTREAM) 5 RIVER WATER(DOWNSTREAM) 6 POND 7 RAIN WATER …… 8 COLLECTED RAIN WATER…… 9 OTHERS (Specify)…… 10	
208a	How much money is spent for the alternate water source ? Rs.	☐☐☐☐☐ Yearly Monthly	
209	How much total money do you spend to irrigate farms? Rs.	☐☐☐☐☐ Yearly Monthly	
210	Do you grow crops all year round? (No--> If No Specify the seasons crops are grown)	Yes 1 No--> Specify 2	
211a	What is the main output from your farm? (More than one can apply)	CEREALS Wheat 1a Rice 1b Jowar 1c Sorghum 1d Millets 1e VEGETABLES 2 Green leafy 2a Seasonal 2b Potatoes 2c SUGARCAINE 3 OIL SEEDS 4 ANIMAL FODDER 5 FRUITS 6 OTHER (Specify) 7	

NO.	QUESTIONS AND FILTERS	Coding Categories		Skip
211b	What is the secondary output from your farm? (More than one can apply)	CEREALS	1	
		Wheat	1a	
		Rice	1b	
		Jowar	1c	
		Sorghum	1d	
		Millets	1e	
		VEGETABLES	2	IF NO SKIP TO 214
		Green leafy	2a	
		Seasonal	2b	
		Potatoes	2c	
		SUGARCAINE	3	
		OIL SEEDS	4	
		ANIMAL FODDER	5	
		FRUITS	6	
		OTHER (Specify)	7	
212	Do you consume the vegetables grown in your farms? (If vegetables in 211a or 211b)	YES	1	
		NO	2	
213	How far do you have to travel to sell your vegetables? Kms			
214	How is water transported to the field?	SURFACE	1	
		LOCALIZED-Drip,Spray,sprinkler	2	
		MANUAL-BUCKETS	3	
		AUTOMATIC-NON ELECTRIC-BUCKETS	4	
		OTHERS (SPECIFY)	5	
215	What do you think is the quality of water you use in farming?	CLEAN	1	
		CONTAMINATED-SEWAGE	2	
		CONTAMINATED-INDUSTRIAL	3	
		CONTAMIATED-BOTH	4	
216	Are there any problems related to irrigation water in the farms? (Tick all that apply)	NO PROBLEM	1	
		SCARCE SUPPLY	2	
		NOT AVAILABLE THE WHOLE YEAR	3	
		POOR QUALITY	4	
		FOUL SMELL	5	
		INFECTIONS	6	
		MOSQUITOS	7	
		OTHERS	8	
		(Specify)		
217	What peventive measures do you take to protect yourselves from contaminated water used in fields?	WEAR PROTECTVE FOOTWEAR IN FARMS	1	
		WASH HANDS AND FEET AFTER WORK	2	
		WASH HANDS BEFORE EATING	3	
		VISIT THE PHC TO RECIEVE ANTIHELMINTHIC TABLETS for children	4	
		OTHERS	5	
		(Specify)		

Unique Identification Number_____

Water and Sanitation Baseline Survey

(Can we request the female (eldest) from your family to answer the water and sanitation related questions of the survey)

NAME OF RESPONDENT _____	
Line Number (From household questionnaire) ……..	☐☐
Gender (Male=M, Female=F) …….	☐☐
Age ……..	☐☐
Time of form filling	

SUPERVISOR	OFFICE EDITOR	DATA ENTRY
NAME _____	NAME _____	NAME _____
DATE _____	DATE _____	DATE _____

Water and Sanitation Baseline Survey

Q1:Source of water

Source		Drinking		other HHs Activities, Bathing,Washing clothes		Live- stock	
	Code	Sum	non-sum	Sum	non-sum	Sum	non-sum
TWAD Domestic Connection	1						
Public tap	2						
Hand pump(public)	3						
Hand pump(private)	4						
Tanker supply-Town Panchayat	5						
Tanker supply–NGO	6						
Ponds	7						
River	8						
Open well	9						
Private vendor	10						
Others	11						

Can we take a sample of your drinking water for testing?	Yes No
Specify from where is the sample collected	

1. Stored Water container
2. Source water

Record the time of tap water

Unique Identification Number_____

No.	Questions	Coding Categories			Skip
2	Distance that you have to go in order to fetch water for domestic uses?	Distance	Sum	Rain	
		No Travel(Home Tap)	S0	R0	→ if no skip to Q 4a
		Less than 50 m	S1	R1	
		50 – 100 m	S2	R2	
		100 m to 200 m	S3	R3	
		200 m to 500 m	S4	R4	
		More than 500 m	S5	R5	
3	What is the frequency of drinking water supply in 24 hrs?	Once ..... 1 Twice ..... 2 Thrice ..... 3 All day 4			
3a	For how much time does the water comes from tap? Hrs	☐☐			
4	How much is your tap bill? Rs.	☐☐☐☐ Montly / Yearly			skip to Q5
4a	How much money per month do you spend on water? Rs. (For those without tap connection at home)	☐☐☐☐ Monthly / Yearly			
5	How much time do you spend in a day to collect water? (In hrs.) (For those without tap connection at home)	SUMMER ☐☐ RAIN ☐☐ WINTER ☐☐			
6	What are the problems you find in your major water supply? (Tick all that apply)	No Problem..... 1 Water is dirty..... 2 Water is Saline..... 3 Supply is irregular..... 4 Source is far..... 5 Source dries ..... 6 Others(Specify) 7			
7	Who collects water for domestic purposes? (Tick all that apply)	Women .... 1 Men ..... 2 Girls under 15 yrs of age ..... 3 Boys under 15 yrs of age ..... 4 Others ..... 5 (Specify)			

No.	Questions	Coding Categories	Skip
8	What type of container do you use to store drinking water in your house? (Mainly)	Clay pots 1 Stainless Steel pots/vessels 2 Brass/Copper pots 3 Plastic containers 4 Others 5 (Specify) 6	
9	What is the size of your water storage container? (drinking)	Specify in Litres ☐☐	
10	How often do you refill your water storage container? (drinking)	Specify times per day ☐☐	
11	How often do you clean your water storage container? (drinking)	Daily ..... 1 Weekly ..... 2 Monthly ..... 3 Yearly ..... 4 Don't Know 5	
11a	How do you clean the water container?	Rinse with water 1 Mud 2 Detergent 3 Don't know 4	
12	Do you have a separate container for storing water for other household purposes (cleaning, washing)	Yes..... 1 No..... 2	
13	What is the size of your water storage container? (Cleaning,washing)	Specify in Litres ☐☐☐☐	
14	How often do you refill your water storage container? (Cleaning,washing)	Specify times per day ☐☐	
15	Where do you take baths?	Bathroom Inside ..... 1 Bathroom outside ..... 2 Well ..... 3 River/Stream ..... 4 Other(Specify) 5	
16	How often do you bath your children? (less than 5 yr old)	Every day ..... 1 Most days ..... 2 Weekly ..... 3 Monthy 4	

No.	Questions	Coding Categories		Skip
17	Where are clothes washed?	Bathroom Inside	1	
		Bathroom outside	2	
		Well	3	
		River/Stream	4	
		Other(Specify)	5	
18	How often do you wash your cloths?	Every day	1	
		Most days	2	
		Weekly	3	
		Monthy	4	
19	When do you clean your hands?	After work	1	
		After cleaning dish	2	
	(Tick all that apply)	After cleaning vessels	3	
		Before food	4	
		After defecation	5	
		After washing children's bottom	6	
		Others(Specify)	7	
20	What cleansing agent do you use to wash your hand after defecation?	Nothing	1	
		Soap	2	
		Ash	3	
		Sand	4	
		Others (specify)	5	
21	How often do you wash your children's hands throughout the day?	Never	1	
		Once	2	
		Twice	3	
		Three times	4	
		Four Times	5	
		More than 4 times	6	
		Other(Specify)	7	

No.	Questions	Coding Categories	Skip
22a	Do you use rain water?	YES 1 NO 2	1→23 2→22
22	Why don't you use rain water as a major source of drinking water in rainy season?	Rain water not clean ..... 1 Bad Taste ..... 2 Other sources Nearby ..... 3 Others(Specify) 4	skip to28
23	How long do you keep rain water for future use?	Not Keeping ..... 1 One week ..... 2 Two weeks ..... 3 One month ..... 4 More than one month 5	
24	What is your rain water storage facility?	Ltr No Storage Vessels Jars Tanks	
25	What are the positive aspects of rain water collection and usage?	Abundance of water ..... 1 No smell ..... 2 No colour ..... 3 Reduction in diseases ..... 4 Getting water near by ..... 5 Others(Specify) ..... 6 Don't know 7	
26	What are the negative aspects of rain water collection and usage?	Not Clean ..... 1 Bad Taste ..... 2 Colour ..... 3 Causes disease ..... 4 Others(Specify) ..... 5 don't know	
27	Obstacles in making a sustainable/ permanent rain water harvesting facility?	No obstacles ..... 1 No interest ..... 2 No money ..... 3 No space ..... 4 Germs grow in stored water ..... 5 Others(Specify) 6	

28 Where do different members of your household defecate?

	Men	Women	Under 5 Children	Old	Disabled/ Diseased	Pregnant women/post delivery
Own latrine						
Community latrine						
Pit latrine						
Shrubs, bushes						
Near River/water body						
Faecal matter picked away						
Any other (Specify)						

No.	Questions	Coding Categories		Skip/Comments
29	What are the issues related open defecation?	No Privacy	1	To be asked even if the household members do not use open defaecation
		Low status in society	2	
		Has to walk long distance	3	
		Has to wake up in the morning… ..	4	
		Difficult during rainy season…... … ...	5	
		Difficut for adolescent females….	6	
		Difficult during pregnancy and delivery	7	
		Difficult for old and disabled	8	
		Illness worsens the situation……. ...	9	
		Water Pollution	10	
		Environment Pollution	11	
		Fly menace	12	
		Fowl smell	13	
		Diseases common	14	
		Time loss	15	
		Others(Specify)	16	
30	Where do you dispose of your household waste? (Kitchen and Other solid waste)		Kitchen waste / Solid waste	
		Throw in the backyard	K1 / S1	
		Throw in open spaces	K2 / S2	
		Deposit in the dumping space..	K3 / S3	
		In the canal	K4 / S4	
		In the river	K5 / S5	
		In the sea	K6 / S6	
		Burying	K7 / S7	
		Burning	K8 / S8	
		Collected by town panchayat….	K9 / S9	
		Collected by NGO	K10 / S10	
		Others (Specify)		
31	Is waste a problem where you live?	No problem	1	
		Bad smell	2	
		Clogging of canals	3	
		Makes the village dirty	4	
		Causes mosquito menace	5	
		Causes stray dog menace	6	
		Pollutes water sources	7	
		Causes flies menance ……	8	
		Others (Specify) ……	9	

No.	Questions	Coding Categories	Skip/Comment
32	Present methods of waste water disposal?	In the road ..... 1 Water reservoir ..... 2 Backyard ..... 3 Plants ..... 4 Leach pits ..... 5 Drainage ..... 6 Others (specify) 7	
33	What measures do you take against mosquitoes?	No measures ..... 1 Use mosquito nets 2 Mosquito Coils ..... 3 Clears stagnant water ..... 4 Larvicides ..... 5 Creams ..... 6 Liquid repellent ..... 7 Neem Smoke ..... 8 Electric mosquito repellents 9 Others (specify) 10	
34	At any time in the past 12 months, has anyone sprayed the interior walls of your dwelling against mosquitoes?	YES . . . . . 1 NO . . . . . 2 DOES NOT KNOW 3	if no skip to 37
35	How many months ago was the house sprayed?	Months ago	
36	Who sprayed the house?	GOVERNMENT WORKER / PROGRAM ..... 1 PRIVATE COMPANY . . . . 2 HOUSEHOLD MEMBER . . . . 3 OTHER _____ 4 (SPECIFY) DOES NOT KNOW 5	
37	What are the common diseases in your village?	Diarrhoea ..... 1 Chikun gunya ..... 2 Skin diseases ..... 3 Malaria ..... 4 Typhoid ..... 5 Hepatitis/ ..... 6 Filariasis ..... 7 Dengue fever ..... 8 Lepto spirosis ..... 9 Others (Specify) ..... 10 DK 11	

No.	Questions	Coding Categories		Skip/Comment
38	What are the three diseases that your family has suffered from during last three months?	Diarrhoea	1	
		Chikun gunya	2	
		Skin diseases	3	
		Respiratory infection	4	
		Malaria	5	
		Typhoid	6	
		Hepatitis/	7	
		Filariasis	8	
		Dengue fever	9	
		Lepto spirosis	10	
		Others (Specify)	11	
		DK	12	
39	What causes diarrhoea, in your knowledge/ opinion? (Tick all that apply)	Germs	1	
		Dirty Food	2	
		Dirty water	3	
		Open deecation	4	
		Uncleanliness/bad hygiene	5	
		Flies	6	
		Mosquitos	7	
		Other(Specify)	8	
		DK		
40	What is the best way to prevent diarrhoea? (Tick all that apply)	Washing hands with soap	1	
		Use of latrines	2	
		Use clean drinking water	3	
		Food covered	4	
		Control of Flies	5	
		Control of Mosquitos	6	
		Others	7	
		(Specify)		
		DK		
41	What do you do when your child gets diarrhoea? (Tick all that apply)	Give ORS	1	
		Give more fluids	2	
		More breast feeding	3	
		Indigenous medicine	4	
		Go for health service/take to doctor	5	
		Other(Specify)	6	
42	How do you make ORS ?	Correct answer	1	
		Incorrect answer	2	
		Not responded	3	
		Don't Know	4	

ORS Preperation (correct method)

Put the contents of the ORS packet in a clean container.

Check the packet for directions and add the correct amount of clean water.

(Remember:Too little water could make the diarrhea worse).

***Add water only** . Do **not** add ORS to milk, soup, fruit juice or soft drinks. Do **not** add sugar*

***Stir well, and feed it to the child from a clean cup** . Do not use a bottle*

No.	Questions	Coding Categories		Skip/Comment
43	Have you ever received any information on water, sanitation, waste management or health?	Not received any information	1	
		From Hospital	2	
		From Anganwadi	3	
		From Health Worker	4	
		Radio	5	
		TV	6	
		Newspaper	7	
		Programmes of NGOs	8	
		During trips outside the village	9	
		Other(Specify)	10	
44	Did any health worker visit your house in the last 3 month?	NO	1	
		YES-once	2	
		YES- Twice	3	
		YES-3 or more times	4	
		Do not Know	5	
45	What are the attributes of a clean and healthy village? (tick all that apply)	Every household owns a latrine	1	
		Every individual uses a latrine including children	2	
		No waste scattered around	3	
		No waste water stagnant around	4	
		Water bodies are clean	5	
		Clean drinking water availability	6	
		The market place is clean	7	
		Clean public places	8	
		Clean river shore	9	
		All institutions are clean	10	
		Healthy citizen	11	
		No flies	12	
		No mosquitoes	13	
		Other(Specify)	14	
46	What are the benefits if your village becomes a clean village? (tick all that apply)	Status of the village improved	1	
		Status of villagers improved	2	
		No communicable diseases	3	
		Increase the beauty of the village	4	
		Healthy community	5	
		Healthy generations	6	
		Other(Specify)	7	

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
47	Who prepares food in your household? (Tick all that apply)	Self ..... 1 Wife ..... 2 Mother ..... 3 Sister ..... 4 Daughter ..... 5 Other Relative ..... 6 Not Related ..... 7 Sister/Brother 8	
48	Where is food usually prepared?	Flour Inside House ..... 1 Flour Ourside house ..... 2 Cutting Board ..... 3 Raised Counter/Table ..... 4 Kitchen ..... 5 Month 6	
49	What water do you use to wash food before cooking?	No wash 1 Water used in cooking 2 Water stored for washng hands 3 Drinking water 4	
50	How often have you eaten away from home in the past 7 days?	# DAYS ☐	
51	What foods have you eaten in the past seven days?	Raw 1 Cooked 2 Own Produce 3 Friends/Neighbours farm produce 4 Market 5 Supermarket 6	
52	Where do you keep food in house	No Storage ..... 1 Refrigerator ..... 2 Closed Cupboard ..... 3 Open cupboard 4	
53	What vegetable do you consume raw? (Specify)		
54	What fresh fruit are availble to you? (Specify)		
64	Please explain your dieatry pattern	No Meal ..... 1 Tea Only ..... 2 Raw Food only ..... 3 Full meal ..... 4 Snacks ..... 5 Others(specify) 6	

Observation Format

No.	Questions	Coding Categories			Skip/Comments
1	Drinking water storage	Water not stored……	1		
		Stored in covered container……..	2		
		Stored in open container……..	3		
			Yes	No	
2	Drinking water collection points	Cleanliness……..			
		Plat form……			
		Drain facility……..			
			Yes	No	
3	Solid and liquid waste in the courtyard	Kitchen waste……			
		Plastic waste……			
		Human/animal excreta…….			
		Stagnant water……..			
4	Latrine (Individual or community)				
	Latrine	Not allowed to check	1		
		No latrine……	2		
		Own latrine……	3		
		Attached to house……	4		
		Separate……	5		
		Community latrine……	6		
5	Functionality		Good	Bad	
		Pit condition……			
		Structure……			
		Closet condition……			
		Floor……			
6	Cleanliness		Good	Bad	
		Closet……			
		Floor……			
		Surroundings……			
7	Bathroom	No bath room……	1		
		Attached to house……	2		
		Separate……	3		
		Drain facility……	4		

Hygiene Index

Category	Items	Score	Index
Environment	Fecal contamination / waste piles / stagnant water/ free roaming animals	-1	
	Significant number of flies / some waste /restraint animals	0	
	No sign of contamination / insignificant number of flies	1	
Sanitation	No sanitation / open defecation	-1	
	Unimproved sanitation / no water access /fecal contamination	0	
	Improved sanitation with water access	1	
Water	Unimproved drinking water source /water source visibly polluted / water storage container polluted /no water availble from source	-1	
	Water storage container not covered /inadaquat withdrawl method	0	
	Improved water source with adaquate water storage	1	
Food	Inadaquate food storage /significant number of flies / kitchen area contaminated	-1	
	Food stored uncovered/ food stored on the ground / dirty dishes	0	
	Food stored covered and raised / clean dishes covered	1	
Personal	Visible sign of dirt under finger nails /dirty hands / black or red teeth	1	
	Dirty cloths / not wearing shoes	0	
	Clean hands, cloths, teeth, wearing shoes	1	

[1.2] consumption of edible oil, egg, fish and meat, vegetables, fruits, spices, beverages and processed food and pan, tobacco and intoxicants during the last *7* days ended on …….....

item	code	consumption out of home produce		total consumption		source$
		quantity	value (Rs.)	quantity	value (Rs.)	
1	2	3	4	5	6	7
vanaspati, margarine	190					*
mustard oil	191					
groundnut oil	192					
edible oil: others	194					
edible oil: s.t. (190-194)	199					
eggs (no.)	200					
goat meat/mutton	202					
chicken	205					
egg, fish & meat: s.t. (200-206)	209					
potato	210					
onion	211					
other vegetables	242					
vegetables: s.t. (210-242)	249					
fruits (fresh): s.t.(250-268)	269					
coconut: copra	270					
groundnut	271					
dates	272					
cashewnut	273					
walnut	274					
other nuts	275					
raisin, kishmish, monacca, etc.	276					
other dry fruits	277					
fruits (dry): s.t. (270-277)	279					

***$Source code** : only purchase –1, only home-grown stock –2, both purchase and home-grown stock –3, only free collection –4, only exchange of goods and services –5, only gifts / charities – 6, others –9*

*Source code cannot be 2, 3 or 4 for these items. For home-processed items consumption should be recorded against ingredients.

[1.2] consumption of edible oil, egg, fish and meat, vegetables, fruits, spices, beverages and processed food and pan, tobacco and intoxicants during the last *7* days ended on …….

item	code	consumption out of home produce		total consumption		source$
		quantity	value (Rs.)	quantity	value (Rs.)	
1	2	3	4	5	6	7
garlic (gm)	280					
ginger (gm)	281					
turmeric (gm)	282					
pepper (gm)	283					
curry powder (gm)	286					
other spices (gm)	288					
spices: s.t. (280-288)	289					
tea : leaf (gm)	291					
coffee: powder (gm)	293					
mineral water (litre)	294					
cold beverages: bottled/canned(litre)	295					*
other beverages: cocoa, chocolate,etc.	297					*
biscuits (બીસ્કીટ)	298					*
other processed food	308					*
beverages, etc.: sub-total (290-308)	**309**					
pan	320					
bidi (no.)	321					
cigarettes (no.)	322					
leaf tobacco (gm)	323					
snuff (gm)	324					
zarda, kimam, surti (gm)	325					
other tobacco products	326					
tobacco: s.t. (320-327)	**329**					
ganja (gm)	330					
other intoxicants	335					
intoxicants: s.t. (330-335)	**339**					

***$Source code** : only purchase –1, only home-grown stock –2, both purchase and home-grown stock –3, only free collection –4, only exchange of goods and services –5, only gifts / charities – 6, others –9*

*Source code cannot be 2, 3 or 4 for these items. For home-processed items consumption should be recorded against ingredients.

Expenditure module

[1.1] consumption of cereals, pulses, milk and milk products, sugar and salt during the last *30* days ended on .....

Item	Code	Consumption out of home produce		Total consumption		Source code
		Quantity	Value(Rs.)	Quantity	Value(Rs.)	
1	2	3	4	5	6	7
Rice– PDS	101					1
Rice-other sources	102					
other rice products	106					*
wheat/ atta – PDS (ઘઉં)	107					1
wheat/ atta – other sources	108					
maida	110					
suji, rawa	111					*
other wheat products	114					*
jowar & its products	115					
bajra & its products	116					
maize & products	117					
barley & its products	118					
other cereals	122					
cereal: sub-total (101-122)	**129**					
cereal substitutes: tapioca, etc.	**139**					
arhar, tur	140					
gram	142					
moong	143					
other pulses	148					
gram products	150					
other pulse products	152					
pulses & pulse products: s.t. (140-152)	**159**					
milk: liquid (litre)	160					
curd	163					*
ghee	164					*
butter	165					*
other milk products	167					*
milk & milk products: s.t.(160-167)	**169**					
sugar - PDS	170					1
sugar - other sources	171					*
gur	172					*
sugar: s.t. (170-174)	**179**					
salt (મીઠું)	**189**					

@Unit is kg unless otherwise specified in col(1).

***$Source code** : only purchase –1, only home-grown stock –2, both purchase and home-grown stock –3,*
only free collection –4, only exchange of goods and services –5, only gifts / charities – 6, others –9

*Source code cannot be 2, 3 or 4 for these items. For home-processed items consumption should be recorded against ingredients.

[6] expenditure on miscellaneous goods and services including medical (non-institutional), rents and taxes during the last 30 days ended on ….....

Item	code	value(Rs.)
1	2	3
cinema, theatre	430	
mela, fair, picnic	431	
sports goods, toys, etc.	432	
goods for recreation and hobbies	434	
cable TV	437	
other entertainment	438	
entertainment: sub-total (430-438)	**439**	
spectacles	440	
lock	442	
umbrella, raincoat	443	
lighter (bidi/ cigarette/ gas stove)	444	
other minor durable-type goods	445	
minor durable-type goods: sub-total (440-445)	**449**	
domestic servant/cook	480	
sweeper	482	
barber, beautician, etc.	483	
washerman, laundry, ironing	484	
tailor	485	
grinding charges	486	
telephone charges: landline	487	
telephone charges: mobile	488	
miscellaneous expenses	491	
priest	492	
repair charges for non-durables	494	
other consumer services excluding conveyance	496	
consumer services excluding conveyance: sub-total (480-496)	**499**	
toilet soap	450	
toothpaste, toothbrush, comb, etc.	451	
powder, snow, cream, lotion and perfume	452	
hair oil, shampoo, hair cream	453	
shaving blades, shaving stick, razor	454	
shaving cream, aftershave lotion	455	
other toilet articles	457	
toilet articles: sub-total (450-457)	**459**	

[6] expenditure on miscellaneous goods and services including medical (non-institutional), rents and taxes during the last 30 days ended on ….....

Item	code	value(Rs.)
1	2	3
electric bulb, tubelight	460	
electric batteries	461	
other non-durable electric goods	462	
earthenware	463	
glassware	464	
bucket, water bottle/ feeding bottle & other plastic goods	465	
coir, rope, etc.	466	
washing soap/soda/powder	467	
other washing requisites	468	
flower (fresh): all purposes	471	
mosquito repellent, insecticide, acid etc.	472	
other petty articles	473	
other household consumables:sub-total (460-473)	**479**	
air fare	500	
railway fare	501	
bus/tram fare	502	
taxi, auto-rickshaw fare	503	
rickshaw (hand drawn & cycle) fare	505	
petrol for vehicle	508	
diesel for vehicle	510	
lubricants & other fuels for vehicle	511	
school bus, van, etc.	512	
other conveyance expenses	513	
conveyance: sub-total (500-513)	**519**	
house rent, garage rent (actual)	520*	
hotel lodging charges	521	
residential land rent	522*	
other consumer rent	523	
rent: sub-total (520-523)	**529**	
house rent, garage rent (imputed-urban only)	**539**	
water charges	540*	
other consumer taxes & cesses	541*	
consumer taxes and cesses: sub-total (540-541)	**549**	

[2] consumption of energy (fuel, light and household appliances) during the last *30* days ended on…....

item	code	consumption out of home produce		total consumption		sources
		quantity@ 0	value (Rs.)	quantity@ 0	value (Rs.)	
1	2	3	4	5	6	7
firewood and chips	341					
electricity (std. unit)	342					
dung cake	343					
kerosene – PDS (litre)	344					1
kerosene – other sources (litre)	345					
coal	347					
LPG [excl. conveyance]	348					*
charcoal	350					
petrol (litre) [excl. conveyance]	353					*
diesel (litre) [excl. conveyance]	354					*
other fuel	355					
fuel and light: s.t. (340-355)	**359**					

@Unit is kg unless otherwise specified in col(1).

s***Source code*** *: only purchase –1, only home-grown stock –2, both purchase and home-grown stock –3, only free collection –4*

, only exchange of goods and services –5, only gifts / charities – 6, others –9. *Source code cannot be 2, 3 or 4 for these items.

[3] consumption of clothing, bedding, footwear etc. during the last *365 days* ended on ……..……

Item	code	quantity	value(Rs.)
1	2	3	4
clothing: sub-total (360-374)	**379**		
bed sheet, bed cover (no.)	380		
rug, blanket (no.)	381		
pillow, quilt, mattress (no.)	382		
bedding, etc.: s.t. (380-387)	**389**		
footwear: sub-total (390-395)	**399**		

[5] expenditure on education and medical (institutional) goods and services during *the last 365 days* ended on…….

item	code	value (Rs.)
1	2	3
books, journals	400	
newspapers, periodicals	402	
stationery, photocopying charges	404	
tuition and other fees (school, college, etc.)	405	
private tutor/ coaching centre	406	
educational CD	407	
other educational expenses	408	
education: s.t. (400-408)	**409**	
medicine	410	
X-ray, ECG, pathological test, etc.	411	
doctor's/surgeon's fee	412	
hospital & nursing home charges	413	
other medical expenses	414	
medical - institutional: s.t. (410-414)	**419**	

[7] expenditure for purchase and construction (including repair and maintenance) of durable goods for domestic use during the last 365 days ended on …….....

item		Purchase	
description	code	Quantity	value(Rs.)
1	2	3	4
almirah, dressing table	551		
chair, stool, bench, table	552		
suitcase, trunk, box, handbag and other travel goods	553		
foam, rubber cushion	554		
carpet, *daree* & other floor mattings	555		
paintings, drawings, engravings, etc.	556		
other furniture & fixtures (couch, sofa, etc.)	557		
furniture & fixtures:sub-total (550-557)	**559**		
television	561		
VCR/VCD/DVD player	562		
camera & photographic equipment	563		
other goods for recreation	566		
goods for recreation: sub total (560-566)	**569**		
crockery & utensils: sub-total (570-573)	**579**		
electric fan	580		
air conditioner, air cooler	581		
lantern, lamp, electric lampshade	582		
sewing machine	583		
washing machine	584		
stove	585		
refrigerator	587		
water purifier	588		
electric iron, heater, toaster, oven & other electric heating appliances	590		
other cooking/ household appliances	591		
cooking & other household appliances: sub-total (580-591)	**599**		

[7] expenditure for purchase and construction (including repair and maintenance) of durable goods for domestic use during the last 365 days ended on …….....

item		Purchase	
description	code	Quantity	value(Rs.)
1	2	3	4
bicycle	600		
motor cycle, scooter	601		
motor car, jeep	602		
tyres & tubes	603		
other transport equipment	604		
personal transport equipment : sub-total (600-604)	**609**		
contact lenses, hearing aids & orthopaedic equipment	610		
other medical equipment	611		
therapeutic appliances sub total (610-611)	619		
clock, watch (ઘડિયાળ)	620		
other machines for household work	621		
PC/ Laptop/ other peripherals incl. software	622		
Mobile handset	623		
telephone instrument (landline)	624		
any other personal goods	625		
other personal goods: sub-total (620-625)	**629**		
bathroom and sanitary equipment	630		
plugs, switches & other electrical fittings	631		
residential building & land (cost of repairs only)	632		
other durables (specify)….....	633		
residential building, land and other durables: sub- total (630-633	**639**		
Jewelers and Ornaments: sub-total (640-643)	649		
durable goods: total (559+569+579 599+609+619+629+639+649)	659		

Household's Income in the last 12 months

	Code	Cash	(value)
Current transfers and other benefits			
Pension and life insurance annuity benefits			
Family allowances			
Social security benefits			
Remittances and assistance received from others			
Other income (inheritance, scholarship and other unspecified income)			
Income from Farm Business			
Crop farming			
Livestock			
Other			
Income from non-farm business			
Household based enterprises			
Non-household based enterprises			
Income from Employment			
Salary/wage			

[8] summary of consumer expenditure

srl. no.	item description	reference			value of consumption (in Rs)
		block	item	column	**during last 30 days**
1	2	3	4	5	6
1	cereals	1.1	129	6	
2	cereal substitute	1.1	139	6	
3	pulses & products	1.1	159	6	
4	milk & milk products	1.1	169	6	
5	sugar	1.1	179	6	
6	salt	1.1	189	6	
7	**sub-total (1-6)**				
					during last 7 days
8	edible oil	1.2	199	6	
9	egg, fish & meat	1.2	209	6	
10	vegetables	1.2	249	6	
11	fruits (fresh)	1.2	269	6	
12	fruits (dry)	1.2	279	6	
13	spices	1.2	289	6	
14	beverages etc.	1.2	309	6	
15	pan	1.2	319	6	
16	tobacco	1.2	329	6	
17	intoxicants	1.2	339	6	
18	**sub-total (8-17)**				
19	**(30÷7) × srl. no. 18**				
					during last 30 days
20	fuel and light	2	359	6	
22	entertainment	6	439	3	
23	minor durable-type goods	6	449	3	
24	toilet articles	6	459	3	
25	other household consumables	6	479	3	
26	consumer services excl. conveyance	6	499	3	
27	conveyance	6	519	3	
28	rent	6	529	3	
29	consumer taxes & cesses	6	549	3	
30	**sub-total (20 – 29)**				
					during last 365 days
31	clothing	3	379	4	
32	bedding etc.	3	389	4	
33	footwear	3	399	4	
34	education	5	409	3	
35	medical (institutional)	5	419	3	
36	durable goods	7	659	4	
37	**s.t. for 365 days' data (31-36)**				
38	**(30÷365) × srl. no. 37**				
39	srl. nos.(7 + 19 + 30 + 38) [monthly household consumption expenditure]				
40	household size	3	1	×	
41	imputed rent	10	539	3	
42	**monthly per capita expenditure (Rs. 0.00) [srl. no. 39 ÷ srl. no. 40]**				

Under 5 Children Questionnaire:Age and Feeding Practices Module

	Note all under 5 kids in the household (Record from household schedule) Child Line Number:					
	Questions	Name:				Skip
1	I would like to ask you some questions about (Name of Child) What is your relationship to (Name of Child))?					
		MOTHER (line number)	_____	_____	_____	
		FATHER (line number)	_____	_____	_____	
		OTHER (line number)	_____	_____	_____	
		(Specify Relationship)				
BR1	Does (name)have a birth certificate? If yes, ask:May I see it?					
	Yes, seen		1	1	1	
	Yes, not seen		2	2	2	
	No		3	3	3	
	DK		8	8	8	
BR2	On what day, month and year was (name) born?	Day	_____	_____	_____	
		DK	99	99	99	
		Month	_____	_____	_____	
		DK	99	99	99	
		Year	_____	_____	_____	
		DK	99	99	99	
BR3	How old is (name)?	Yrs	_____	_____	_____	
		Months	_____	_____	_____	
BR4	Where was the (Name) delivered?	Home	1	1	1	
		Health Centre/Hospital	2	2	2	
		DK	8	8	8	
BR5	What was (name) his/her birth weight (kgs)?	Card	☐☐	☐☐	☐☐	
		Memory	☐☐	☐☐	☐☐	
		Don't Know	X	X	X	

	Note all under 5 kids in the household (Record from household schedule) Child Line Number:	_____	_____	_____	
	Questions Name:				Skip
BR6	How many Antenatal visits did the mother go for before (name) birth?	____ Dk	____ Dk	____ Dk	
BR7	What is the birth order(name) of ?	__/__	__/__	__/__	
BR8	What is the age difference between of (name) his/her elder sibling?				
BD1	Has (name) ever been breastfed?				
	Yes	1	1	1	
	No	2	2	2	2-BD4
	DK	8	8	8	8-BD4
BD2	How long after birth did you first put [NAME] to the breast?				
	Within 1st hour of birth	1	1	1	
	Less than 24 hrs	2	2	2	
	More than 24 hrs	3	3	3	
	DK	8	8	8	
BD2a	During the first three days after delivery, was (name) given yellowdish liquid (Collustrum) that came from mother's breasts?				
	YES	1	1	1	
	NO	2	2	2	
	DK	8	8	8	
BD3	Till how many months was (name) given only breast milk? (Specify)				
BD3a	Is (name) still being breastfed?				
	Yes	1	1	1	
	No	2	2	2	
	DK	8	8	8	
BD4	Yesterday, during the day or night, did (name) drink anything from a bottle with a nipple?				
	Yes	1	1	1	
	No	2	2	2	
	DK	8	8	8	

	Note all under 5 kids in the household (Record from household schedule) Child Line Number:	_____	_____	_____	
	Questions Name:				Skip
BD6	Did (name) drink or eat vitamin or mineral supplements or any medicines yesterday, during the day or night?				
	Yes	1	1	1	
	No	2	2	2	
	DK	8	8	8	
BD7	Now I would like to ask you about (other) **liquids** that (name) may have had yesterday during the day or the night. I am interested to know whether (name) had the item even if combined with other foods. Please also include liquids consumed outside of your home.				
	Did (name) drink (Name of item) yesterday during the day or the night:	**Y N DK**	**Y N DK**	**Y N DK**	
	[A] Plain water?	1 2 8	1 2 8	1 2 8	
	[B] Juice or juice drinks?	1 2 8	1 2 8	1 2 8	
	[C] Clear broth/clear soup? (insert local name for clear broth/soup	1 2 8	1 2 8	1 2 8	
	[D] Milk such as tinned, powdered, or fresh animal milk?	1 2 8	1 2 8	1 2 8	
	If yes: How many times did (name) drink milk? If 7 or more times, record '7'. If unknown, record '8'.	☐	☐	☐	
	[E] Infant formula?	1 2 8	1 2 8	1 2 8	
	If yes: How many times did (name) drink infant formula? If 7 or more times, record '7'. If unknown, record '8'.	☐	☐	☐	
	[F] Any other liquids?	1 2 8	1 2 8	1 2 8	

	Note all under 5 kids in the household (Record from household schedule) Child Line Number:	_____	_____	_____	
	Questions Name:				Skip
BD8	Now I would like to ask you about (other) **foods** that (name) may have had yesterday during the day or the night. Again, I am interested to know whether (name) had the item even if combined with other foods. Please include foods consumed outside of your home. Did (name) eat (Name of food) yesterday during the day or the night:	**Y N DK**	**Y N DK**	**Y N DK**	
	[A] Yogurt?	1 2 8	1 2 8	1 2 8	
	If yes: How many times did (name) drink or eatyogurt? If 7 or more times, record '7'. If unknown, record '8'. .	☐	☐	☐	
	[B] Any commercially fortified baby food e.g., cerelac?	1 2 8	1 2 8	1 2 8	
	Insert brand name	_____	_____	_____	
	[C] Bread, rice, noodles, porridge, or other foods made from grains?	1 2 8	1 2 8	1 2 8	
	[D] Pumpkin, carrots, squash or sweet potatoes that are yellow or orange inside?	1 2 8	1 2 8	1 2 8	
	[E] White potatoes, white yams, cassava, or any other foods made from roots?	1 2 8	1 2 8	1 2 8	
	[F] Any dark green, leafy vegetables?	1 2 8	1 2 8	1 2 8	
	[G] Ripe mangoes, papayas or insert any other locally available vitamin A-rich fruits?	1 2 8	1 2 8	1 2 8	
	[H] Any other fruits or vegetables?	1 2 8	1 2 8	1 2 8	
	[I] Liver, kidney, heart or other organ meats?	1 2 8	1 2 8	1 2 8	
	[J] Any meat, such as lamb, goat, chicken?	1 2 8	1 2 8	1 2 8	
	[K] Eggs?	1 2 8	1 2 8	1 2 8	
	[L] Fresh or dried fish?	1 2 8	1 2 8	1 2 8	
	[M] Any foods made from beans, peas, lentils, or nuts?	1 2 8	1 2 8	1 2 8	
	[N] Cheese or other food made from milk?	1 2 8	1 2 8	1 2 8	
	[O] Any other solid, semi-solid, or soft food that I have not mentioned?	1 2 8	1 2 8	1 2 8	
	Specify				
BD9	Check BD8 (Categories "A" through "O") ¨At least one "Yes" or all "DK"→Go to BD11 ¨Else → Continue with BD10				
BD10	Probe to determine whether the child ate any solid, semi-solid or soft foods yesterday during the day or night ¨The child did not eat or the respondent does not know → Go to Next Module ¨The child ate at least one solid, semi-solidor soft food item mentioned by the respondent→Go back to BD8 and record food eaten yesterday [A to O]. When finished, continue withBD11				
BD11	How many times did (name) eat any solid, semi-solid or soft foods yesterday during the day or night? If 7 or more times, record '7'.				

Under 5 Children Questionnaire:Immunization Module

	(Record from household schedule) Child Line Number: Name: Questions	_____	_____	_____	Skip
	If an immunization (child health)card is available, copy the dates in IM3 for each type of immunization and Vitamin A recorded on the card.				
IM1	Do you have a card where (name)'s vaccinations are written down? If yes: May I see it please?				
	Yes, seen	1	1	1	1->IM3
	Yes, not seen	2	2	2	2->IM6
	No card	3	3	3	
IM2	Did you ever have a vaccination (child health)card for (name)?				
	Yes	1	1	1	1->IM6
	No	2	2	2	2->IM6
IM3	Copy dates for each vaccination from the card. Write '44' in day column if card shows that vaccination was given but no date recorded. if card not available go to IM4				
	Measles (or MMR or MR) Day Month Year				
	Vitamin A (first dose) Day Month Year				
	Vitamin A (second dose) Day Month Year				
	Pntavalent vaccine Day Month Year				
IM4	IM4. Has (name) ever received a Measles injection (or an MMR or MR)– that is, a shot in the arm at the age of 9 months or older - to prevent him/her from getting measles?				
	Yes	1	1	1	
	No	2	2	2	
	DK	8	8	8	

Under 5 Children Questionnaire: Anthropometry AN

	Questions	Child Line Number: Name				Skip
AN1	AN1. Measurer's name and number:					
A21	Result of height/length and weight measurement					
	Either or both measured 1		1	1	1	
	Child not present 2		2	2	2	
	Child or mother/caretaker refused 3		3	3	3	
	Other (specify) 6		6	6	6	
AN3	Child's weight					
	Kilograms (kg) __ __ . __		_____	_____	_____	
	Weight not measured 99.9		99	99	99	
AN3a	Was the child undressed to the minimum?					
	Yes		1	1	1	
	No, the child could not be undressed to the minimum		2	2	2	
AN3b	Check age of child in BR3:					
	¨ Child under 2 years old ->Measure length (lying down).					
	¨ Child age 2 or more years-> Measure height (standing up).					
AN4	Child's length or height					
	Length / Height __ __ __ . __ Cms.		_____	_____	_____	
	Length/ Height not measured (X)999.9		X	X	X	
AN4a	How was the child actually measured?					
	Lying down or standing up?					
	Lying down 1		1	1	1	
	Standing up 2		2	2	2	
STS	Please take these 3 named container for stool samples of the 3 children					
	Please keep the stool sample for your these children in these containers. A laboratory person will come to collect it tomorrow.					
	Container given	YES	1	1	1	
		NO	2	2	2	

Under 5 Children Questionnaire:Care and Illness Module

	Child Line Number: Questions Name				Skip
CA1	In the last two weeks, has (name) passed any loose stools?				
	Yes (1)	1	1	1	
	No (2)	2	2	2	2→CA10
	DK(8)	8	8	8	8→CA10
CA1a	How many times did (Name) pass loose stools in a day?	☐☐	☐☐	☐☐	
CA2	How much (name) was given to drink during the diarrhoea (including breastmilk). During the time (name) had diarrhoea, was he/she given less than usual to drink, about the same amount, or more than usual?				
	Much less (1)	1	1	1	
	Somewhat less (2)	2	2	2	
	About the same (3)	3	3	3	
	More (4)	4	4	4	
	Nothing to drink(5)	5	5	5	
	DK(8)	8	8	8	
CA3	During the time (name) had diarrhoea, was he/she given less than usual to eat, about the same amount, more than usual, or nothing to eat? If 'less', probe: Was he/she given much less than usual to eat or somewhat less?				
	Much less(1)	1	1	1	
	Somewhat less(2)	2	2	2	
	About the same(3)	3	3	3	
	More(4)	4	4	4	
	Stopped food(5)	5	5	5	
	Never gave food(6)	6	6	6	
	DK(8)	8	8	8	
CA3a	Did you seek any advice or treatment for the diarrhoea from any source?				
	Yes (1)	1	1	1	
	No (2)	2	2	2	2→CA9
	DK(8)	8	8	8	3→CA9

	Questions	Child Line Number: Name				Skip
CA3b	From where did you seek advice or treatment? Circle all providers mentioned, but do NOT prompt with any suggestions.					
	Public sector					
	Government hospital	A	A	A	A	
	Government health centre	B	B	B	B	
	Village health worker	D	D	D	D	
	Other public (specify)	H	H	H	H	
	Private medical sector					
	Private hospital / clinic	I	I	I	I	
	Private physician	J	J	J	J	
	Other private medical (specify)	O	O	O	O	
	Other source					
	Relative / Friend (P)	P	P	P	P	
	Shop (Q)	Q	Q	Q	Q	
	Traditional practitioner (R)	R	R	R	R	
	Other (specify) (X)	X	X	X	X	
CA3c	Was the village Govt. Health centre functioning when the child (name) was taken to the centre? (Doctor and medications available at times when needed)	Doctor was there	1	1	1	
		Medications received free	2	2	2	
		None available	3	3	3	
CA3d	Was (name) prescribed medications or was admitted?					
		OPD treatment	1	1	1	
		Admission	2	2	2	
CA4	How far did you had to travel to seek advice?.	Kms.				
	What were your health care costs (direct) in Rs. ?:					
CA4a	Doctors fee		Dk	Dk	Dk	
	Medicines		Dk	Dk	Dk	
	Diagnostic (lab tests etc)		Dk	Dk	Dk	
	Total (Lum sum) (If individual costs unknown ask total cost)		Dk	Dk	Dk	

	Child Line Number: Questions Name									Skip
CA4b	What were your health care costs (indirect) ?:									
	Transport to the facility		Dk		Dk		Dk			
	Stay cost (If hospitalized)		Dk		Dk		Dk			
	Other		Dk		Dk		Dk			
	Total (Lum sum) (If individual costs unknown ask total cost)		Dk		Dk		Dk			
CA6	During the time (name) had diarrhoea, was (name) given to drink	Y	N	DK	Y	N	DK	Y	N	DK
	[A]A fluid made from a special packet called [ORS, PEDIALYTE, OR OTHER LOCAL NAME FOR ORS]?	1	2		1	2		1	2	
	[B] A pre-packaged ORS fluid for diarrhoeainsert local name, if any pre-packaged ORS fluid?	1	2		1	2		1	2	
	[c] Government-recommended homemade fluid ?	1	2		1	2		1	2	
CA6a	During the time (name) had diarrhoea, was (name) given:	Y	N	DK	Y	N	DK	Y	N	DK
	[A] zinc tablets?	1	2		1	2		1	2	
	[B] zinc syrup?	1	2		1	2		1	2	
CA7	Was anything (else) given to treat the diarrhoea?									
	Yes (1)		1			1			1	
	No (2)		2			2			2	2→CA9
	DK(8)		8			8			8	8→CA9
CA8	What (else) was given to treat the diarrhoea?									
	Oral Medicines		A			A			A	
	Injections		B			B			B	
	Intravenous Fluids		C			C			C	
	Other (specify)..... X		D			D			D	
CA9	How many days the mother or father of the child had to take leave or did not work to take care of child? (Record '00' if Nil)									

Under 5 Children Questionnaire:Care and Illness Module

	Questions	Child Line Number: Name			Skip
CA10	In the last two weeks, has (name) been ill with a fever at any time?				
	Yes (1)	1	1	1	
	No (2)	2	2	2	
	DK(8)	8	8	8	
CA11	At any time in the last two weeks, has (name) had an illness with a cough?				
	Yes (1)	1	1	1	
	No (2)	2	2	2	2→CA14
	DK(8)	8	8	8	8→CA14
CA12	When (name) had an illness with a cough, did he/she breathe faster than usual with short, rapid breaths or have difficulty breathing?				
	Yes (1)	1	1	1	
	No (2)	2	2	2	2→CA15
	DK(8)	8	8	8	8→CA15
CA13	Was the fast or difficult breathing due to a problem in the chest or a blocked or runny nose?				
	Problem in chest only (1)	1	1	1	1→CA15
	Blocked or runny nose only (2)	2	2	2	2→CA15
	Both (3)	3	3	3	3→CA15
	Other (specify) (6)	6	6	6	6→CA15
	DK 8	8	8	8	8→CA15
CA14	Check CA8A: Had fever? ¨ Child had fever → Continue with CA15 ¨ Child did not have fever → Go to CA23				
CA15	I would like to know how much (name) was given to drink (including breastmilk) during the illness with a (fever/cough). During the time (name) had (fever/cough), was he/she given less than usual to drink, about the same amount, or more than usual? If 'less', probe: Was he/she given much less than usual to drink, or somewhat less?				
	Much less (1)	1	1	1	
	Somewhat less (2)	2	2	2	
	About the same (3)	3	3	3	
	More (4)	4	4	4	
	Nothing to drink (5)	5	5	5	
	DK (8)	8	8	8	
CA16	During the time (name) had (fever/cough), was he/she given less than usual to eat, about the same amount, more than usual, or nothing to eat? If 'less', probe: Was he/she given much less than usual to eat or somewhat less?				
	Much less (1)	1	1	1	
	Somewhat less (2)	2	2	2	
	About the same (3)	3	3	3	
	More (4)	4	4	4	
	Stopped food (5)	5	5	5	
	Never gave food (6)	6	6	6	
	DK 8	8	8	8	

CA17	Did you seek any advice or treatment for the illness from any source?				
	YES(1)	1	1	1	
	No (2)	2	2	2	2→CA23
	DK (8)	8	8	8	8→CA23
CA18	From where did you seek advice or treatment? Circle all providers mentioned, but do NOT prompt with any suggestions.				
	Public sector				
	Government hospital ..... A	A	A	A	
	Government health centre ..... B	B	B	B	
	Village health worker ..... D	D	D	D	
	Other public (specify) ..... H	H	H	H	
	Private medical sector				
	Private hospital / clinic I	I	I	I	
	Private physician ..... J	J	J	J	
	Other private medical (specify) ..... O	O	O	O	
	Other source				
	Relative / Friend (P) ..... P	P	P	P	
	Shop (Q) ..... Q	Q	Q	Q	
	Traditional practitioner (R) ..... R	R	R	R	
	Other (specify) (X) X	X	X	X	
CA19	How far did you had to travel to seek advice?. Kms.	☐☐	☐☐	☐☐	
CA19a	What were your health care costs (direct) in Rs. ?:				
	Doctors fee	_____ Dk	_____ Dk	_____ Dk	
	Medicines	_____ Dk	_____ Dk	_____ Dk	
	Diagnostic (lab tests etc)	_____ Dk	_____ Dk	_____ Dk	
	Total (Lum sum) (If individual costs unknown ask total cost)	_____ Dk	_____ Dk	_____ Dk	
CA19b	What were your health care costs (indirect) ?:				
	Transport to the facility	_____ Dk	_____ Dk	_____ Dk	
	Stay cost (If hospitalized)	_____ Dk	_____ Dk	_____ Dk	
	Other	_____ Dk	_____ Dk	_____ Dk	
	Total (Lum sum) (If individual costs unknown ask total cost)	_____ Dk	_____ Dk	_____ Dk	
CA20	At any time during the illness, was (name) given any medicine for the illness?				
	Yes (1)	1	1	1	
	No (2)	2	2	2	2→CA22
	DK (8)	8	8	8	8→CA22

CA21	What medicine was (name) given? Circle all medicines given. Write brand name(s) of all medicines mentioned. Medicines Injections Intravenous Fluids Other (specify) DK (Z)	 A B C D E	 A B C D E	 A B C D E	
CA22	How long after the fever started did (name) first take medications? Same day (0) Next day (1) 2 days after the fever (2) 3 days after the fever (3) 4 or more days after the fever(4) DK(8)	 0 1 2 3 4 8	 0 1 2 3 4 8	 0 1 2 3 4 8	
CA23	How many days the mother or father of the child had to take leave or did not work to take care of child? (Record '00' if Nil)	☐☐	☐☐	☐☐	
CA23	Check AG2: Age of child ¨ Child age 0, 1 or 2 → Continue with CA24 ¨Child age 3 or 4→ Go to next module (anthropometry module)				
CA24	The last time (name) passed stools, what was done to dispose of the stools? Child used toilet/latrine (1) Put / Rinsed into toilet or latrine(2) Put / Rinsed into drain or ditch (3) Thrown into garbage (solid waste)(4) Buried (5) Left in the open (6) Other (specify)(7) DK (8)	 1 2 3 4 5 6 7 8	 1 2 3 4 5 6 7 8	 1 2 3 4 5 6 7 8	

Adults Illness Module: Diarrhea

NO.	Questions	Coding Categories	Skip
201	Has any member in the household had stomach upsets at any time in the last 15 days?	Yes . . . . . 1 No . . . . . 2 Don't Know 8	 2->301 8->301
202	How many members in the family (above 5 years of age) had stomach upsets in the last 7 days? (From household schedule)	Specify in No. ☐☐ Line Number a _____ b _____ c	

			a	b	c	
202a	We request the person who had stomach upset answer the following questions. If they are not available we request you to answer them.	Line Number Name	_____	_____	_____	
203	Did you eat outside food the day before you had stomach upsets?	Yes No Don't Know	1 2 8	1 2 8	1 2 8	
204	How many times did you pass stools in a day? (When you had stomach upset)		☐☐	☐☐	☐☐	
205	What was the stool consistency? (When you had stomach upset)	Loose Watery Semisolid	1 2 3	1 2 3	1 2 3	
205(a)	Was there blood in stools? (When you had stomach upset)	YES NO Don't Know	1 2 3	1 2 3	1 2 3	
206	Did you also had vomiting along with the stomach upset?	YES NO	1 2	1 2	1 2	
	If yes what was the frequency?		☐☐	☐☐	☐☐	

Adults Illness Module: Diarrhea

NO.	Questions	Coding Categories a	b	c	Skip
	Line Number Name	_____	_____	_____	
207	Did you seek advice or treatment from any source? (When you had stomach upset) YES NO	1 2	1 2	1 2	 to 213
208	How many days after the stomach upset began did you first seek advice or treatment for (NAME)? IF THE SAME DAY, RECORD '00'.				
209	Where did you seek advice or treatment?				
	PUBLIC SECTOR				
	GOVT HOSPITAL (CHC, DH)..... A	A	A	A	
	GOVT HEALTH CENTER(PHC,SC)..... B	B	B	B	
	FIELDWORKER ..... E	E	E	E	
	OTHER PUBLIC _____ (SPECIFY) F	F	F	F	
	PRIVATE MEDICAL SECTOR				
	PRIVATE HOSPITAL/ CLINIC G	G	G	G	
	PRIVATE DOCTOR I	I	I	I	
	OTHER PRIVATE MED. _____ (SPECIFY) L	L	L	L	
	OTHER SOURCE				
	SHOP ..... M	M	M	M	
	TRADITIONAL PRACTITIONER N	N	N	N	
	OTHER _____ (SPECIFY) X	X	X	X	
210	Was the village Govt. Health centre functioning? (when (Name) taken for treatment) (Doctor and medications available at times when needed)				
211	How far did you had to travel to seek advice?. Kms.				

NO.	Questions		Coding Categories a	b	c	Skip
		Line Number	_____	_____	_____	
		Name				
212a	What were your health care costs (direct) in Rs. ?: Doctors fee		_____ Dk	_____ Dk	_____ Dk	
	Medicines		_____ Dk	_____ Dk	_____ Dk	
	Diagnostic (lab tests etc)		_____ Dk	_____ Dk	_____ Dk	
	Total (Lum sum) (If individual costs unknown ask total cost)		_____ Dk	_____ Dk	_____ Dk	
212b	What were your health care costs (indirect) ?: Transport to the facility		_____ Dk	_____ Dk	_____ Dk	
	Stay cost (If hospitalized)		_____ Dk	_____ Dk	_____ Dk	
	Other		_____ Dk	_____ Dk	_____ Dk	
	Total (Lum sum) (If individual costs unknown ask total cost)		_____ Dk	_____ Dk	_____ Dk	
213	How many days you had to take leave from work/ or not able to work due to stomach upsets? (Record '00' if Nil)		[ ][ ]	[ ][ ]	[ ][ ]	
214	Is (NAME) still having stomach upset?					
		Yes	1	1	1	
		No	2	2	2	
		Don't Know	8	8	8	

Adults Illness Module: Infections

No.	Questions	Coding Categories	Skip
301	Has any member in the household had fever at any time in the last 15 days?	YES . . . . . 1 NO . . . . . 2 DON'T KNOW 8	2->child qs 8->child qs
302	How many members in the family (above 5 years of age) had fever in the last 7 days? (From household schedule)	Specify in No. ☐☐ Line Number a _____ b _____ c	

	Questions		Coding Categories a	b	c	Skip
	We request the person who had fever answer the following questions. If they are not available we request you to answer them.	Line Number Name	_____	_____	_____	
303	What was the type of fever?					
	High Grade Fever without chills		1	1	1	
	High grade fever with Chills		2	2	2	
	Low grade fever with lethargy		3	3	3	
303 (a)	Did you also had vomiting with fever?					
	YES		1	1	1	
	NO		2	2	2	
	If yes what was the frequency?		☐☐	☐☐	☐☐	
304	Did you seek advice or treatment for the fever from any source?					
	Yes		1	1	1	
	No		2	2	2	Skip to 310
305	How many days after the fever began did you first seek advice or treatment for (NAME)? IF THE SAME DAY, RECORD '00'.		☐☐	☐☐	☐☐	

Adults Illness Module: Infections

No.	Questions		Coding Categories a	b	c	Skip
		Line Number				
		Name				
306	Where did you seek advice or treatment?					
	PUBLIC SECTOR					
	GOVT HOSPITAL (CHC;DH)	A	A	A	A	
	GOVT HEALTH CENTER (PHC,SC)	B	B	B	B	
	FIELDWORKER	E	E	E	E	
	OTHER PUBLIC					
	_____ (SPECIFY)	F	F	F	F	
	PRIVATE MEDICAL SECTOR					
	PRIVATE HOSPITAL/ CLINIC	G	G	G	G	
	PRIVATE DOCTOR	I	I	I	I	
	OTHER PRIVATE					
	MED. _____ (SPECIFY)	L	L	L	L	
	OTHER SOURCE					
	SHOP	M	M	M	M	
	TRADITIONAL PRACTITIONER	N	N	N	N	
	OTHER _____ (SPECIFY)	X	X	X	X	
307	Is the village Govt. Health centre functioning? (Doctor and medications available at times when needed)					
308	**How far did you had to travel to seek advice?.** Kms.					
309a	What were your health care costs (direct) in Rs. ?: Doctors fee		Dk	Dk	Dk	
	Medicines		Dk	Dk	Dk	
	Diagnostic (lab tests etc)		Dk	Dk	Dk	
	Total (Lum sum) (If individual costs unknown ask total cost)		Dk	Dk	Dk	

No.	Questions		Coding Categories a	b	c	Skip
		Line Number	_____	_____	_____	
		Name				
309b	What were your health care costs (indirect) ?:					
	Transport to the facility		_____ Dk	_____ Dk	_____ Dk	
	Stay cost (If hospitalized)		_____ Dk	_____ Dk	_____ Dk	
	Other		_____ Dk	_____ Dk	_____ Dk	
	Total (Lum sum) (If individual costs unknown ask total cost)		_____ Dk	_____ Dk	_____ Dk	
310	How many days you had to take leave from work due to fever? (Record '00' if Nil)		[ ][ ]	[ ][ ]	[ ][ ]	
311	Is (NAME) still having fever?					
		Yes	1	1	1	
		No	2	2	2	
		Don't Know	8	8	8	
312	Do you suffer from any long term/ chronic disease?					
		Yes	1	1	1	
		No	2	2	2	2→U5 module
		Don't Know	8	8	8	8→U5 module
313	What chronic diseases you have? (Tick all that apply)					
		Persistent Diarrhea	1	1	1	
		Skin Rashes	2	2	2	
		Hypertension	3	3	3	
		Diabetes Mallitus	4	4	4	
		Tuberculosis	5	5	5	
		Cancer	6	6	6	
		Asthma	7	7	7	
		Physical Deformity	8	8	8	
		Other(Specify)	9	9	9	
314	What is your occupation?					
		FARMER	1	1	1	
		OffICE WORK	2	2	2	
		LABOURER	3	3	3	
		OTHER	4	4	4	
		(Specify)				

Hygiene Survey

Unique Identification Number

Head of the Household _____

Date of Visit _____

Time of Visit _____
(a. m.)

A. Type of House
- ☐ 1 KACHHA
- ☐ 2 SEMI-PUCCA
- ☐ 3 PUCCA

B. Animals in house
- ☐ Yes
- ☐ No

B. Animals-Any Comments _____

1. Environment
- ☐ 1 FECAL CONTAMINATION
- ☐ 2 WASTE PILES
- ☐ 3 STAGNANT WATER
- ☐ 4 FREE ROAMING ANIMALS
- ☐ 5 SIGNIFICANT NUMBER OF FLIES
- ☐ 6 SOME WASTE
- ☐ 7 RESTRAINT ANIMALS
- ☐ 8 NO SIGN OF CONTAMINATION
- ☐ 9 INSIGNIFICANT NUMBER OF FLIES

(tick all that apply)

Environment-Any Comments _____

2. Sanitation
- ☐ 1 NO SANITATION
- ☐ 2 OPEN DEFECATION
- ☐ 3 UNIMPROVED SANITATION (Swachta sari nathi)
- ☐ 4 NO WATER ACCESS
- ☐ 5 FECAL CONTAMINATION
- ☐ 6 IMPROVED SANITATION WITH WATER ACCESS

(tick all that apply)

Sanitation- Any Comments _____

3. Water
- ☐ 1 UNIMPROVED DRINKING WATER SOURCE
- ☐ 2 WATER SOURCE VISIBLY POLLUTED
- ☐ 3 WATER STORAGE CONTAINER POLLUTED
- ☐ 4 NO WATER AVAILABLE FROM SOURCE
- ☐ 5 WATER STORAGE CONTAINER NOT COVERED
- ☐ 6 INADAQUATE WITHDRAWL METHOD
- ☐ 7 IMPROVED WATER SOURCE WITH ADEQUATE WATER STORAGE

(tick all that apply)

Water-Any Comments _____

4. Food
- ☐ 1 INADAQUATE FOOD STORAGE
- ☐ 2 SIGNIFICANT NUMBER OF FLIES
- ☐ 3 KITCHEN AREA CONTAMINATED
- ☐ 4 FOOD STORED UNCOVERED
- ☐ 5 FOOD STORED ON THE GROUND
- ☐ 6 DIRTY DISHES
- ☐ 7 FOOD STORED COVERED
- ☐ 8 FOOD STORED AT PLATFORM OR CUPBOARD
- ☐ 9 CLEAN DISHES

(tick all that apply)

Food-Any Comments

5. Personnel

- ☐ 1 VISIBLE SIGN OF DIRT UNDER FINGER NAILS
- ☐ 2 DIRTY HANDS
- ☐ 3 BLACK OR RED TEETH
- ☐ 4 DIRTY CLOTHS
- ☐ 5 NOT WEARING SHOES
- ☐ 6 WEARING SHOES
- ☐ 7 CLEAN HANDS, CLOTHS, TEETH (tick all that apply)

Personnel-Any Comments

1. Drinking water storage

- ☐ 1 Water not stored
- ☐ 2 Stored in covered container
- ☐ 3 Stored in open container

2. Drinking water collection points

	Yes	No
Cleanline	☐	☐
ss Plat	☐	☐
form	☐	☐
Drain		
facility		

3. Solid and liquid waste in the courtyard

	Yes	No
C Kitchen waste	☐	☐
Plastic waste	☐	☐
Human/animal	☐	☐
excreta Stagnant	☐	☐
water		

4. Latrine (Individual or community) Latrine

- ☐ 0 None
- ☐ 1 Individual
- ☐ 2 Communty

4a. Latrine

- ☐ 1 Not allowed to check
- ☐ 2 No latrine
- ☐ 3 Own latrine
- ☐ 4 Attached to house
- ☐ 5 Separate
- ☐ 5 Community latrine

5. Functionality

	Good	Bad
Pit condition	☐	☐
Structure	☐	☐
Closet condition	☐	☐
	☐	☐

Floor

6. Cleanliness

	Good	Bad
Closet	☐	☐
Floor	☐	☐
Surroundings	☐	☐

7. Means of washing hands inside the toilet building?
☐ 1 Yes
☐ 2 No

8. Means of washing hands immediately on exit of the toilet building?
☐ 1 Yes
☐ 2 No

9. Source of water for handwashing
☐ 0 None
☐ 1 Basin with tap water (functioning)
☐ 2 Handwashing stand with water
☐ 3 Bowl or container to put hands in
☐ 4 Container of water, water given to wash hands
☐ 5 Other (Specify)

If Q 9= Other (Specify) _____

10. Is soap available for handwashing?
☐ 1 Yes
☐ 2 No

11. Bathroom
☐ 1 No bath room
☐ 2 Attached to house
☐ 3 Separate
☐ 4 Drain facility

Any Comments _____