Embedding Innovative Sanitation Technology:

An Assessment of Urine Diversion Dry Toilets in Bangladesh

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BARD
2005

Opposite:

Top Left: Urine Diversion Dry Toilet (UDDT) in Tengra Village, Jessore District.
Top Right: Farmer in a boro paddy field, Amarak Village, Rajshahi District.
Bottom Left: Rice grown with excreta fertilizers, Jessore District.
Bottom Right: Faecal manure in a UDDT, Joypur South Village, Comilla District.

All photos taken by A. Guadagni (2011).

Statement of Authenticity of Material

This thesis contains no material which has been accepted for the award of any other degree or diploma in any institution and to the best of my knowledge and belief, the research contains no material previously published or written by another person, except where due reference has been made in the text of the thesis.

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Abstract

Compared with many other developing countries, Bangladesh has been reasonably successful in its more recent attempts to provide improved sanitation facilities to its population. However, many of the most common sanitation solutions advocated by the Government and development NGOs perform poorly in flood prone and water stressed areas, and fail to address other underlying issues such as poverty and food security in the country. Beginning in 2004, the ecological sanitation (ecosan) ideology was introduced in Bangladesh, offering a superior sanitation technology in the form of the urine diversion dry toilet (UDDT). This paper aims to assess how this innovative sanitation technology has become embedded in the socio-cultural fabric of several case study areas throughout Bangladesh, and better understand the processes by which this embedding occurs. A qualitative indicator set has been developed to assess the embeddedness of the UDDT technology and is applied to each of the case study areas in order to make determinations regarding the acceptance of and future prospects for this sanitation technology.

Keywords: Bangladesh, ecosan, UDDT, social embeddedness, sanitation

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List of Acronyms

BARD	Bangladesh Academy for Rural Development
BASA	Bangladesh Association for Social Advancement
BDT	Bangladeshi Taka (currency)
CBO	Community Based Organization
CVDP	Comprehensive Village Development Program
DPHE	Department of Public Health and Engineering
DSK	Dushtha Shasthya Kendra
ecosan	Ecological Sanitation
GoB	Government of Bangladesh
GTZ / GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
JADE	Japanese Association for Drainage and the Environment
JMP	WHO / UNICEF Joint Monitoring Programme
LDCs	Least Developed Countries
MDG	Millennium Development Goal
NGO	Non-Governmental Organization
SHEWA-B	Sanitation, Hygiene Education and Water Supply in Bangladesh
SPACE	Society for People's Actions in Change and Equity
UD	Urine Diversion
UDDT	Urine Diversion Dehydrating Toilet
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WSSCC	Water Supply and Sanitation Collaborative Council

1.0 Introduction

1.1 The State of Sanitation: The World and Bangladesh

The scale of the world sanitation situation has reached the level of a crisis. Estimates by the World Health Organization (WHO) and United Nations Children's Fund's (UNICEF) Joint Monitoring Project (JMP) indicate that approximately 2.6 billion people, or roughly 40% of the world's population, live without access to improved sanitation[1] facilities (WHO & UNICEF 2010b). The detriment to human development is staggering, as those individuals without sanitation disproportionately suffer from chronic disease and premature death, limited access to education and labor markets and a cycle of poverty which, for many, is hopelessly inescapable (COHRE et al 2008). Despite continued investment and an increased focus from the international development community, the Millennium Development Goal (MDG) to halve the number of individuals lacking access to improved sanitation 2015 is well out of reach (UN 2010).

Bangladesh (Figure 1) has fared better than most of the world's least developed countries (LDCs)[2] with regards to providing access to improved sanitation for its citizens. On average, only 35% of the residents of the world's 48 least developed countries have access to improved sanitation (WHO & UNICEF 2010a). In Bangladesh, this number is 53% (WHO & UNICEF 2010a). Though providing improved sanitation facilities for just over half of a population should not necessarily be heralded as an unmitigated success, it is considerably more impressive when seen in the light of its recent sanitation history: in less than 20 years, from 1990 to 2008, nearly 40 million people in Bangladesh secured improved sanitation facilities for the first time (WHO & UNICEF 2010a).

[1] Sanitation is defined as '…a multi-step process in which wastes are managed from the point of generation to the point of use or ultimate disposal' (Tilley et al 2008, p. 9).

[2] The United Nations (UN) lists Bangladesh amongst the world's 48 least developed countries for the period of 2000 to 2010 (UN 2011). The list is based primarily on economic indicators, but also includes some social and environmental indicators.

Figure 1: **Bangladesh**
Highlighted near center. (Source: Wikimedia 2011)

National prioritization of sanitation initiatives and successful educational outreach programs have contributed significantly in this front (Hanchett et al 2011). While the Government of Bangladesh (GoB) and other organizations involved in these country-wide efforts to improve sanitation do deserve commendation, these projects must be observed through a more contextual lens to assess their actual success. Many of the most common sanitary solutions advocated in Bangladesh are technically inappropriate for the world's largest deltaic floodplain, in which 80% of the land mass is prone to inundation in extreme flood events (Heitzman & Worden 1989). Furthermore, these conventional sanitation[3] strategies pay no heed to the fact that nearly 60 million people in the country are victims of food insecurity (Mishra & Hossain 2005), and that domestic food production is hindered by decreasing soil fertility and dramatically increasing fertilizer costs (Jahiruddin et al 2008; Islam 2008).

As early as 2004, non-governmental organizations (NGOs) and research institutions in Bangladesh began to pilot sanitation technologies that could contribute more to the country's overall development than conventional solutions (JADE 2011). These technological solutions fit within the broad ideology of *ecological sanitation*, or ecosan, which aims to: i) prevent environmental pollution resulting from human

[3] This report refers to conventional sanitation solutions as those technologies that have been traditionally applied in Bangladesh, namely the ring-slab latrine, pit latrine and septic system.

waste, rather than merely mitigating its deleterious effects; ii) sanitize human excreta; and iii) create productive agricultural applications for the excreta based fertilizer and soil conditioner (Stockholm Environmental Institute 2004). Though similar practices have, in fact, been the norm through most of history (Lüthi et al 2011), the reincarnation of this ideology late in the 20th Century represents a paradigm shift with regards to waste management in the international development dialogue (GTZ 2003).

A cursory review of the ideology indicates that Bangladesh, as a whole, is especially well suited for the various technological systems that fit under the ecosan umbrella. The most common ecosan system in Bangladesh, the urine diversion dry toilet (UDDT) (Figure 2), performs well during flood events, improves public health outcomes through the effective containment and sterilization of feces, and allows for the reuse of valuable nutrients that would otherwise percolate into the subsurface or be lost in the country's surface water bodies (GTZ [undated]). Additionally, UDDT systems have been widely implemented throughout South Asia, creating a well-documented template for design and construction of the simple sanitation technology (Neupane 2010; WaterAid 2008).

Figure 2: Urine Diversion Dry Toilet
A UDDT (at right) next to a home in the Pobonkul village, Bangladesh. (Photo: A. Guadagni)

However, the implementation of UDDT systems is generally not viewed as strictly a technical endeavor. Attempts to implement such interventions without adequate focus on the social context of the target locality have frequently resulted in project failure (UNESCO & GTZ 2006). Such failure is not only a drain on limited resources, but can also negatively impact the perceptions of UDDT systems and ecosan ideology in the project area. Socio-cultural, religious and behavioral barriers, especially with regards to the reuse of human excreta, are strong deterrents that are not easily overcome; technological advancement in the sanitation sector is impossible without, and in many regards inseparable from, social development with regards to these barriers (Hegger et al 2008). In the words of Dr. Masudul Hoq Chowdhury, joint director of the Bangladesh Academy for Rural Development in Comilla (Comilla BARD) and part of the team responsible for the introduction of UDDT technology to Bangladesh in 2004, 'ecosan in a *hard* solution' to the challenge of creating wider access to improved sanitation (Interview with Dr. Masudul Hoq Chowdhury Sept 15 2011). Sustainable development of UDDTs requires significant modification of the user's established toilet behaviors, as well as dramatic shifts in pervasive socio-cultural attitudes with regards to the reuse of human excreta for agricultural applications (Mazeau & Delepiére 2009).

1.2 Embedding Sanitation Systems

Increasingly, research regarding sustainable sanitation solutions has pointed to the importance of the embedding of the selected socio-technical system in the local context (Hegger et al 2008; Netherlands Waste Partnership 2006; Sustainable Sanitation Alliance 2011). Markard and Lüthi (2010, p. 889) have shown that the success of sanitation solutions '…crucially depends on how well they are embedded into existing contexts'. This is a particular challenge for novel sanitation concepts implemented in an area with no previous knowledge of the system, and with countervailing sanitation systems and associated behaviors already embedded in the local culture.

Of course, the success or failure of an innovative sanitation technology is influenced not only by the social acceptance of its users, but also by its fit within or adaptability to the established frameworks for planning, financing, water supply and housing

(Markard & Lüthi 2010). Given the comparatively limited capacity for planning (Titumir & Rahman 2011) and historically poor environmental regulation and enforcement (Esty & Porter 2001), socio-cultural factors are thought to have the greatest influence on the embedding of UDDT technologies in Bangladesh.

Social embeddedness, for the purposes of this report, refers to the condition in which a sanitation system becomes part of, rather than ancillary to, the socio-cultural fabric of a given group, community or household. An embedded system is a facet of daily life; a widely accepted solution that is indispensible to its owners.

2.0 Research Question and Structure

Though there is wide agreement as to the importance socially embedded sanitation technologies, mechanisms to assess the embeddedness of the technology in the local context and the very processes by which this embedding occurs are not well understood. The body of literature regarding the embedding of socio-technical sanitation systems is particularly deficient with regards to the developing world. This study aims to further this discussion by answering the following questions:

- What indicators can be used to effectively assess the social embeddedness of UDDT technology in Bangladesh? and
- What factors influence the process of socially embedding UDDT technology in the case study areas?

2.1 Structure

This paper is divided into ten sections. Section 1.0 and Section 2.0 provide the basic background, research objectives and scope of the study. Section 3.0 establishes the theoretical framework on which this study is based, describing the basic tenets of the ecosan ideology, the importance of social embeddedness, the history of both conventional and ecological sanitation solutions in Bangladesh and makes the argument that the Bangladeshi context is quite well suited to, and could indeed benefit from, a proliferation of UDDT systems. Section 4.0 through Section 9.0 describe and discuss the empirical research that was conducted in Bangladesh between August 16 and November 26, 2011. They describe the selected research methodology, provide an abbreviated profile of each of the case study areas, and discuss the status quo of UDDT technology and implementation models most commonly utilized in Bangladesh. The paper concludes with a discussion of the findings of the research and a brief discussion of the future of ecosan in Bangladesh.

2.2 Justification of Case Study Selection

Bangladesh was selected as an excellent country for a case study based on a number of criterion. First, it was determined that in order to assess the processes by which sanitation systems become socially embedded, it would be beneficial to assess UDDT systems at different stages in the embedding process. This, in theory, requires a case study area that has had a temporally consistent proliferation of UDDT systems, but also sufficient spatial separation between the individual localities to make the likelihood of knowledge flows between unrelated intervention sites unlikely. With installations of UDDTs beginning in 2005 and continuing to the present day, and the low-level of interconnection between geographically distant villages, Bangladesh is a suitable candidate in this regard.

Secondly, Bangladesh presents some rather interesting characteristics that provide a unique context for a study of embedding UDDT systems. With Muslims accounting for nearly 90% of the country's population (GTZ 2010), Bangladeshis exhibit strong religiously rooted socio-cultural attitudes regarding sanitation, water and cleanliness, creating a potentially difficult context for the successful embedding of an UDDT system (Nawab et al 2006; Qazi 2006). The Bangladeshi context can also be seen as reasonably representative of the developing world with respect to sanitation. In the case of Bangladesh and most other LDCs, no single technology represents the most common approach to sanitation solutions (WHO & UNICEF 2010b). As opposed to the developed world, in which large scale centralized trunk infrastructure dominates, sanitary systems in LDCs are often developed as rather ad hoc, decentralized processes, subject to a variety of localized influences. The result is often comparatively variable technical solutions and correspondingly variable embedding mechanisms that can differ from household to household, village to village or region to region.

Finally, Bangladesh was chosen as the focus of this study as a review of available literature suggests that Bangladesh could benefit substantially from a proliferation of UDDTs (see Section 3.4).

2.3 Scope and Limitations of Research

This paper focuses primarily on the ways in which UDDT systems become embedded in the socio-cultural fabric of households and communities in Bangladesh. The assessment was conducted through a series of field excursions to areas that had been the subject of NGO driven UDDT interventions between 2004[4] and 2011. Given the relative obscurity and limited socio-economic data for many of the areas visited during the research period, it was not possible to develop an exhaustive socio-cultural profile for each of the case study areas. Instead, abbreviated profiles focused on the historical development of sanitation facilities and specific socio-cultural indicators are used.

This study also does not attempt to make a financial justification or develop innovative financing models for the expansion of UDDT technology in Bangladesh. This study addresses only those interventions in which NGOs have acted as a partner, both as technical consultant and financier. The significantly higher construction costs of UDDTs, as compared to traditional sanitation solutions, result in a sanitation system that in most cases cannot be user financed. For this reason, the considering the UDDT as *the solution* for the Bangladeshi sanitation situation is unrealistic in the near future.

[4] The first intervention introducing UDDTs in Bangladesh was undertaken in late 2004, with installation of the toilets beginning in 2005.

3.0 Literature Review

3.1 ecosan: An Ideology of Reuse

The following section provides a description of the ecosan ideology, including a brief discussion of its origins, historical background and some common technical solutions that fall under the ecosan umbrella. The focus of this section is on the low-cost technical solutions that are most commonly employed in the developing world.

3.1.1 Decentralized Sanitation

While centralized trunk sewage infrastructure has been the established ideal in Western cities since the industrial revolution, these solutions are often viewed as technically inappropriate for the developing world. Trunk sewer infrastructure provides an unprecedented level of convenience for users, but also mandates extremely capital-intensive engineering and construction costs, making it unfeasible for less densely populated areas with limited resources (Franceys & Weitz 2003; Lüthi et al 2011). Furthermore these systems require a tremendous volume of water to flush waste through the system, diluting valuable nutrients found especially in the urine, and creating a significantly larger effluent stream requiring treatment prior to discharge into the environment. Stockholm Environment Institute (2004) suggests that for each person using such a 'flush and discharge' system, 450-550 liters of excreta are washed away with 15,000 liters of water each year, resulting in a wastewater stream roughly 30 times greater than the volume of the excreta alone. In areas that do not have the fundamental capacity to treat this vast volume of wastewater, the effluent stream is often discharged directly into the environment.

In response to the failure of centralized network systems to reach a wider population in the developing world, decentralized approaches of sewage collection and treatment have received an increasing amount of attention in the development discourse (Parkinson & Taylor 2003). This paradigm shift in the developing world, from the ideal of centralized network systems to that of decentralized waste management, is also more reflective of the world-wide sanitation situation, in which only a small

percentage of both urban and rural dwellers have access to centralized flushing systems (WHO & UNICEF 2010b). However, the decentralized sanitation solutions common in much of the world tend to be inadequate and poorly maintained, allowing disease causing vectors to escape into the environment, contaminating water resources and resulting in wide-spread health and economic impacts to the local community (Lüthi et al 2011; Gillespie 2005).

3.1.2 ecosan Ideology

There has been increasing concern that common sanitation solutions, even those decentralized technologies advocated in the developing world, are failing with regards to sustainability (UNESCO & GTZ 2006). The world's fresh water resources are becoming depleted or polluted at an alarming rate, creating what is widely recognized as an impending water crisis, a problem exacerbated by the high water demands of centralized sewage systems and by inadequate sanitation (UNDP 2006). Furthermore, the world's supply of mineral phosphorous, an essential element for plant growth, is limited, with some indication that known resources will be completely depleted within 60 to 130 years (Weikard & Seyhan 2009). More surprising than the limited nature of such an essential mineral compound is the sheer volume that is wasted annually as human urine, which contains between 470 milligrams and 1,070 milligrams of total phosphorous per liter (Putnam 1971), is flushed into surface water bodies and ultimately washed into the world's oceans. The modern conception of ecosan developed out of recognition of this waste.

Rather than describing a specific technical sanitation solution, the term ecosan is generally understood as descriptive of the ideology surrounding the containment, treatment and reuse of human excrement. At is very core is a fundamental shift in the way people view human waste (Neupane 2010). Rather than a waste stream that should be merely disposed of, human excreta are seen as a resource with tremendous potential to contribute to agricultural production and food security (Stockholm Environment Institute 2004). The ideology is fundamental to sustainable waste and wastewater management systems that treat material flows as a cyclical, rather than linear, process and take into account the needs of the local populous (GTZ 2003).

The ecosan ideology has been widely accepted as representing a paradigm shift with regards to sustainable sanitation in both the developed and developing world (GTZ 2003). During a meeting of the Water Supply and Sanitation Collaborative Council (WSSCC) in 2000, renowned water and sanitation experts from across the globe outlined a foundation for sanitation solutions in the future, an approach that mandated a radical overhaul of contemporary practices and policies in order to create '…universal access to safe environmental sanitation, within a framework of water and environmental security and respect for the economic value of wastes' (Eawag [undated], p. 1). The so-called *Bellagio Principles* have increasingly come to the forefront of sustainable sanitation efforts in the international development discourse (Lüthi et al 2011; GTZ 2003).

3.1.3 History

The ideology on which the modern concept of ecosan is based is by no means new. Lüthi et al (2011) cite evidence that excreta had been commonly used in agriculture and aquaculture at least 2,500 years ago, with distinct cultures from all corners of the globe replenishing soil fertility through the application of human waste. In many instances, the practice continued well into the era of urbanization, with excreta collected from urban centers being transported to the periphery for use in agriculture (Lüthi et al 2011). However, continued urban growth, a proliferation of piped water systems and the development of chemically produced fertilizers ultimately lead to more convenient means of both sanitation and fertilization, effectively eliminating the practice by the early-20th Century in most industrialized countries (Lüthi et al 2011).

The modern resurgence of the reuse ideology began to gain traction in Sweden in the 1980's as a means to recover valuable nutrients from human excreta through a system that is now widely referred to as 'closed-loop sanitation' (UNESCO & GTZ 2006). Since then, specific sanitation technologies designed to create hygienic environmental conditions and recover nutrients from human excreta have been installed at a moderate rate, in both developing and developed countries all over the world (GIZ 2011a).

3.1.4 ecosan Technical Solutions

Urine contains the majority of nutrients that are beneficial to plant growth and can, in most cases, be agriculturally applied without treatment[5] (Neupane 2010). Feces, on the other hand, are widely responsible for transmitting disease vectors and require significant treatment before they can be safely handled and applied in the agricultural context (Stockholm Environment Institute 2004). Technical solutions that fit within the broad ecosan ideology are generally designed to separate urine and feces at the source, creating an environment in which feces can be most adequately contained and the pathogen load can be effectively reduced (WASTE 2005). Such technology is most commonly referred to as a *urine diversion* (UD) toilet, the design of which can be widely variable so as to fit most seamlessly within the local environmental and socio-cultural context (GIZ 2011b).

The on-site treatment of feces is generally undertaken through the process of dehydration or composting. Dehydration, which can be achieved by adding dry materials such as ash or sawdust to the feces and allowing for adequate aeration, can virtually eliminate the bacterial pathogen content of the feces in six to 12 months and significantly reduce the virus, protozoa and parasite load as well (Stockholm Environment Institute 2004). The destruction of fecal borne pathogens is most efficient in alkaline environments, which can be easily and cheaply created by the addition of ash, lime or urea to the fecal material (Stockholm Environment Institute 2004). Composting, on the other hand, requires a degree of moisture within the system to stimulate the destruction of pathogens through naturally occurring microbial activity (Neupane 2010). In both instances, Stockholm Environment Institute (2004) recommends that the treated fecal material be subjected to secondary processing, usually mandating additional storage time, to ensure that the feces can be safely returned to the soil.

Though designs can vary widely, the low-cost technological components of composting and dehydrating toilets most commonly implemented in the developing world are fairly similar. The fundamental design of both toilets includes a pan

[5] Stockholm Environment Institute (2004) notes that viruses and protozoa can be present in urine and recommends storage of urine in a hermetically sealed vessel for one month prior to use.

designed for the source separation of urine and feces, a urine collection vessel and a feces chamber. Most low-cost composting and dehydrating toilets are designed with a minimum of two feces chambers, that are alternated to allow for continuous use of the toilet (GIZ 2011b). Additionally, while the feces chambers of the dehydrating toilet must be sealed to prevent moisture from entering the system, the chambers in a composting system are usually equipped with a floor drain to allow leachate to percolate into the subsurface (GTZ 2010).

Despite similar design, the operation of the two toilets and the mechanisms that allow for the destruction of disease vectors are quite different. Following defecation in a dehydrating toilet, users add sufficient alkaline dry material to cover the ash in order to absorb moisture and raise the pH of the system (JADE 2011). Composting toilets have the additional benefit of creating compost from organic domestic waste, which can be added to the feces chamber at any point (Neupane 2010).

The choice between composting and dehydrating toilets can largely be seen as a reflection of the environmental context in which the toilet is to be installed. While both toilets can effectively mitigate the dangers associated with fecal pathogens, the rate at which pathogen destruction occurs is largely dependent on creating optimal conditions within the feces chamber (GIZ 2011b). Creating such optimal conditions can be significantly more difficult in composting toilets and, without sophisticated technology, can be largely climate dependent (GIZ 2011b). Creating optimal conditions in the feces chamber of a dehydrating toilet is comparatively simple, making UDDTs the preferred technical option in many climatic regions (Stockholm Environment Institute 2004).

3.1.5 Social Perspectives on ecosan

Despite clear health and economic benefit associated with the ecosan ideology, construction of such toilets cannot be viewed as a strictly technical endeavor. Attitudes regarding the reuse of excreta can be deeply engrained in the socio-cultural fabric of a given context, what Stockholm Environment Institute (2004) refers to as ‘fecophobic’ culture, requiring significant cultural adaptation before the benefit of the toilet can be realized (GTZ 2003). Participatory processes of planning ecosan

interventions are frequently cited as a primary means of overcoming these socio-cultural barriers, serving as an introduction to the concept of excreta reuse and as a fundamental starting point in the acceptance of the practice (UNESCO & GTZ 2006; Stockholm Environment Institute 2004). Once the fundamental ideology of excreta reuse and behavioral adjustments have been accepted, they can then become embedded as part of the socio-cultural fabric of the local context (Onyango & Odhiambo 2009).

3.2 Social Embeddedness and Changing Sanitation Attitudes and Behaviors

The concept of social embeddedness was coined by Dr. Mark Granovetter to describe the influence of social relationships on economic decisions. Though the theory was initially applied to the field of economic sociology, it has come to be seen as a fundamental theory in many of the social sciences, especially with regards to evaluating decision-making processes (Moody & White 2003). The following section describes the theory of social embeddedness and its importance within the realm of sanitation.

3.2.1 Weak Ties and Social Embedding

In his seminal 1973 paper *The Strength of Weak Ties*, Granovetter developed what would later serve as the basis for his social embeddedness theory. Granovetter suggests that links between micro- and macro-level sociological analyses can best be achieved through an examination of dyadic relationships (Granovetter 1973). Granovetter (1973) theorizes that relatively insubstantial relationships between two individuals can have profound effects in shaping the attitudes and social norms of each individual's larger social network. This process is seen as cyclical, as small-scale interactions are translated into large-scale patterns and, in turn, propagated back into smaller social networks (Granovetter 1973).

Granovetter built upon this theory of personal relationships and their affect on larger social networks to develop a novel theory that centered upon the fundamental importance of social norms on individual behaviors. Granovetter (1985) rejects the utilitarian approach that rational beings act predominantly in their own best interest

and are minimally affected by social pressures, instead stating that individual behaviors 'are so constrained by ongoing social relations that to construe them as independent would be a grievous misunderstanding' (Granovetter 1985, pp. 481-482). The theory incorporates both relational and structural theory into understanding human behavior, noting that embedding of socio-cultural norms relies on both personal relationships and the structural cohesion of social networks in which actors are involved (Granovetter 1992). The emphasis on structural cohesion allows for a concept fitting between 'undersocialized' behavioral theories that treat individuals as merely self-interested and 'oversocialized' theories that effectively render individuals incapable of acting outside of accepted norms (Moody & White 2003).

Granovetter's theory has since been applied to describe a wide range of sociological phenomena as a means of understanding individual attitudes and behaviors within a sub-set of a social network and, more broadly, within society as a whole. Most often, embeddedness is viewed as a constraining factor in behavior, limiting the activity of individuals to those actions that are embedded in social norms and customs (Moody & White 2003). Cleaver (2002) suggests that understanding the ways in which certain attitudes and beliefs are embedded within a given culture is fundamental to determining the scope for flexibility and the mechanisms which are most appropriate to negotiate change within a community; some norms are so deeply embedded, however, that individuals may find it impossible to be critical of them (Cleaver 2002).

3.2.2 Social Embeddedness in the Water and Sanitation Sector

The recent emphasis on sustainability in the water and sanitation sector has lead to increased recognition of the importance of social embeddedness theory in the successful implementation of innovative service delivery technologies (Markard & Lüthi 2010). Accepted norms surrounding sanitation practices are created through peer emulation and collective rituals of a given culture and are ultimately embedded in the local context through habituation (Mader 2011). It is widely recognized that the success of novel sanitation solutions is not merely a question of the appropriateness or benefit of the technology, but is fundamentally related to the ability of the technology to become embedded in the context in which it has been

implemented (Hegger et al 2008, Netherlands Waste Partnership 2006; Lüthi et al 2011; Markard & Lüthi 2010; Sustainable Sanitation Alliance 2011).

Despite wide agreement as to the importance of embedding innovative sanitation technologies in a given society, there is considerable variation in the application of the term *embedded*. Hegger et al (2008) and Markard and Lüthi (2010), drawing from experience with societies relying on centralized infrastructure as a primary method of sanitation, focus on the importance of the technology becoming embedded in the institutions responsible for providing sanitation services. Others involved in sanitation in areas in which sanitation decisions are more individualized, namely in the developing world, point to the importance of the proposed technology becoming embedded in the socio-cultural fabric of the local context (Netherlands Waste Partnership 2010; Sustainable Sanitation Alliance 2011). However, both treatments of the concept recognize the fundamental importance of social values and norms in the ultimate acceptance of the technology. Sustainability of innovative sanitation technologies is largely dependent on the ability of a group to adapt socio-cultural values, practices and perceptions, thus socially embedding the technology in the local context (Markard & Lüthi 2010).

3.2.3 Planned Behavior

Various researchers have drawn on the theory of planned behavior as a means of understanding what influences individual's decisions within the realm of sanitation (Hegger et al 2008). Ajzen (1982) has shown that an individual's attitudes[6] on a certain subject are often the best indicator of the way said individual will behave with regards to that subject[7]. These attitudes are not innate, but acquired based on response to external stimuli, determined by the information presented to an individual (Ajzen and Gilbert 2008).

[6] Ajzen (1982, pp. 3-4) defines an attitude as 'a predisposition to respond in a favorable or unfavorable manner with respect to the object of the attitude'.

[7] It should be noted here that Ajzen finds fault with models that attempt to predict behavior based on general attitudes. Instead, specific behaviors can be effectively predicted, and on a limited basis, only by analyzing attitudes that relate specifically to that behavior (Ajzen 1982; Ajzen and Fishbein 2005).

The theory also offers some insight into the processes by which individuals may change attitudes regarding certain sanitation practices. Fishbein and Ajzen (1975) have identified two mechanisms that are fundamental in forming an individual's attitudes: *subjective norms* and *normative beliefs*. Subjective norms relate to an individual's perception of normative pressures from a given society or culture and their ability to influence that individual's behavior. Normative beliefs relate to an individual's perception of how 'important referent individuals or groups approve or disapprove of performing a given behavior' (Ajzen 1991, p. 195).

Both subjective norms and normative beliefs can be seen as significant in the process of embedding innovative sanitation technology (Hegger et al 2008). Existing attitudes relating to sanitation practices and behaviors are likely to be formed based on subjective norms, through recognition of culturally relevant attitudes and peer emulation. The conditions under which these practices and behaviors can be manipulated, however, are more related to normative beliefs, as individual attitudes are subject to influence by stimulus from external authorities.

3.2.4 Transition Management

Initially developed as part of research related to biological sciences and population dynamics, the field of transition management has come to be seen as fundamental to the study of hygiene and health care policy (Rotmans et al 2001). Loorbach and Rotmans (2006, p. 2) define a transition as 'a long-term process of change during which a society or a subsystem of society fundamentally changes'. Central to the theory of transition management is the ideal that social, technical, ecological and economic factors must be effectively integrated at all levels to achieve sustainability (Kemp et al 2005).

Most relevant to this study is the insight provided by transition management theory into the processes by which fundamental changes occur at various levels. Kemp and Loorbach (2003) have identified three distinct levels on which transitions occur: the *micro*-level (or niche), the *meso*-level (or regime), and the *macro*-level (or landscape). Arguably the most important, the meso-level is defined as the 'dominant practices, rules and technologies…that pertain in a domain, giving it stability and guiding

decision making' (Kemp & Loorbach 2003, p. 9). The micro-level can be seen as the laboratory for innovative technologies and practices, and is the context in which deviations from the status quo or most likely to occur (Loorbach & Rotmans 2006). The macro-level represents large-scale societal transitions, which generally occur slowly and often only after successful integration at the other two levels (Kemp & Loorbach 2003; Loorbach & Rotmans 2006). Kemp and Loorbach (2003) note that a successful transition can be viewed as a macro-level outcome based on micro-level decisions within a diverse cultural and technical landscape. Thus, there is a limited degree of control that can be exerted over the system as a whole.

3.3 Sanitation in Bangladesh

Between 1990 and 2008, the percentage of rural and urban dwellers with access to improved sanitation in Bangladesh increased from 39% to 53%, as nearly 40 million individuals were provided with improved sanitation facilities (WHO & UNICEF 2010a) (Figure 3). Such success can largely be attributed to the dissemination of simple and inexpensive improved sanitation technologies that have been advocated by both GoB and development NGOs involved in the water and sanitation sector. While these technologies mostly fit within the parameters set by both the JMP and GoB for improved sanitation[8], up to 70% of the toilets can be rendered seasonably unusable due to ground or floodwater inundation (Uddin 2011).

[8] The GoB definition is somewhat generalized, stating that a 'hygienic latrine' should 'effectively break the cycle of disease transmission' (Government of Bangladesh 2005b, p. 8). The *National Sanitation Strategy* further specifies that a hygienic latrine should: i) confine feces away from the environment; and ii) seal the passage between the squat hole and the pit to effectively block the pathways for flies and other insect vectors, thereby breaking the cycle of disease transmission (Government of Bangladesh 2005b). Conversely, the JMP definition for improved sanitation relies on describing specific technologies as 'improved' or 'unimproved' (WHO & UNICEF 2010b).

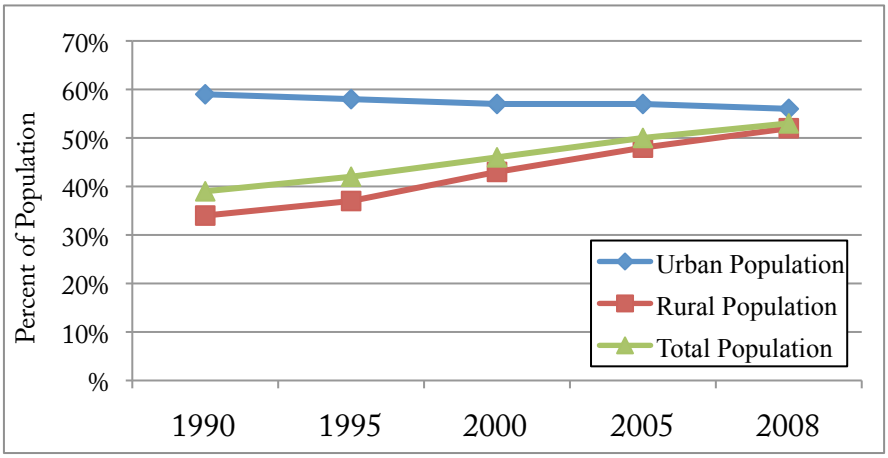

Figure 3: Access to Improved Sanitation in Bangladesh, 1990 – 2008
The overall trend indicates a significant increase in the rural population and slight decrease in urban access to sanitary facilities. (Source: WHO & UNICEF 2011)

The following section briefly describes the national level initiatives undertaken by GoB and its development partners to provide improved sanitation facilities to its population. The most common sanitation technologies are described and an argument is made that Bangladesh could benefit significantly from a proliferation of UDDTs.

3.3.1 National Sanitation Initiatives

Following independence in 1971, GoB set forth a massive campaign to repair the country's ailing water supply and sanitation infrastructure (Government of Bangladesh 2008). Initial protocol mandated that the Department of Public Health and Engineering (DPHE) oversee a majority of works, which were undertaken with national level funding (Government of Bangladesh 1998). However, the slow rate of improvement and limited funds for sanitation resulted in a gradual shift from top-down sanitation planning to a wider degree of local and individual involvement in securing sanitation facilities (Government of Bangladesh 1998).

The Government of Bangladesh's commitment to ensuring access to affordable water and sanitation services through participatory mechanisms was formally codified in 1998 with the acceptance of *The National Policy for Safe Water Supply and Sanitation* (Government of Bangladesh 1998). The document marked a significant shift in the Government's official stance regarding provision of sanitation services, recognizing for the first time that behavioral aspects of the sanitation challenge can be equally as important as the physical infrastructure (Government of Bangladesh 2008).

The paradigmatic shift in sanitation ideology necessitated the introduction of innovative institutional and financial arrangements and laid the basic framework for the model of sanitation service provision today (Government of Bangladesh 1998; Government of Bangladesh 2005a).

The most comprehensive national sanitation policy to date, the *National Sanitation Strategy* was drafted by GoB in 2005. Inspired in part by the MDGs, the policy set the ambitious goal of eliminating open defecation and providing 100% access to improved sanitation facilities by the year 2010[9] (Government of Bangladesh 2005b). The policy differed from previous legislation in that it placed increased emphasis on NGO involvement in meeting sanitation targets and shifted the focus from constructing secure sanitary facilities to adequately confining feces and preventing transmission of fecal pathogens to the environment (Hanchett et al 2011).

In 2007, the DPHE and its partners launched what would be the largest sanitation initiative ever undertaken in a developing country (Alam 2010). The project, called *Sanitation, Hygiene Education and Water Supply in Bangladesh* (SHEWA-B), aimed to bring sanitation facilities to some 30 million of Bangladesh's poorest citizens, with initial funding amounting to approximately US $90 million (UNICEF 2007). Contrary to previous sanitation initiatives in Bangladesh that sought to maximize funding for the proliferation of well-established sanitation technologies, SHEWA-B funds have been allocated to allow for some experimentation with alternative sanitation delivery mechanisms (Alam 2010). This funding has been used to finance several pilot projects aimed at identifying the most appropriate UDDT designs for specific environmental contexts in Bangladesh (Practical Action 2011).

3.3.2 Sanitation Technology in Bangladesh – The Ring-Slab Latrine

Conventional sanitation solutions in Bangladesh have primarily centered on technologically unsophisticated, decentralized systems. While open defecation, hanging latrines and unlined pit latrines are common in Bangladesh, they do not fit within either the GoB or JMP definitions[10] of hygienic or improved sanitation. The

[9] The target date has since been extended to the year 2013 (Hanchett et al 2011).
[10] While the GoB and JMP definitions of improved sanitation are similar, GoB protocol does not

following section is limited to the discussion of the most common form of improved sanitation found in Bangladesh.

The ring-slab latrine has been widely advocated as a simple and inexpensive sanitation solution for both urban and rural contexts in Bangladesh. Rapid dissemination of the toilets began in the early 1990's, and began to reach the more impoverished sector of the population by the early 2000's (Biliqis et al 1994). The required supplies for the construction of a ring-slab latrine are widely available through privately operated sanitary supply outlets and are affordable to most households (Figure 4). The supplies themselves are, in fact, so pervasive that in a survey of nearly 3,000 households across Bangladesh, Hanchett et al (2011) identified that approximately 98% of respondents had access to the raw materials to construct such a latrine.

Figure 4: Sanitation Supplies Depot
Prefabricated concrete rings and slabs for sale in the Narayanganj District just east of Dhaka City. (Photo: A. Guadagni)

A basic ring-slab latrine consists of prefabricated interlocking concrete rings and metal or plastic slab with a water seal. The concrete rings are generally set within a dug pit and left unsealed at the bottom, allowing fluids to percolate into the subsurface (Uddin 2011). In many instances, one or more rings are installed above ground surface to minimize the impact of potential floodwater inundation (Figure 5). Urine and feces are deposited in an access hole in the slab and flushed through the water seal into the lined pit. In most instances, the properly maintained water seal is

recognize those toilets with a poorly functioning water seal as 'improved'. Consequently, sanitation statistics reported by GoB and the JMP can be widely variable (Hanchett et al 2011).

effective in preventing the transmission of fecal pathogens to the user (Tilley et al 2008).

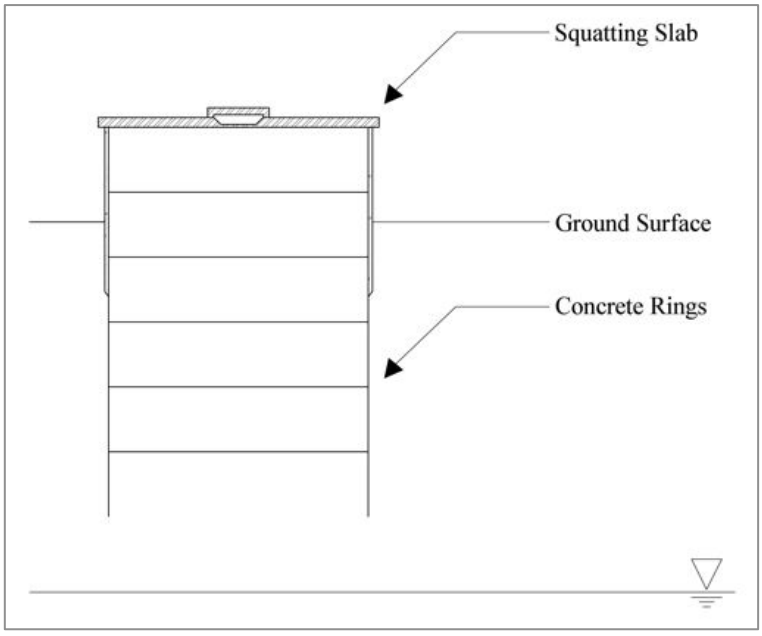

Figure 5: Ring-Slab Schematic
A schematic diagram of a ring-slab latrine. The squatting pan is equipped with a water seal. (Design: A. Guadagni 2011)

Shortcomings of the Ring-Slab Latrine

Despite its affordability and potential effectiveness in confining disease-causing vectors, the ring-slab latrine is by no means a perfect sanitary system. The unsealed bottom of the pit allows untreated sewage to percolate into the subsurface, potentially contaminating ground water and adjacent surface water resources. Hanchett et al (2011) also found that a large number of ring-slab latrines were prone to inundation by floodwater and seasonally affected by elevated water tables, resulting in disuse and spreading fecal bacteria to the environment. Furthermore, the water seal in many toilets has frequently been observed to poorly maintained, creating a clear route of direct contact with contaminated media for its users (Hanchett et al 2011). The toilets have also been shown to be technically inappropriate for water stressed areas, as the process of flushing excreta through the water seal into the pit requires high volumes of water (Practical Action 2010a).

3.4 The UDDT as an Appropriate Sanitation Technology in Bangladesh

While demanding significantly higher installation costs than the ring-slab latrine, the UDDT performs quite well in a number of areas in which the ring-slab latrine has been shown to be deficient. The following section argues that UDDT technology is particularly well suited for the Bangladeshi context and has potential to make significant contributions even beyond the realm of sanitation.

3.4.1 Resilience in Flood Events

While seasonal flood events in Bangladesh are fairly predictable and even seen as important to the country's economic productivity (Xian 2007), relatively minor rises in river levels can have significant impacts on the nation's sanitation infrastructure. WHO (2007) has recognized that damage to sanitation infrastructure related to floods in Bangladesh has been associated with myriad environmental and health problems, including degradation of water resources, infectious diarrheal disease, cholera, skin disease and acute respiratory infection. While local populations have largely developed mechanisms for adapting livelihoods during flood events (Xian 2007), experts anticipate that the effects of global climate change will be disproportionately felt in Bangladesh, leading to unprecedented flood impacts (Alam & Rabbani 2007).

Considerable research has been undertaken to develop effective means of providing emergency sanitation facilities for those effected by flood events (Alam & Rabbani 2007; Schmerbeck 2008). It can be argued, however, that it is more efficient to provide flood resilient sanitation technologies before flood events occur. The construction of UDDTs, with feces contained in a watertight brick and cement plaster chamber, has been shown to be amongst the most effective low-cost sanitation technologies with regards to flood resilience (Uddin 2011). Consequently, sanitation experts in Bangladesh continue to identify UDDT technology as an appropriate solution for flood prone areas (Practical Action 2010b; Uddin 2011).

3.4.2 Contribution to Agricultural Productivity

Agriculture remains the dominant economic sector in Bangladesh, accounting for approximately 36% of the national GDP and providing employment for some 23 million individuals (Mustafi & Islam 2008). Given the large number of individuals and the generally low availability of arable land, recent trends in Bangladesh's agricultural sector have placed increased emphasis on increasing crop productivity, primarily through the use of chemical fertilizers and pesticides (Kafiluddin & Islam 2008). Consequently, the domestic demand for chemical fertilizers has increased astronomically since its introduction in the early 1950's, with modern day consumption totaling approximately 400 million tons (Kafiluddin & Islam 2008).

While the introduction of chemical fertilizers was critical in helping Bangladesh's agricultural sector transition from small-scale subsistence farming to methodologies more capable of creating self-sufficient grain production (Islam 2008), the practice has also had negative impacts. Prolonged application of chemical fertilizers to the soil coupled with other detrimental agricultural practices, such as insufficient crop rotation, have substantially degraded the quality of the native soil, requiring increased application of chemical fertilizers to maintain consistent levels of crop production (Mustafi & Islam 2008; Jahiruddin et al 2010). Currently, a majority of the arable land in Bangladesh suffers from serious depletion of nitrogen and potassium, near exhaustion of phosphorous and concentrations of organic matter well below the recommended minimum of three percent (Huq & Joardar 2008; Islam 2008; Azad-uz-zaman et al [undated]).

Bangladesh's heavy reliance on chemical fertilizers has also created a system in which food security is largely dependent on the unpredictable international fertilizer market. International shortages of urea in 1995 lead to wide spread hunger throughout the country, and sharp increases in the price of chemical fertilizers in 2003 and 2004 necessitated the creation of a GoB sponsored fertilizer subsidization program (Kafiluddin & Islam 2008). However, even with government subsidization of approximately 25%, fertilizer costs have rapidly increased since the early 2000's, straining farmers and affecting food supply throughout the country (Kafiluddin & Islam 2008; Shah et al 2008). In the summer of 2011, the price of urea fertilizer saw

its most dramatic increase since the introduction of the government subsidy, nearly doubling in price to 20 BDT (US $0.24) per kilogram (National Food Policy Capacity Strengthening Programme [undated]).

The proliferation of UDDTs or other ecosan compatible toilets in Bangladesh can likely provide significant contribution to the agricultural sector. Human urine contains high concentrations of nitrogen and phosphorous and can significantly reduce reliance on chemical fertilizer alternatives (Neupane 2010). Treated feces, though containing a much smaller nutrient load, can reintroduce a tremendous amount of organic material into the native soils (Azad-uz-zaman [undated]). In a study of UDDTs installed in the Comilla District, Uddin (2011) found that the nutrient content of the urine and feces produced in the area would be sufficient to replace approximately 78% of the total chemical fertilizer demand. The vast majority of these valuable nutrients, however, are currently not utilized, and are ultimately washed into the countries waterways and ground water resources.

4.0 Methodology

This section describes the research methodology employed to empirically assess the social embeddedness of UDDT technology in various contexts and settlement typologies in Bangladesh during field research conducted between August 20 and September 24, 2011.

4.1 Field Research

This study relied on three distinct empirical research methodologies: qualitative assessment, quantitative assessment and a diagnostic survey. The processes of data collection for each methodological approach are detailed below.

4.1.1 Qualitative Analysis

Qualitative research uses the natural setting of the case study as a means to collect narrative, descriptive data (Hoepfl 1997). The methodology is termed 'qualitative' as it does not attempt to artificially divide social reality into a series of independently measurable facts (Gatti & André 2010). Most commonly applied in the realm of social sciences, qualitative evaluation is thought to provide a more accurate assessment of human interactions, especially in instances in which the subject is likely to be influenced by such interactions (Denscombe 2007). Furthermore, Strauss and Corbin (1990) suggest that a qualitative analysis may be most applicable in grounded theory, namely in those instances in which few theories abound regarding a given subject.

Due to the inherent importance of human interactions and dyadic relationships in the embedding of new technologies (Granovetter 1992) and the generally limited theoretical framework regarding the processes under which social embedding occurs, a qualitative methodology was selected as the primary means of data collection for this study. The findings of this research, presented in Section 6.0 through Section 9.0, rely primarily on data collected during interviews with users of UDDTs (referred to here as *users*) and with development experts (referred to as *experts*) involved in the

implementation of both UDDT and conventional sanitation interventions throughout the country.

User Interviews

User interviews were administered as open-ended, semi-structured discussions, allowing the respondent the opportunity to respond freely to all questions. Interviews were conducted with the assistance of English language translation and were digitally recorded. User interviews emphasized the behavioral adjustment to UDDT technology and any attitudinal changes related to the use of excreta based fertilizers and soil conditioners.

Respondents were selected to create a balanced demographic and social stratigraphic cross section of UDDT users; however, heads of households and female heads of households are disproportionately represented in the data set, as it was determined that these individuals were the primary decision makers regarding the use of sanitary latrines. Interviews were conducted inside or immediately adjacent to the home and were, when possible, administered privately so as to minimize potential discomfort when discussing toilet behaviors.

Observational data regarding the setting of each interview and emotional cues of respondents were also recorded in a field book. These observations were used in order to establish an informal record of the context in which each the interview took place and in which each UDDT system exists (Patton 1980).

Expert Interviews

Expert interviews were also administered as open-ended, semi-structured interviews. With a few exceptions, these interviews were conducted in English. Expert interviews sought to identify elements in the NGO's implementation model that affect the social embedding of the new sanitation system and to attain an account of the context specific process of embedding from the perspective of sanitation professionals. When possible, interviews were conducted with both individuals responsible for the planning of the intervention, as well as field practitioners responsible for the implementation and monitoring of the intervention activities.

Expert interviews were conducted with individuals or in small groups. In instances in which no published data could be found, demographic and socio-economic data pertaining to case study areas was also obtained during expert interviews.

4.1.2 Quantitative Analysis

Prior to or following each user interview a brief questionnaire was administered to each respondent. The questionnaire (Appendix I and Electronic Appendix) was designed to gather basic demographic information about the respondent and the UDDT's users. In particular, the questionnaire sought to determine factors that could potentially affect the embedding of a new sanitation technology that may have otherwise been overlooked in the qualitative interviews, such as the respondent's experience with conventional sanitation systems, the current number of users of the UDDT system and the respondent's role within the household. Results of this quantitative analysis provide an abbreviated contextual background for each respondent or household and were primarily used as an interpretive tool for the qualitative data set.

4.1.3 Diagnostic Survey

A diagnostic survey was conducted in order to visually assess elements of each UDDT system. Factors pertaining to system design, maintenance and proper usage were assessed and documented. Six different UDDT system components were visually assessed and their condition was recorded on a *UDDT System Evaluation Form* (Appendix II and Electronic Appendix) as a ranging from 'very good' to 'very bad'. Specific notes were also recorded for each of the UDDT system components assessed. Results of this observational survey were coupled with qualitative data obtained during user interviews to further assess the respondent's understanding of the UDDT technology and ability or willingness to properly maintain the sanitation system. Additionally, the survey sought to assess the design criteria for each UDDT system and identify specific elements of the design that could potentially affect the social and behavioral adaptation of its users.

4.2 Case Studies

Prior to the commencement of field research, a series of interviews was conducted with representatives of several NGOs at their Dhaka offices. The purpose of these interviews was, in part, to obtain information regarding areas in which UDDT interventions have been previously conducted and to assess which of these areas would be most suitable to serve as case studies for this report. Information regarding prospective case study locations was then evaluated to determine its appropriateness within the research design frame.

Given the scope of the research proposal, it was decided that a data set obtained from a varied set of case studies would be necessary to assess the social embedding of UDDT technology outside of a singular context. The elements detailed below were determined to have particular significance with regards to the potential embedding of a new sanitation technology, and were critical elements in the selection of the case study locales.

Temporal Distribution

The first ecosan intervention in Bangladesh was initiated as a joint effort of Japanese Association for Drainage and the Environment (JADE) and the Bangladesh Association for Rural Development, Comilla (BARD) in 2004, with the physical installation of the UDDT systems occurring in early 2005 (Azad-uz-zaman et al [undated]). NGO initiated UDDT interventions continued each year following the initial JADE/BARD pilot project, with a sharp increase in both the total number of interventions and the number of UDDTs installed after 2006 (GIZ 2011a).

Given the social and behavioral adjustment required in the adaptation to UDDT technologies in a virgin population (those with no prior knowledge of UDDT technology or ecosan ideology) (Onyango & Odhiambo 2009), it was determined that temporal factors would be likely to influence the embedding of this new sanitation solution at both the household and community levels. More specifically, the study sought to assess whether UDDT systems had become more deeply embedded within the given context the passage of time. In order to evaluate these considerations, case

studies were selected to achieve a reasonably balanced temporal distribution of both the earliest and more recent UDDT interventions undertaken in Bangladesh.

Settlement Typology

Creating sustainable sanitation solutions is largely dependent on the selected technology's applicability within the local context (Sustainable Sanitation Alliance 2011). Subtle differences in local institutions, socio-cultural attitudes, political entities and motivations could have substantial affects on the embedding of the technology (Netherlands Waste Partnership 2006). Factors such as availability of local resources, strength and structure of social networks and willingness to work with NGOs are likely to vary within each settlement and may be even more profound when comparing rural and urban settlements.

Different contextual arrangements in different settlement typologies could have profound affects on the embedding of new sanitation technologies in Bangladesh. For example, the GTZ (2010) cites evidence of a lesser degree of social cohesion in Bangladesh's urban settlements than in their rural counterparts. Such information could suggest that the processes that contribute to the embedding a new sanitation technology could vary significantly by settlement typology. In order to account for such contextual variations, case study areas were selected to represent UDDT interventions undertaken in rural and peri-urban villages, as well as urban slums.

NGO Involvement

With a few possible, albeit unconfirmed, exceptions, all UDDTs installed in Bangladesh between 2005 and September 2011 were installed with technical oversight or financial contributions from an NGO or the DPHE. The GIZ (2011a) has identified at least seven[11] NGOs currently or formerly involved in the UDDT interventions throughout Bangladesh. Though published accounts of best practices regarding procedures for the implementation of ecosan toilets abound, financial limitations, personal experience and preference, and degree of expertise are likely to

[11] The GIZ (2011a) list, which does not include smaller scale research projects, identified the following NGOs as involved with ecosan interventions in Bangladesh: BARD, BASA, JADE, Oxfam, SPACE, Terre des Hommes and WASTE Netherlands. The author of this report also determined that the Bangladeshi NGOs DSK and Green Hill are also involved in UDDT interventions.

create some variability in the implementation and monitoring models of the interventions undertaken by each NGO.

4.3 Data Analysis

Qualitative Data

Following the collection of field data, transcripts were created from audio recordings of each interview. During the transcription process, notes were taken to determine a preliminary set of thematic topics under which portions of interviews would later be categorized. When all interviews were transcribed, the transcripts were then analyzed and individual passages were categorized and assigned codes to represent one or more of the thematic topics identified during the transcription.

The coded data was then condensed to a thematically organized matrix, documenting each respondent's response or attitude with regards to a given theme. This matrix divided the data set into categorized themes, as well as by more intrinsic specificities such as the location and date of installation of the UDDT, in order to more easily identify contextual variables in user's responses. The data set was then analyzed for patterns and trends, identifying issues specific to a given context and examining those cross-cutting issues which appeared consistently throughout the field research.

4.4 Preliminary Results

User Interviews

A total of 52 interviews were conducted with users of 37 UDDTs. These interviews took place in 11 different villages of six Districts of Bangladesh. A minimum of one interview was conducted for every UDDT visited during the research. In the event that a child under the age of 15 was interviewed, a second interview was always conducted with either the male or female head of household. Due largely to availability or willingness to participate in the interviews, men are slightly better represented in the data set.

Of the 52 interviews conducted between August 20 and September 24, 2011, 28 were conducted with male and 24 with female respondents (Table 1). Nineteen of these identified themselves as the primary head of household and another 16 identified themselves as the female head of household[12]. Interviews had an average duration of 32.7 minutes (median: 33), and tended be slightly longer for adults than for children.

Age	Gender	
	Male	Female
9-15	3	1
16-25	1	2
26-45	9	13
46-65	14	8
>65	1	0
Total	28	24

Table 1: Demographic Distribution of Respondents

Analysis of the quantitative data identified that the average number of users per UDDT sampled for this study was 6.2 (median: 5). A further breakdown of respondent's is provided in Appendix III. No interviews were conducted with the users of any UDDTs installed in 2006 or 2007, as comparatively few UDDT systems were installed during this temporal span.

Expert Interviews

A total of 21 interviews were conducted with 32 sanitation professionals from 11 NGOs and research institutions in Bangladesh (Appendix IV). Of these 32 respondents, nine identified themselves as primarily working in the field in a training or monitoring capacity, with the remainder holding positions primarily related to planning of the interventions.

[12] Due to the general proclivity for male members of family's in Bangladesh to live with their extended families throughout adulthood, several instances were noted in which a male respondent owned his own home and acted as the primary decision-maker with regards to the family's sanitation situation, but identified an elder male family member as the head of the household. The information regarding head of household status above is based solely on self-reporting.

5.0 Introduction of Case Study

The following section describes the generalized context for each of the case studies assessed as part of this research. Each of the case study areas was selected with the assistance of ecosan experts in Bangladesh to fit within the criteria established in Section 4.2 of this report. The information provided in this section was primarily obtained during interviews with experts involved in sanitation interventions in the area unless otherwise noted.

5.1 Introduction of the Case Study Areas

The following section provides a brief description of the demographic, environmental and sanitation history of each of the case study areas from which data was collected for this study. The following descriptions are organized according to Division and District[13]. Proximal villages with similar characteristics are considered to be part of the same case study. A summarized account of the information provided on these pages can be found in Table 2. The approximate location of each of the case study areas is indicated in Figure 6.

Division	Village (District)	Settlement Typology	No. of Households	No. of UDDTs
Chittagong	Raicho, Hatigara and Joypur South (Comilla)	Peri-urban	<500 (each)	114
	Jelepara (Rangamati)	Rural / Island	120	4
Dhaka	Bhashantek (Dhaka City)	Urban slum	2,500	2
	Pajulia (Gazipur)	Peri-urban	329	29
	Behaykor and Pobonkul (Narayanganj)	Peri-urban	<500 (each)	4
Khulna	Shamta and Tengra (Jessore)	Rural	2,500 (total)	20
Rajshahi	Amarak	Rural	30	7

Table 2: Summary of Case Study Area Information

[13]Bangladesh is divided into seven Divisions, the largest sub-national administrative unit. Each division is then sub-divided into any number of districts. For more information, see UN ESCAP [undated].

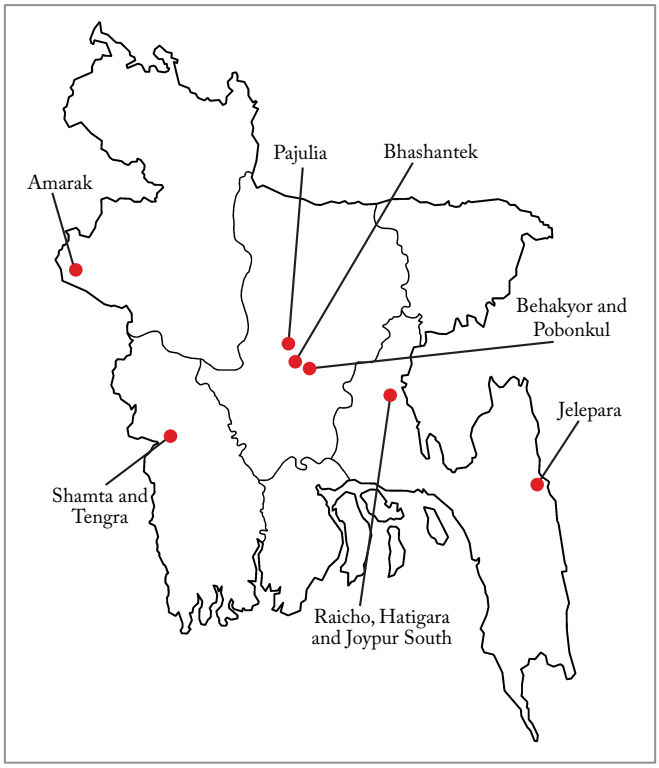

Figure 6: Case Study Location Map
Divisions of Bangladesh with approximate location of case study villages indicated in red. Not to scale. (Source: Wikimedia 2010)

5.1.1 Chittagong Division

Comilla District

The villages of *Raicho*, *Hatigara* and *Joypur South* (Comilla Upazilla) were selected as a case study area in the Comilla District. The villages are located within a few kilometers of each other and lie in a peri-urban area immediately outside of the Comilla City. Each village is home to less than 500 households. Incomes in the villages are primarily related to rice production, with a significant percentage of families receiving a secondary income from one or more family members working abroad.

The villages of Raicho, Hatigara and Joypur South are the only villages investigated in this study that have well established CBOs, which were organized under the GoB *Comprehensive Village Development Program* (CVDP). These cooperative organizations are designed to foster a self-help initiative within the communities and to provide a number of administrative programs to enhance social development (Reza

[undated]). Though the community organization was not formally involved in the JADE/BARD UDDT interventions of 2005 and 2008, it has come to serve as an ad hoc forum for the transference of information regarding ecosan technologies in the area.

All three of the villages were subject to the first UDDT interventions undertaken in Bangladesh in 2005 as a joint effort of JADE and BARD. A second phase of UDDT installations took place throughout the villages in 2008. A total of 114 households have been equipped with UDDT systems in the three villages, with a majority of the remaining households using ring-slab latrines.

Rangamati District

The village of *Jelepara* (Rangamati Upazilla) was selected as a case study area for the Rangamati District. The village of approximately 120 households is located on a small island in the Karnaphuli Reservoir within Bangladesh's lone mountainous region, the Chittagong Hill Tracts. The village is home to an exclusively Hindu population. There is a single, privately owned deep tube well operating in the village that all families rely on as a primary source of potable water. Primary incomes in the village are derived almost exclusively from fishing. There is a small amount of arable land during the winter months when the water level in the Karnaphuli is low. However, few families utilize this land for agricultural or horticultural purposes and there is virtually no land available for year-round cultivation. Regular erosion to the island's land mass has gradually decreased the village's size and currently threatens the stability of several structures. Flooding is a regular threat to the island during the rainy season.

Four UDDT systems were planned and installed in Jelepara by SPACE in 2008. Those families who do not own UDDTs generally rely hand dug pit latrines, ring-slab latrines and hanging latrines. Open defecation is practiced by a small number of individuals.

5.1.2 Dhaka Division

Dhaka City

The *Bhashantek Slum Settlement* in the Mirpur Zone of Dhaka City was selected as the sole urban case study for this report. Located on GoB owned land, the settlement is one of the oldest and best-established slum settlements in Dhaka. Despite the lengthy duration of tenure and provision of several basic services by both GoB and NGO activities, the residents face regular threat of eviction and resettlement into one of several large-scale housing projects currently under construction in the area (Awal & Nishidie 2010). Though the Mirpur Zone lies on some of the highest elevation in Dhaka city, the area is subject to flooding when waters in the Turag River reach approximately 6.5 meters above the Mean Sea Level (MSL) datum, an event that has occurred twice since 1985 (Hoq and Alam 2003).

The informal settlement of approximately 2,500 households (Khan 2010) is home to two UDDT toilets installed by DSK in 2011. As of September 2011, the Bhashantek slum is the only urban area in Bangladesh that has been the subject of an ecosan intervention (Interview with Ranajit Das on Aug 23 2011). The ring-slab latrine is the most commonly employed conventional sanitation technology, with a small number of hanging latrines installed adjacent to aquaculture ponds within the slum. A small number of residents practice open defecation on settlement's periphery.

Gazipur District

The village of Pajulia (Gazipur Upazilla) was selected as a case study area in the Gazipur District. Located a short distance from Joydebpur center and approximately 30 km north of central Dhaka City, the peri-urban village is home to approximately 329 households (Interview with Md. Abdul Khaleque on Sept 24 2011). Incomes in the village are primarily related to the cultivation of rice, though smaller vegetable fields are frequently maintained. The environment is considered semi-arid plain with low risk for seasonal flooding (Hanchett et al 2011).

UDDT systems were initially introduced to the village in 2008 as part of the *Integrated Support for a Sustainable Urban Environment* (ISSUE) project,

collaboratively undertaken by BASA, WASTE Netherlands and Practical Action. A total of 29 UDDTs were installed in the village over a two-year period beginning in 2008, with four additional UDDT systems installed in an adjacent village. Additionally, BASA has installed multi-seat UDDTs at three high schools in the Gazipur District (Alam 2010). Ring-slab latrines have developed as the most commonly used sanitation system in the area, with a marked decrease in the instance of open defecation in recent years.

Narayanganj District

The villages of *Behakyor* (Sonargaon Upazilla) and *Pobonkul* (Rupgong Upazilla) were selected as case study areas in the Gazipur District. Located approximately 15 kilometers east and across the Buriganja River from central Dhaka City, these two peri-urban villages are each home to less than 500 households. Incomes in the area are largely derived from the cultivation of rice, although a large number of small-scale weaving factories and a smaller number of large jute mills contribute significantly to local employment.

The first and only UDDT system installed in Behakyor village was installed by DSK in 2010. This installation represents DSK's first foray into ecological sanitation interventions. Due to generally low interest in the community following this pilot installation, DSK shifted efforts to the nearby Pobonkul village to continue promoting UDDT technology (Interview with Ranajit Das on Aug 23 2011). As of October 2011, a total of three UDDT systems have been installed in the village, with a fourth UDDT scheduled for completion in November 2011. DSK's efforts continue in Pobonkul, with plans to scale-up the intervention in the next several years. A majority of households in both Behakyor and Pobonkul rely on ring-slab and hand dug pit latrines as their primary sanitation facilities.

5.1.3 Khulna Division

Jessore District

The neighboring villages of Shamta and Tengra (Sharsha Upazilla) were chosen as case study areas in the Jessore District. Located approximately 35 kilometers west of

Jessore City, these two rural villages are home to approximately 2,500 families. Incomes in the area are predominantly derived from cultivation of rice, with a seasonal jute crop accounting for additional income. The two villages are severely affected by arsenic contamination in the ground water[14], which is often used as a source of drinking water, resulting in a high number of arsenicosis sufferers in the area.

A total of 20 UDDTs were installed in Shamta and Tengra in late 2010 and 2011 by SPACE. Following installation on the toilets, SPACE recruited and trained several local residents to oversee the long-term monitoring activities associated with the intervention, creating a well-connected monitoring network within the community. The most common sanitation systems used in the two villages are ring-slab latrines and hand-dug pit latrines

5.1.4 Rajshahi Division

Rajshahi District

The village of *Amarak* (Nawabganj Sadar Upazilla) was selected as a case study area in the Rajshahi District. Located approximately 40 kilometers northwest of Rajshahi City and a short distance from Chapai Nawabganj, this rural village is home to approximately 30 households (Practical Action 2011). The village was incrementally settled on GoB owned land beginning in the mid-1990's, largely as a refuge for those affected by environmental displacement associated with erosion along the banks of the nearby Padma River. Incomes are primarily derived from cultivation of rice, with a number of local families receiving secondary incomes from family members employed abroad.

UDDT technology was first introduced to the village by SPACE in 2010, when five UDDT systems were installed with funding from the SHEWA-B project. The village was also included in the UNICEF implemented study *Action Research on Ecological*

[14]The instance of naturally occurring dissolved arsenic in aquifers throughout Bangladesh has been called the greatest instance of mass poisoning in world history, with an estimated 50-80 million individuals affected by arsenic laden drinking water (Sambu and Wilson 2008). For more information, consult the *Arsenic Project* at Harvard University (2008).

Alternatives in Sanitation in Difficult Areas of Bangladesh[15]. Due to the village's inclusion in the study, there is some variety in the design of the UDDTs, specifically with regards to variations in the construction materials and configuration of the toilet pan (Practical Action 2010b). A majority of households in the village rely on hand-dug pit latrines and ring-slab latrines as primary sanitation technology. A small number of households practice open defecation in the paddy fields surrounding the village.

[15] This study was conducted by Practical Action, along with its partners BASA, SPACE and Commitment Consultants and sought to identify appropriate design criteria to account for variable environmental factors across Bangladesh.

6.0 Research Findings

6.1 UDDT System Design

Despite recent research conducted by NGOs to identify the most appropriate ecosan solutions applicable within various environments in Bangladesh (see Practical Action 2010a, Practical Action 2010b), the majority of eco-toilets installed in the country are based on very similar UDDT design criteria. Though there is some variability in the use of construction materials, the basic configuration of the toilet's functional components remain fairly consistent.

The most common eco-toilet in Bangladesh is the fixed chamber UDDT and consists of two adjacent sealed feces chambers (Figure 7). The dual-chamber design allows for continuous use of the toilet, as one chamber is sealed and allowed to rest while the other remains in active use. The feces chambers are kept dry by the point-of-source diversion of urine into a separate containment vessel, the diversion of the anal wash water into an external leach pit and the deposition of a small quantity of ash on top of the feces. This section describes UDDT design from a technical perspective, highlighting a few common variations on the standard design encountered in Bangladesh.

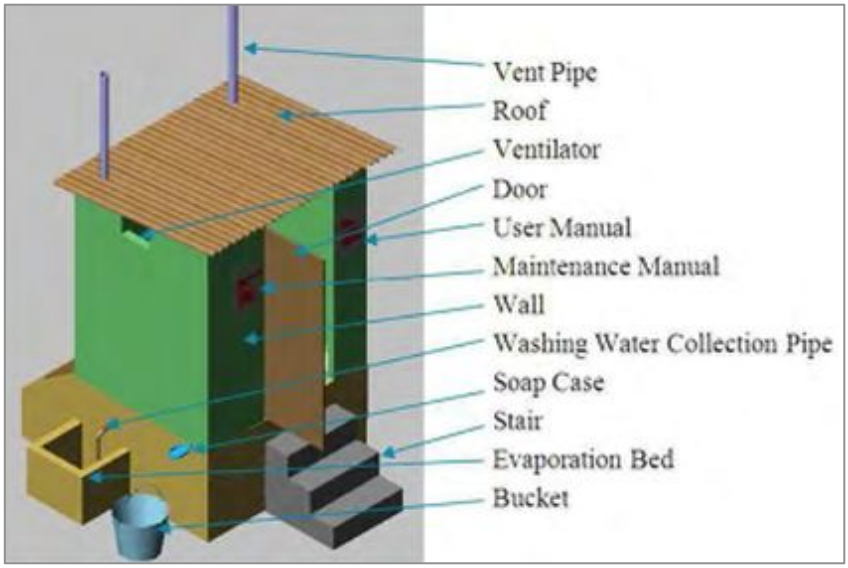

Figure 7: UDDT Diagram and Functional Components
Sketch of a dual fixed-chamber urine diversion dry toilet. (Source: Practical Action 2010a)

Substructure

The substructure or foundation refers to the sub-surface elements on top of which the UDDT is built. Like any foundation, the substructure of a UDDT creates a stable base to support the overlaying structure. However, the substructure of the UDDT also serves as the base of the feces chamber. It is critical that the substructure be sealed to prevent inundation of the feces chamber in the event an elevated water table and to prevent liquid that may enter the chamber from leaching into the subsurface.

The basic construction of the substructure calls for a shallow excavation around the planned footprint of the UDDT. The subsurface is then compacted and a single layer of mortared brick is laid in the excavated area. The brick is finished with a layer of concrete to effectively sealing the foundation. Designs advocated by certain NGOs, notably DSK, call for a brick or poured concrete footing around the perimeter of the substructure to increase stability.

Feces Chamber, Heat Panels and Ventilation

The feces chamber is the brick vault immediately atop the substructure and serves as the location for the storage and treatment of feces (Figure 7 and Figure 8). The substructure is generally divided laterally with a brick partition to create two adjacent chambers. The dimensions of these chambers can vary depending on the anticipated number of users and to account for certain environmental factors, such as typical flood levels. Following the completion of the mason work, the interior and exterior of the feces chamber are sealed with concrete to prevent water intrusion through the mortar and to prolong the life span of the masonry.

Figure 8: Feces Chamber
A local mason lays bricks for the feces chamber of a dual chambered UDDT in the Pobonkul Village. (Photo: A. Guadagni)

The UDDT's heat panels (Figure 7 and Figure 9) are generally installed at a 45˚ angle along a rectangular protrusion at the rear of the feces chamber, opposite the entrance to the toilet. These metal panels allow for the transfer of solar energy to the contents of the feces chamber, increasing the system temperature and creating more optimum conditions for dehydration and pathogen destruction (GTZ 2006). The removable heat panels also serve as the primary access to the feces chamber interior for removal of the treated excreta. The panels are generally affixed to the exterior of the feces chamber using a thin layer of concrete plaster, which is cracked and broken prior to the removal of the heat panels. Alternatively, panels were also observed to be hinged and locked in place with a watertight seal created by a rubber grommet. During the field investigation associated with this report, faulty heat panel sealant and corrosion to the heat panels themselves were identified as the most likely routes of water intrusion into the feces chamber[16].

[16] It is quite likely that during the initial phase of toilet use by unhabituated individuals, improper use of the toilet would be the most likely route of entry for liquids into the feces chamber.

Figure 9: Heat Panels
Locking heat panels installed on a UDDT in the Pobonkul village.
(Photo: A. Guadagni)

The feces chamber is also equipped with at least one vertical vent allowing for the exchange of gasses with the atmosphere (Figure 7). The vent enters the feces vault through a penetration in the floor adjacent to the toilet pan and is vented to the exterior of the super structure, preventing foul odors from accumulating in the structure and increasing the rate of dehydration of the fecal material. UDDT systems in Bangladesh are constructed with both single and double exhaust ventilation systems, most frequently constructed from 5-centimeter diameter PVC piping.

Toilet Pan

The toilet pan is set in the floor directly above the feces chamber and includes the fundamental mechanisms for the point-of-source separation of liquid and solid excreta (Figure 7 and Figure 10). The most common configuration includes the vertical alignment of a urine diversion basin and drain, an approximately 23-centimeter (9-inch) diameter feces chamber port and an anal washing basin and drain. Two toilet pans are generally installed immediately adjacent to one another, mirrored above both feces chambers. Raised lips surround both basins and the feces chamber port to prevent mixing of media. Separate drainage pipes mounted within the floor beneath the toilet pan divert urine to a dedicated collection vessel and anal wash water to external leach pit. A toilet pan design with a single anal wash basin had been

commonly installed in early UDDT interventions in Bangladesh, but has largely fallen out of favor as the dual anal wash basin configuration reportedly improves user comfort with only marginal increases in installation cost (Interview with Monirul Alam on Aug 28 2011).

Figure 10: Variable Toilet Pan Design
Left: Plastic toilet pan with dual anal washing beds, fabricated in India; installed in Amarak village. Right: Concrete toilet pan with single anal wash bed and ceramic footholds; installed in Joypur South village. (Photos: A. Guadagni)

The design and construction materials of the toilet pan have been the subject of considerable research on the part of the Bangladeshi ecosan community (Practical Action 2010a, Practical Action 2010b). The varieties of toilet pan configurations examined during this study do not appear to have significant influence on the toilet's function, and are therefore not elaborated upon in this report. The construction materials, however, may be of greater importance with regards to the embedding of UDDT technology. Respondents showed a clear preference for certain construction materials, notably the tiled floor and runner surrounding the concrete pan, which is common in UDDTs installed by SPACE[17], potentially contributing to a heightened sense of ownership of the toilet.

The toilet pan design is quite significant with regards to the embedding of the sanitation technology, as the use of the toilet requires substantial behavioral adjustment. The Bangladeshi custom of washing the anus following defecation requires the user to shift their position from above the feces chamber port to the above the anal wash basin, a process which is a source of initial discomfort for the users. This behavioral adjustment is a regular challenge faced during awareness raising

[17] See, for example, Interview 018, page 3.

activities associated with UDDT interventions (Practical Action 2011, Interview with Monirul Alam on Aug 28 2011).

Leach Pit

The purpose of the leach pit[18] (Figure 7) is to confine the effluent anal wash water and minimize potential exposure to the water borne disease vectors. The leach pit is generally designed as a raised concrete box or cylinder attached or adjacent to the exterior wall of the toilet, with a vertical pipe directly discharging wastewater from the anal washbasin. The leach pit is filled with coarse material, generally crushed brick, to maximize hydraulic conductivity within the pit and prevent overflow of the contaminated media.

Super Structure

The super structure (Figure 7 and Figure 11) is the housing on top of the feces chamber that allows for privacy during defecation and urination. The roofed super structure also prevents rainwater from entering the feces chamber and is critical in ensuring the longevity of the toilet's brickwork and foundation (Hanchett et al 2011). The super structure is generally brick and mortar construction with a corrugated tin roof, sloped to allow for effective drainage of rainwater. Ventilation is provided by a small gap between the roof and the exterior walls, and often by small open windows in the walls.

[18] The UDDT system component referred to in this report as a *leach pit* is most commonly described as an *evaporation bed* Bangladesh. This term, however, is misleading as the pit itself is constructed with an open bottom, allowing fluid to percolate through coarse material and leach into the subsurface, rather than evaporate.

Figure 11: UDDT Super Structure
A brick super structure with corrugated tin roof and door, installed by SPACE in Shamta village. (Photo: A. Guadagni)

The super structure accounts for a significant portion of the overall construction costs. JADE (2011) suggests that the implementation cost of a single UDDT unit can be decreased by approximately one third by using locally available construction materials, such as bamboo, rather than brick and mortar construction for the super structure. However, Practical Action (2011) and others found that when presented with construction options, prospective UDDT users invariably selected the more costly super structure option, opting for what they considered to be a more permanent structure and perhaps contributing to a sense of increased social standing amongst its owners (Interview with Monirul Alam on Aug 28 2011).

Additional Considerations

Siting is often the first consideration with regards to the design and installation of a UDDT system. The dual-chambered UDDTs most common in Bangladesh generally have a footprint of no smaller than 3.25 meters^2 (35 feet^2), requiring considerably more space than conventional sanitation solutions. Spatial limitations of a given property are a frequent problem in the installation of UDDTs in Bangladesh. Such spatial constraints have been addressed by installing the UDDT immediately adjacent to, or in certain cases, within the home. Such proximity to home is generally

appreciated by the UDDT's owners, especially those with young women in the family, as it provides a measure of physical security that was previously unavailable[19]. This proximity to the home is possible as the UDDT systems, when properly use, emit very few odors and contain the feces in a sealed chamber to prevent transmission of disease vectors.

6.2 NGO Implementation Model

Less than half UDDT users in Bangladesh are familiar with the ecosan ideology prior to an NGO's initiation of a UDDT intervention (Practical Action 2011). This number is likely considerably smaller for the first phase of an intervention. The NGO's chosen model for the implementation of the intervention is critical to its ultimate embedding in the households and community, as it generally serves as an introduction to the fundamental ideology surrounding the toilet and continued support mechanism for the toilet's users.

This section describes a generalized model for implementation employed by a number of Bangladeshi NGOs, highlighting those aspects that are thought to contribute most significantly to the eventual embedding of the sanitation technology. The information contained in this section was obtained primarily through interviews with experts involved in the planning and implementation of those interventions which serve as the case studies for this research. Notable variations on this generalized model are also taken into consideration.

Awareness Raising

Likely a result of the several large-scale sanitation campaigns undertaken in the country, individuals in Bangladesh have a comparatively high level of understanding of the importance of adequate sanitation, especially amongst the younger generation (Hanchett et al 2011). However, the level of awareness of the potential economic and health benefits of UDDT systems remains largely unknown, especially in those communities with no history of ecosan interventions. Initial introductions to the

[19] See, for example, Interview 014, page 1; Interview 016, page 2; and Interview 050, page 2.

ecosan ideology, especially with regards to the reuse of the excreta based fertilizers and soil conditioners, are often met with disgust[20].

The first step in the implementation of an UDDT intervention involves creating demand for the technology, usually through an educational outreach program. Social and religious stigmas surrounding the ecosan ideology in Bangladesh are serious barriers in the proliferation of UDDTs and are not easily overcome (Practical Action 2011). One unit manager interviewed as part of this study reported conducting daily awareness raising activities within his village for nearly a month before any residents expressed interest in installing a UDDT system (Interview with Shahjahan Monbal on Sept 6 2011). Even when an NGO representative was able to convince a household to consider installing a UDDT, it was not uncommon for the family to take three to six months to finalize their decision. The challenge is particularly difficult in areas where a large number of families have already been convinced to invest their limited resources in a conventional sanitation system. Of the 37 households surveyed as part of this study, 25 had previously owned a latrine that was in accordance with both the GoB and the JMP definitions of improved sanitation.

Educational outreach took a variety of forms in the target communities, ranging from training sessions and community planning events, to less traditional community theater presentations. The educational program generally extolled both the potential economic productivity of the UDDT, as well as its capacity to provide improved sanitation and security to the household. One particularly successful, albeit resource intensive, method was the agricultural exhibition undertaken independently by Bard in the Comilla District and by Practical Action in the Gazipur District (Interview with Shishir Munshi on Sept 15 2011; Interview with Farhana Rahman on Sept 12 2011). Adjacent crop fields were sewn and one conventionally fertilized with urea and the other with the UDDT's excreta based fertilizer equivalent, allowing community members the opportunity to witness the effectiveness of the human manure in a practical setting.

[20] See, for example, Interview 010, page 2; and Interview 013, page 3.

Capacity Building and Community Development

Due to the recent arrival and relative obscurity of UDDTs in Bangladesh, knowledge regarding proper construction techniques is largely unknown in Bangladesh, even amongst conventionally trained sanitation engineers. NGOs traditionally extended their outreach programs to include training of skilled masons in the construction of UDDTs, farmers in the application of the soil conditioner and, in some cases, members of the local administration in promotion of the new technology. At is most basic level, capacity building must include training of local individuals in construction techniques, allowing for the possibility of repairs to be completed locally.

Methods of community development within the implementation model are highly variable and largely depend on the implementing NGOs ideology and funding capacity. In some instances, existing formal CBOs were adapted to include support structures for UDDT households (see Section 5.1.1, *Comilla District*). More commonly, community leaders were trained or representatives of the NGOs were implanted in the community to continue educational outreach and combat persistent negative attitudes related to the agricultural application of excreta based soil conditioners. Informal networks between UDDT users were observed to develop spontaneously within target communities, as the common experience and novelty of ownership of the latrine formed a common link between individuals.

User Selection, Construction and Training

In the event that the demand created by the awareness raising campaign outweighs the NGOs capacity to construct the toilets, beneficiaries are selected by the NGO based on their perceived suitability and acceptance of the UDDT technology. Access to agricultural land is usually, though not always, prerequisite for selection. Those beneficiaries selected for UDDT construction are presented with a contract detailing the mutual financial obligations of the household and the NGO, as well as a 'mental contract' cementing a commitment to use the toilet. Construction is conducted using local masons with the oversight of NGO engineers or representatives.

Upon completion of the structure, a practical training session is administered. Though heads of households are generally aware of the basic ideology and behaviors associated with the UDDT by this point, this session is inclusive to all users and utilizes a hands on approach to creating familiarity with UDDT operations and maintenance (Figure 12). Users are familiarized with general operating procedures and solutions to the most common problems encountered. The training also includes proper application procedures for the urine fertilizer and an overview of safe handling procedures for the fecal soil conditioner.

Figure 12: Training Session
Children in the Pobonkul village pose with a sketch of their new UDDT following a training session conducted in their home by a DSK training officer. (Photo: A. Guadagni)

Monitoring

Though all NGO implementation models include a monitoring program in the initial stages of and intervention, the duration and logistics of the monitoring program tend to be somewhat variable and largely dependent on the arrangements with the funding organization. Immediately following installation, all project sites were visited by a unit manager on a daily basis, establishing a continuing line of contact with the users. Site visits are generally conducted by field managers (alternatively referred to as unit managers) and generally reduce in frequency over the life span of the toilet. These early site visits are critical to the longevity of the toilet, as research has shown that a number of UDDTs installed in rural Bangladesh fell into disuse due to unsanitary conditions created by misuse in the first several weeks after construction (Azad-uz-

zaman et al [undated]; Interview with Farhana Rahman on Sept 12 2011; Interview with Abdus Salam and others on Aug 23 2011).

Additional training activities are undertaken prior to and during the first episode in which treated fecal matter is removed from the feces chamber, usually approximately one year after the toilet's installation. NGO support during this process is critical, as negative attitudes regarding the handling and use of the fecal soil conditioner generally persist, and the potential larval content of the treated faeces mandates safe handling and processing procedures (Interview with Azahar Pramantik on Aug 29 2011; Interview with Monirul Alam on Aug 28 2011).

Financing

The total cost of system construction, generally ranging between 15,000 BDT (US $185) and 40,000 BDT (US $485), is prohibitively expensive for even the more solvent households in Bangladesh. Therefore, financing models for the construction of UDDT systems generally rely heavily on NGO subsidy. NGOs primarily employ a cost-sharing financing mechanism, with user contributions amounting to between 25% and 50% of the total construction costs. The actual monetary contribution of each household is determined by the NGO, with the household's ability to pay influencing the user input. Following installation, households pay the NGO in monthly installments until the contractually agreed upon contribution has been met. In certain cases, households were also allowed to contribute supplies or labor to the construction process, the estimated dollar value of which was credited to the family's account.

In two of the case study areas that were examined as part of this research, UDDT systems were installed solely with NGO financing. The UDDTs installed as part of the Phase I intervention in the Comilla District in 2005 and the four UDDTs in Jelepara were constructed without any cost-sharing mechanism. As the first UDDTs installed in the country, those installed in 2005 in Comilla District were installed based on an untested design and implementation model. In order to generate interest and incentivize prospective users, the only user costs associated with these Phase I toilets was a nominal fee for a training course conducted by JADE and BARD. The

UDDTs installed by SPACE on the island village Jelepara in the Rangamati District were installed with solely NGO funding, in accordance with an agreement struck between the NGO and their foreign donor organization.

7.0 Assessing Social Embeddedness: A Qualitative Indicator Set

The social embedding of sanitation technology occurs on the household and, more widely, on the community scale[21]. However, the processes of socially embedding innovative technologies on these two levels should not necessarily be viewed as distinct phenomena. Granovetter (1992) recognized that all social actions and outcomes are affected by the relationships and network structures existing within the socio-cultural setting in which decisions are made and attitudes are shaped. Applying this theory to the sanitation sector, Mader (2011) found that in India and Vietnam, sanitation practices are deeply rooted in cultural norms, developing out of peer emulation and collective rituals. Embedding innovative sanitation technologies at the household and community levels should be looked upon as interrelated processes, with prevailing attitudes and norms of the community manifested in those decisions made on the household level.

It would, then, seem reasonable to conclude that without at least some degree of acceptance within the community, that embedding of a novel sanitation technology on the household level is unlikely. And, in some regards, this has been observed during this research. However, the attitudes surrounding the use of UDDTs in Bangladesh are subject to external influences as well, primarily as result of interactions with representatives of NGOs targeting specific communities. Individual's attitudes and behaviors are linked to what Fishbein and Ajzen (1975) refer to as *normative beliefs*, namely, those beliefs and actions that are influenced by the individual's perception of how referent individuals within the community will judge this action. NGOs represent a powerful entity with regards to steering the attitudes of the community towards the use of UDDT technology. Though innovative sanitation solutions may initially be viewed with an air ambivalence or even disdain in the prevailing collective opinion, persuasive communication from important figures, in this case NGOs, can significantly alter the attitudes and opinions of individuals within the community (Ajzen 1991).

[21] For the purposes of this study, these levels correspond roughly to the micro- and meso-levels discussed in the Section 3.2.4 of this report.

In the case of innovative sanitation technologies, attitudinal changes occur first on the household level, and, as exposure to and acceptance of the technology increases, can eventually develop as a normative practice socially embedded on a community level. Embedding of the technology on the community wide scale is critical to the continued proliferation and ultimate sustainability of UDDTs in Bangladesh, but is unlikely to proceed in an efficient manner without the technology first becoming embedded on the household level (Loorbach & Rotmans 2006).

The indicators described in this section were developed during the empirical research associated with this study and, to a lesser degree, through a review of available literature. They are presented in what is considered to be most representative of the actual process of social embedding, first describing those that are applicable to the household level, followed by those that are applicable to the wider community. Both sets of indicators, as well as a reflection on the process of embedding UDDT technology, are summarized in Appendix V.

7.1 Household Level Indicators

Changes in User Rituals

The transition to the use of a UDDT system requires significant adjustment to the user's previously embedded rituals, specifically those related to toilet behaviors and agricultural practices. With regards to sanitation behaviors, the degree to which the UDDT technology has become socially embedded is reflected in the household's habituation to the use of the toilet. Proper use of the toilet is critical in creating a sanitary environment and producing fertilizers and soil conditioners for agricultural application. Whether pre-existing sanitation rituals are broken or maintained can be seen as a reflection of the household's acceptance of the technology. Similarly, the individual's ability to adapt to the behavioral requirements of the new sanitation scheme is a critical first step in the long-term process of embedding the technology.

Modifications of agricultural practices are perhaps even more important in the embedding process. While the behavioral adjustment associated with the transition to a UDDT system can happen relatively quickly, changes in patterns of fertilizer usage

are generally more prolonged, as attitudes regarding the reuse of human excreta are often deeply rooted and can persist despite the household's adjustment to the day-to-day use of the toilet. Regular use of the excreta based fertilizers represents an attitudinal shift on behalf of the users and recognition of the inherent value of the toilet itself.

Perceived Value of the UDDT System

The perception of the UDDT as a productive asset, rather than merely a means of improved sanitation, is a fundamental component in the user's appreciation of the toilet and is critical to socially embedding the sanitation technology. Research regarding innovative sanitation designs in Africa indicates that those systems perceived as valuable to the user were more likely to be properly maintained and utilized (Sugden 2006). This valuation of the UDDT can be reflected in a variety of ways. Primarily, value is expressed in monetary terms. The UDDT's production of organic fertilizer can significantly reduce a household's chemical fertilizer expenditures, allowing farmers a wider profit margin each growing cycle. A direct monetary valuation of the toilet can be assessed by inquiring how much the farmer would be willing to contribute to the construction of a UDDT in the future.

Non-monetary values of the toilet should also be considered. In certain instances, the perceived value of the UDDT can be linked to the fact that fruits and vegetables grown with excreta based fertilizers are perceived as being more nutritious than those grown using chemical fertilizers. The availability of excreta fertilizers can also result in a more productive kitchen garden, contributing significantly to household food security. Other factors that are not easily monetized include a reduced instance of diarrheal illness and perceptions of increased social standing within the community. Both monetary and non-monetary values can be seen as indicative of the degree to which the UDDT has become embedded at the household level.

User Satisfaction

User satisfaction with the UDDT should not be interpreted as a simple question of user friendliness or perceived value. While the user's overall approval of the basic functionality of the toilet is an important consideration, any perceived changes in

social relationships and structures may be as profoundly influential in the embedding of the technology. Auxiliary benefits of the UDDT, such as perceptions of elevated social standing or sentiments of pride in the toilet itself, may be the primary factors relating to the users satisfaction with the installation. Conversely, a variety of factors external to the household can negatively affect the users satisfaction with the toilet. For example, should users feel stigmatized due to their use of the excreta based fertilizers or feel a sense of alienation from a disapproving community, the incremental benefit provided by the UDDT may not be considered worthwhile.

The qualitative nature of this indicator is indispensable in accurately assessing those factors that influence user satisfaction with the UDDT. A simple questionnaire, which seeks to quantify or categorize the users satisfaction, is likely to lose sight of the subtle factors that result in satisfaction or dissatisfaction. In the examination of the embedding of UDDT systems, the question of *why* the user is satisfied is often more important than a quantifiable level of satisfaction itself.

Gender Specific Issues

It is widely acknowledged that women suffer disproportionately from a lack of adequate sanitation (Brewster et al 2006; Parkinson 2003; UN 2005) and are often more keenly aware of the potential benefit of improved sanitation facilities (Allen et al 2006). In an exhaustive evaluation of sanitation facilities in rural Bangladesh, Hanchett et al (2011) note that households with female heads are 2.5 times more likely to have improved sanitation faculties than those with male dominance at the household level. The results of this research indicate that in 63% of the UDDT systems visited, women were either the primary driver or an essential proponent in the decision to install the toilet. Even in strongly patriarchal societies, such as Bangladesh, women exert substantial influence on a household's sanitation decisions. A system that is fully appreciated by women is more likely to be utilized and maintained, and become embedded at the household level.

Women's appreciation of UDDT systems is often based on a much different set of criterion than their male counterparts, relating more to the auxiliary benefits than to the actual function of the toilet. Women appreciate the improved security of a latrine

located near to the house, as well as the privacy provided by the brick super structure. Menstrual hygiene management, an especially difficult topic in Bangladesh, is a critical issue to women. Menstrual hygiene was widely reported to have been improved since the installation of the UDDT, as women find that anal wash pan provides a more hygienic location for washing than was previously available, and that menstrual discharge can be washed into the leach pit where it is not easily identified on top of the crushed brick. Though these factors are not necessarily critical to the overall function of the toilet, they are important with regards to the embedding the sanitation on a household level.

7.2 Community Level Indicators

Community Acceptance of Excreta Reuse

While the embedding of UDDT systems at the household level is largely influenced by the educational outreach and training provided by NGOs to prospective UDDT users, the community as a whole is not necessarily exposed to the information presented by these experts. Rather, attitudinal changes related to the agricultural applications of excreta are generally an outcome of direct exposure to the practice and knowledge gained through interactions with those individuals who are using the excreta based products. Not surprisingly, the ideological shift in attitudes related to excreta reuse at the community level generally lag significantly behind those on the household level.

The degree of acceptance within in the community generally appears to be well understood by the users of the UDDTs themselves. The introduction of a novel sanitation scheme in a village stimulates considerable curiosity in the community as a whole, resulting in focused dialogue between users of UDDTs and conventional sanitation systems. The feedback from these conversations provides valuable insight into the dynamic or static norms surrounding these attitudes and behaviors.

The approval or disapproval of a community can be expressed in a variety of ways. Most directly, an individual may express his opinion that the reuse of excreta in agriculture is repulsive. Attitudes can also be expressed by more subtle means, such

as the community's willingness to consume produce grown using excreta fertilizers or individual's attempts to purchase excreta fertilizers from the owners of UDDTs. These perceptions of community acceptance of excreta reuse can be seen as indicative of the embedding of the UDDT technology at the community level.

Desire for the Proliferation of UDDTs in the Community

The decision to install improved sanitation systems is usually more closely associated with improvements in social status than the improvement of health outcomes or minimization of environmental pollution in developing countries (Hanchett et al 2011). Data collected as part of this study suggests that a rather atypical set of factors influences the decision-making process surrounding the installation UDDT systems in Bangladesh. Notably, individuals identified the production of fertilizers, the desire for a more permanent or resilient sanitation system and the absence of odor as critical in the decision-making process. In assessing the desire within the community for further proliferation of UDDTs, the stated reasons for wanting more UDDTs are just as important as the actual desire itself. Certain justifications may be more indicative of a community's willingness to receive aid from a donor organization or to own a brick made structure for a marginal cost. In general, a community's desire to install more UDDTs can be seen as a reflection of their acceptance of the technology, and more broadly, the ideology surrounding the toilet. This wider acceptance is a crucial element in social embedding at the community level.

This research relied primarily on interviews with sanitation experts and user interviews to assess the community willingness to install more UDDTs. NGO representatives responsible for monitoring operations at an intervention site are generally implanted in the intervention area and have regular interaction with members of the community. Some of these experts reported that the members of the community made frequent requests to install more UDDTs. Similarly, users of UDDTs have an established relationship with the NGO, and many reported that their neighbors sought to use them to establish a line of contact with the NGO representatives.

Several mechanisms can be employed to determine if community interest in UDDTs is related to the function and productivity of the toilet, rather than wanton desire for NGO handouts. Prospective users willingness to pay can be seen as a good indication that these individuals are committed to the ecosan ideology, and are motivated by the toilets productivity. Hegger et al (2008) also suggest that evaluating an individual's willingness to participate in the planning process of subsequent UDDT interventions can serve as an effective indication of motivating factors. Those individuals who are *active participants*, rather than passively accepting the sanitation system, are more likely to express attitudes and behaviors conducive to the embedding of the technology (Hegger et al 2008).

8.0 Assessing the Embeddedness of UDDTs in the Case Study Areas

The following section applies the qualitative indicator set outlined in the previous section to each of the case study areas visited during the research phase in order to assess how UDDT technology has become embedded in the households and communities observed. The assessments below are based on user and expert interviews, and generally treat the most frequent responses to questions as a baseline attitude within the community. In many instances, however, minority opinions that provide insight to a particular subject are also included.

8.1 Raicho, Hatigara and Joypur South (Comilla District, Chittagong Division)

The three villages Raicho, Hatigara and Joypur South are home to the oldest UDDT systems in Bangladesh and also have amongst the highest saturation of UDDTs, with 114 units installed in six neighboring and strongly interconnected villages in the area. It may come as no surprise that, of the 7 case study areas, the findings of this study indicate that the UDDT technology has become most firmly embedded at both the household and community levels in these three villages.

Embeddedness at the Household Level

Respondents in these villages did not consider the behavioral adjustment associated with the transition to the UDDT a significant barrier. Most respondents indicated that they became habituated to the toilet's use in less than one month, with some evidence suggesting that the habituation period was slightly longer for children. This rapid adjustment was generally credited to the effective and intensive training program undertaken by JADE and BARD prior to and immediately following the implementation of the intervention, as well as the support mechanisms of the existing CBO created under the CVDP.

The use of the excreta based fertilizers has also been incorporated into agricultural practices on a wide scale. No respondents expressed attitudes of discomfort with regards to the handling of the treated faeces, though most admitted that immediately

following the installation, the concept was repulsive to them. The quality of the excreta fertilizers was generally viewed as superior to chemical fertilizer alternatives, with one respondent remarking that it is '…the best fertilizer I have ever seen' (Interview 042, page 2, line 39). Treated feces were almost exclusively used as a soil conditioner in the rice paddies, and users reported that the application of the soil conditioner reduced the volume of chemical fertilizers required. However, many respondents lamented that the toilets production of fecal soil conditioner was insufficient to cover their entire crop fields for all three planting cycles in the area, thus not entirely eliminating the demand for chemical fertilizers.

Urine collected from the UDDTs is primarily applied in small kitchen gardens and to fruit trees adjacent to the user's home, with only a few respondents indicating that the fertilizer was applied to crop fields. Though user interviews indicate that the prevalence of reuse of the urine is quite high, two men involved in the planning and research of UDDT interventions in Comilla, Mr. Abdullah Al Mamun and Dr. Masudul Hoq Chowdhury of BARD, expressed disappointment that the urine was not being fully appreciated by the users (Interview with Abdullah Al Mamun on Sept 16 2011; Interview with Dr. Masudul Hoq Chowdhury on Sept 15 2011). Several respondents indicated that the urine was not always used, as they lacked sufficient information as to what crops can benefit most from the fertilizer and in what ratio the urine should be mixed with water.

Owners of UDDTs in these villages generally assessed the inherent value of the UDDT system as quite high. The approximate dollar value that the users considered the toilet to be worth in these villages was the highest encountered in this study, with 50% of the users indicating they would have been willing to self-finance the toilet's construction, and the remaining respondents indicating that they would be willing and able to make financial contributions that amounted to at least 25% of the total cost of installation, or approximately 4,000 BDT (US $50). The non-monetary value of the toilet was also highly regarded, as many of the respondents credited the installation of the UDDT with a significant decrease in the rates of diarrheal disease within the household, though many of these acknowledged that other hygiene behaviors, notably hand washing, had also improved following the UDDT training sessions. Owners of these toilets commonly indicated that they felt a sense of pride in owning an UDDT.

Household attitudes regarding the reuse of excreta are fairly uniform within the community. Most users, especially those who constructed their UDDTs as part of the Phase I intervention in 2005, reported that they initially viewed the reuse of excreta with an air of skepticism and disgust. These attitudes have largely shifted, however, with most individuals referencing the increased crop production when using excreta fertilizers as a catalyst in changing their opinion of the practice. Negative attitudes regarding the treated feces appear to have diminished with continued use of the fertilizer. One respondent rather perceptively linked the transition to the use of excreta fertilizers to the attitudinal changes following the initial introduction of chemical fertilizers to the area, saying: 'At first the people does not want to use chemical fertilizer, but when they learn, they use chemical fertilizer. Now they learn about [excreta based] compost, and they use it and they make a decision to install [a UDDT]' (Interview 032, page 1, lines 8-10).

With regards to gender specific issues in the villages, women appear to be particularly appreciative of the toilet, with a majority of respondents indicating menstrual hygiene management has been significantly improved. Women noted that the toilet's proximity to the home and latching doors allowed them to use the toilet during the day time, preventing discomfort and potentially adverse health effects of having to wait until darkness to relieve themselves. The UDDT also seemed to have contributed to considerable peace of mind for women, as they no longer feared assault when venturing far from the home at night urinate or defecate.

Embeddedness at the Community Level

By virtually all accounts, the practices of agricultural excreta reuse are widely accepted within the community, with only three of 14 respondents in the study indicating that other villagers had expressed negative attitudes regarding the practice. The pattern of attitudinal transition at the community level appears to largely mirror that witnessed on the household level, with feelings of disgust diminishing with increased exposure to the practices. One respondent noted that attitudes in her village changed rapidly after a local Imam had installed a UDDT[22]. Several respondents

[22] See Interview 032, page 1.

reported that other villagers had made regular attempts to purchase their fecal soil conditioner, but that they were unwilling to part with the soil conditioner, as they did not think that the chemical alternatives could match the increased production associated with the excreta fertilizers. The most common objections to the agricultural reuse of excreta were voiced by visitors from outside of the cluster of villages, who were unfamiliar with UDDT technology. In many instances, however, UDDT owners reported employing logical argumentation as to why the UDDT was beneficial, sometimes swaying the opinions of the visitors.

The community's desire for the proliferation of UDDTs also appears to be growing. One respondent linked the increase in demand for the toilets to the changing attitudes in the community regarding the reuse of excreta, saying:

> '…at very first time, people bother me. And they call, 'It is human feces. Why you use this disgusting thing in the crop field?' But interesting thing, I use it, and some people use chemical fertilizer. And I produce huge crops…it is the answer to all bothering things. And now people understand and they tell us, 'Give us an Eco-toilet [UDDT].'' (Interview 037, page 1, lines 36-40)

Such sentiments were regularly reflected in interviews, and many respondents stated that UDDTs were highly regarded within the community, largely due to the perception of the toilet as a productive asset. Many respondents expressed the belief that every household in the cluster of villages would install a UDDT if given the opportunity. Barriers to scaling up the intervention are primarily related to financial constraints, as demand far outweighs the responsible NGO's capacity to fund or offer technical consultancy for the installation of a UDDT for all interested parties.

8.2 Jelepara Village (Rangamati District, Chittagong Division)

UDDT technology has not been successfully embedded at either the household level or the community level on the island village of Jelepara. The island plays host to a number of socio-cultural, religious and geographical barriers that have largely hindered the acceptance of the technology. While the planned intervention in this

village in 2008 had initially called for the installation of 10 UDDTs, complications lead to the termination of the project after only four were installed.

Embeddedness at the Household Level

The ease of the behavioral adjustment to the UDDT technology seems to be somewhat variable in Jelepara. While several respondents indicated that they had become habituated to the toilet's operating procedures in less than one month, others reported that many members of their household did not use the toilet for the first year following its installation, due to difficulty with the behavioral adjustment. Two of the four households that have been equipped with UDDTs still maintain conventional toilets on their properties, as some members of the household prefer these.

Perhaps the largest barrier to the embedding of the UDDT technology in Jelepara is the limited agricultural linkage within the village, a factor that is largely attributable to failures in the site selection process during the planning phases of the intervention. The small island, located a short distance north of the Kaptai Dam in the Karnaphuli Reservoir, is very densely populated with no arable land and few trees. A small amount of land is available for horticulture during the winter months when the water level in the reservoir is low, but few users reported having grown any vegetables on the land. A few residents reported occasional reuse of the urine fertilizer on fruit trees, but the urine from all four UDDT installations was most commonly disposed of in the river when the collection vessel became full. Similarly, none of the households have used the treated feces in agriculture; instead, common practice on the island is to empty the feces chamber and dispose of its contents in the river once it becomes full, rather than allowing the six month residence time to effectively treat the feces.

Attitudes surrounding the reuse of excreta tended to be somewhat mixed, but prevailing sentiments were that the practice was looked upon poorly. This could result from a limited exposure to the practices, failure in the training and orientation programs of the NGO, or be related to specific religious barriers in the community. The island is inhabited by an exclusively Hindu population. Though UDDT interventions have been successful in Hindu communities in other parts of the world (Neupane 2010; WaterAid 2008), sanitation practitioners in Bangladesh generally

agree that Bangladeshi Hindus are more averse to the idea of reusing human excreta (Interview with Ranajit Das on Aug 18 2011; Interview with Monirul Alam Aug 28 2011).

User satisfaction with the UDDT systems is generally moderate. There was universal agreement that the UDDTs improved the sanitary conditions of the household, largely because they did not contribute to surface water pollution like hanging latrines and were not inundated by rising water levels in the reservoir. However, other aspects of the toilet were viewed much less favorably. Due to the limited availability of land on the island, the NGO responsible for the implementation of the intervention in the village advised residents to install the UDDTs within their homes. While the owners ultimately acquiesced, the location of these toilets has been a source of criticism from the community, especially in those instances in which the toilet was located adjacent to a prayer room. One respondent reported feeling chastised by a local religious leader, reporting that '…the Guru, religious leader said, 'One side of your room [is] the prayer places…the other side a toilet. What is this?' ' (Interview 045, page 3, lines 12-15). Others reported that the location of the toilet had been a contentious issue with their neighbors, as the leach pit was located on a busy village pathway and would sometimes overflow, exposing other villagers to unpleasant odors and potentially unsanitary conditions.

Women generally agreed that the UDDT was favorable to other common sanitation solutions in the community, as it provided a degree of privacy and security that was previously unknown. One female respondent also indicated that the toilet allows for better menstrual hygiene management. Several men stated that a primary justification for installing the UDDT was to create a more secure toilet for their children.

Embeddedness at the Community Level

The ideology surrounding the UDDT technology does not appear to have become embedded in the socio-cultural fabric of the community. While most residents of the island are aware of the toilets, they have had virtually no exposure to the reuse of the excreta. Stigmatization of the UDDT users was rooted in the location of the toilet within the home and the perceived inconvenience created by the poor location of the

leaching pits. Despite this, there was high demand for additional installations of UDDTs on the island. This, however, is likely rooted in the fact that the four existing UDDTs were constructed solely with NGO financing and were considered to be preferable to other sanitation systems on the island.

8.3 Bhashantek Slum Settlement (Mirpur Zone, Dhaka City)

The two UDDTs installed in the Bhashantek slum settlement were installed in 2011 and, at the date of the site visit, had been in use for approximately six months. The circumstances in the urban slum are significantly different than those encountered in other localities in this study. The financing model implemented by DSK is based solely on NGO financing, with the eventual sale of the excreta based composts to local nurseries serving as a cost recovery mechanism. Acceptance of excreta reuse is, therefore, less important to the social embedding of the sanitation technology at both the household and community level; rather, the recognition of the UDDT as an improved means of sanitation and the ability to adjust toilet behaviors could prove to be of greater importance.

While some indications suggest that the process of embedding on the household level has been initiated, the wider process of embedding on the community level has been minimal, at best. As only two toilets have been installed in the settlement of 2,500 households (Khan 2010), the exposure to the community as a whole is quite limited.

Embeddedness at the Household Level

Respondents in the Bhashantek slum generally reported a relatively rapid behavioral transition to the use of the UDDT system. One elderly woman, however, indicated that after approximately six months of use, she still felt discomfort in shifting her position from above the feces chamber port to the anal wash bed following defecation. Young children were also prevented from using the toilet, as the DSK representatives who oversaw the toilet's installation advised against it.

There is no arable land in the slum settlement, and neither of the owners of the UDDTs owned any fruiting trees. Consequently, there have been no established

practices of excreta reuse. Currently urine collection vessels are emptied in a nearby ditch when they become full, and neither toilet had produced fully matured soil conditioner at the time of the site visit. While respondent's mentioned a sense of increased social status following the installation of the toilet and a reduction in 'sweeper' fees, a definitive monetary value of the toilet had not been created for the users, potentially creating difficulty in stimulating future user investment in the technology. DSK is currently attempting to find local nurseries that are willing to purchase the treated feces, an ambitious attempt to create a market for the products.

UDDT users in this area generally viewed the sanitation technology favorably, referencing the absence of an odor, reduction in cleaning costs and elevated social status as primary advantages. However, certain aspects of the toilet's use were considered to be a nuisance. In particular, both families interviewed reported having difficulty acquiring sufficient ash to meet the toilet's needs, resulting in lengthy trips to Mirpur center to obtain sacks of ash from restaurants. In certain instances ash had to be purchased from neighbors. Gender specific issues were not mentioned in any of the user interviews, though one elderly woman said she appreciated the improved privacy of the toilet.

Embeddedness at the Community Level

Respondents generally indicated that the level of interest in UDDTs expressed by their neighbors was high. However, this is perhaps a greater indication that the financing model of the toilet, with no user contribution, is viewed favorably. All respondents indicated that they felt a sense of pride in their toilet, and that the response from the community was largely positive. The limited exposure to the UDDT system within the slum has, so far, inhibited embedding on a wider scale; reevaluation will be required as DSK scales up the intervention in the coming years.

8.4 Pajulia Village (Gazipur Distinct, Dhaka Division)

The installation of UDDTs in the Gazipur District began in 2008 and has culminated in the construction of 29 toilets for the 329 households in the Pajulia Village. Data collected as part of this study suggests that the technology has become firmly

embedded on the household level and that the community is also widely accepting the technology and associated ideology.

Embeddedness at the Household Level

The behavioral adjustment to the UDDT technology does not appear to have been a significant problem. Accidental misuse was frequently reported in the initial stages following the intervention, but all respondents indicated that they currently feel very comfortable using the toilet. Children as young as two years old have also been reported to be using the toilet without assistance.

The use of the excreta fertilizers is commonplace and widely appreciated by the users; however, patterns and procedures involved in its use varied slightly from other case study areas in this study. Respondent's commonly reported that the urine was applied around the perimeter of their paddy fields, as they felt that it acted as a natural pesticide and prevented insects from damaging their crops. Additionally, respondents believed that the fecal soil conditioner was more effective when applied in the dry season, and were unwilling to use the treated feces in planting cycles that fell in the rainy months. Regardless, the excreta fertilizer was clearly fully appreciated by its owners, and had been effectively incorporated into agricultural practices on a wide scale. Attitudes regarding the treated feces were also positive. Some respondents indicated that they were initially hesitant to use the fertilizer, but after witnessing its benefits no longer considered it repulsive.

The toilets were also widely viewed as a valuable asset to their owners. In addition to reduced chemical fertilizer expenditures and improved crop yields, respondents also indicated that they had significantly improved health outcomes. One respondent indicated that instances of diarrheal illness had been reduced from between four and six events per year to only one event per year, attributing the decrease to the effective confinement of the feces rather than any specific changes in hygiene habits. Several respondents also linked the toilet to a sense of prestige within the community, noting that '…it a social status, in this poor area here, to have a brick built toilet' (Interview 053, page 1, lines 37-38). Many respondents in the area continued to invest in their toilet after installation, making substantial improvements such as installing electric

lighting, constructing an attached bathing facility and incorporating a water cistern into the design.

Women were also appreciative of the toilet, noting that it was preferable for menstrual hygiene, and contributed significantly to their overall sense of security.

Embeddedness at the Community Level

UDDT technology is revered within the community, both in Pajulia and its surrounding villages, and certain NGO activities have been paramount to this success. Following the installation of the first UDDTs in the village, Practical Action and its partners conducted an agricultural exhibition, growing rice in adjacent paddies, one with excreta fertilizers and one with chemical fertilizers. The exhibition was widely witnessed within the community, and referenced by a number of individuals in influencing their opinions regarding the reuse of excreta. Prior to the initiation of the UDDT intervention, Practical Action had also initiated a program to distribute vermicompost[23] throughout the community, creating a population that was well informed of the potential benefits and proper application procedures for soil conditioner. Finally, several schools in the Gazipur District have been outfitted with multi-seat UDDT systems, spreading awareness of UDDTs to a much wider population base than is possible with solely household level interventions.

The acceptance of excreta reuse in agriculture appears to be looked upon favorably throughout the community. Though some negative opinions had previously been voiced, residents credited the saturation and correspondingly high rate of exposure to the technology with largely shifting attitudes in the area. One respondent commented that '…those who have not installed, they are now aware. This is not he initial stage' (Interview 024, page 1, lines 32-33). Another respondent also indicated that other villagers made regular attempts to purchase his excreta fertilizer, and that in one instance, it was even stolen. Community interest in installing additional UDDTs is strong, with only financial limitations preventing further proliferation of the technology.

[23] Vermicompost is alternatively referred to as worm castings or worm casings.

8.5 Behakyor and Pobonkul Villages (Narayanganj District, Dhaka Division)

Despite their geographic proximity, significant contextual differences in these two villages have resulted in dramatically variable patterns of embedding the sanitation technology. In Behakyor, a single UDDT has been installed. While social embedding appears to have occurred to a limited degree on the household level, the community level awareness of the technology is quite low. Conversely, in Pobonkul, the technology has been rapidly incorporated into the daily routines of its users, and has made a limited, but more positive, impression on the community at large.

Embeddedness at the Household Level

The embedding of the UDDT technology at the household level has been something of a struggle in Behakyor. Immediately following the installation of the UDDT, the owners of this toilet decommissioned their previously used ring-slab latrine. The result has been that all 21 members of the household are using the UDDT, creating an environment in which a single feces chamber is filled in only a few months, and leaving inadequate time for the dehydrating of the manure. The family also derives its sole income from a small *sari* weaving factory operated out of the home, and has no agricultural land. While the family has recently begun to use the urine to fertilize one fruiting tree and a small vegetable garden, the majority of the urine collected is disposed of in an open storm sewer near the home. Several members of the family reported finding the reuse of excreta objectionable.

The situation in the nearby village of Pobonkul has been considerably more successful. Users have efficiently adapted to the behavioral requirements of the UDDT, and consistently report that they feel comfortable using the toilet. While young children use the toilets in this village effectively, several instances were identified in which elderly persons had some difficulty adjusting their toilet behaviors, as they were physically unable to change their position in the toilet while squatting.

The reuse of excreta has also been more successfully included in horticultural practices in the village. While all of the owners of UDDTs in Pobonkul also make

their primary income from *sari* weaving, the village itself is considerably less densely settled, allowing for each household to maintain a sizeable kitchen garden. Urine was regularly applied to these kitchen gardens, and in some cases, to small agricultural fields maintained by the owners as well. None of the four toilets currently installed in Pobonkul had produced fully matured fecal soil conditioner at the time of the site visits, but respondents indicated that they felt that the excreta fertilizers were more beneficial than chemical fertilizers, and were prepared to use them in the gardens. Many of the users also reported having previously used cow dung compost. None of the respondents in Pobonkul reported feeling stigmatized for having installed a UDDT or for their reuse of the urine.

Despite not drawing significant incomes from agriculture, UDDT users in Pobonkul demonstrated a high valuation of the toilet. Respondents here demonstrated the highest willingness to pay for their sanitary systems observed in this study, with average user contributions amounting to approximately 20,000 BDT (US $240)[24]. However, each user ultimately expressed satisfaction with his decision, stating that the improved sanitation alone warranted the high installation costs. One respondent also mentioned that since installing the toilet, he had decided to substantially increase the size of his papaya orchard, as the reduction in chemical fertilizer costs significantly improved the profitability of the venture.

Gender specific issues were not expressly mentioned in any of the interviews conducted in Pobonkul, though improved privacy afforded by the toilet was often considered to be particularly beneficial to women and children.

Embeddedness at the Community Level

The community in Behakyor appears to be largely indifferent or even unaware of the UDDT. Respondents indicated that the latrine, located adjacent to a busy road, would sometimes attract passers by who would make inquiries as to its function. However,

[24] The DSK installed toilet design is the most expensive encountered during this study, with a total installation cost of approximately 40,000 BDT (US $480). Prospective users were asked to contribute 50% of the construction costs, which would be repaid in approximately 1,000 BDT (US $12) monthly installments.

further interest in the village appears to be limited, and the village, as a whole, has virtually no exposure to the reuse of excreta in agriculture.

The situation in Pobonkul is considerably more interesting. All of the households that have installed UDDTs are part of a single extended family, forming a strongly connected kinship network within the village. This has created a small sub-community within the village at large, in which the UDDT toilet is widely accepted and regarded as a beneficial commodity.

The degree of embeddedness in the larger community, however, is fairly minimal. One respondent indicated that when he gathers ash from neighbors for use in the UDDT, they often laugh and consider the practice to be somewhat ridiculous. Respondents reported that guests from other villages have expressed interest in installing UDDTs, but that interest within the village, excepting the kinship network, is not particularly high.

8.6 Shamta and Tengra Villages (Jessore District, Khulna Division)

The construction of UDDT systems in the neighboring villages of Shamta and Tengra began in 2010, and has culminated in the installation of 20 household based units. Results of this study indicate that embedding of the UDDT technology has been similarly rapid at the household level in both villages, as the toilets have been integrated effectively into the daily lives and agricultural practices of their users. Community awareness of the toilets is currently somewhat restricted, but appears to be increasing as exposure to the technology continues.

Embeddedness at the Household Level

Despite widely reported accidental misuse of the toilet immediately following installation, most users ultimately indicated that they had become habituated to the toilets operational procedures and feel comfortable when using it. Young children have also been encouraged to use the toilet, with one respondent indicating that her seven-year-old child was able to make the behavioral adjustment much more rapidly than the adult members of the family.

None of the UDDTs in the village have produced fully matured fecal soil conditioner. However, urine collected from the toilet was much more widely used in the agricultural fields than in any other instance observed in this report. Respondents identified significant improvement in the rice paddy following the application of urine alone, and several noted that their demand for chemical fertilizers had been reduced as well. Attitudes regarding the treated feces were somewhat variable, with some respondents expressing excitement at the prospect of using the manure for the first time, and others indicating that they were not comfortable with the idea of handling the treated fecal matter. Regardless of personal attitudes, however, each respondent indicated that the family would use the fecal soil conditioner when it had matured, and had specific plans to when and how it would be applied.

UDDT users in Shamta and Tengra generally perceive their toilets as an economically productive asset, noting a reduction in chemical fertilizer expenditures as a primary benefit of the toilet. One respondent noted that her kitchen garden had become significantly more productive since she began using the urine fertilizer, saying, '…the number of yield is better than the chemical fertilizer. The other thing is that if we buy the fruits from the market, we have to pay, but now we have something to sell' (Interview 010, page 3, lines 28-34). Respondents also consistently perceived the toilet as having considerable non-monetary value, most frequently noting a perceived increase in social status associated with the toilet. Individuals suffering from arsenicosis seemed to be most appreciative of the toilet, as they considered fruits and vegetables grown with the organic fertilizer to be more nutritious, and that the adequate containment of the feces had lead to a decrease in other illnesses.

Women in Shamta and Tengra widely acknowledged that the installation of the toilet had allowed for more adequate menstrual hygiene management. Though stigmas surrounding menstruation are still commonplace in the villages, the privacy afforded by the improved super structure and comparatively sanitary conditions of the toilet allowed women to more adequately practice effective menstrual hygiene.

Embeddedness at the Community Level

Though the community as a whole appears to view the reuse of excreta somewhat objectionably, most respondents indicated that they felt attitudes were beginning to shift in favor of the practice. It was noted that members of the community would be likely to accept produce known to have been grown with excreta fertilizers, something that was uncertain in the recent past. One respondent still reported feeling stigmatized because of her reuse of the urine, but that her overall opinion of the toilet was still favorable, saying, '…it is my toilet, it is a good toilet, it is an improved toilet, so I am very much happy with this toilet' (Interview 013, page 4, lines 17-18).

Current demand for the UDDTs is moderate. Though most respondents reported some interest in the proliferation of the toilets, they also indicated that the installation costs of the toilet, even when subsidized, were likely more than most inhabitants were willing or able to invest. A large number of residents of the village had already invested in conventional sanitation options and were unlikely to consider the UDDT for that reason.

8.7 Amarak Village (Rajshahi Division, Rajshahi District)

UDDT sanitation was first introduced to Amarak in 2010 and currently serves as the primary sanitation technology for five of the 30 households in the village. Evidence collected as part of this study indicates that the technology has largely become embedded on the household level. While it is not yet embedded on the community level, evidence suggests that attitudes surrounding the sanitation technology are beginning to shift.

Embeddedness at the Community Level

As in many of the other case study areas, UDDT users in Amarak experienced initial problems related to the behavioral adjustment to the toilet system, but became habituated to its use in approximately one month. All respondents indicated that the toilet's operational procedures is now comfortable and feel natural to them.

Use of the urine fertilizer was practiced primarily in the kitchen gardens and, to a lesser degree, in the paddy fields. None of the UDDTs had produced fully matured fecal soil conditioner at the time of the site visit. However, the feces chamber of one of the toilets was opened for the first time prior to an interview with its users, and would be emptied into polyethylene bags later in the day. Attitudes regarding the use of urine were primarily positive, with several respondents pointing to the increased crop production and improved taste of the vegetables grown with the excreta fertilizer. Many users still expressed disgust at the idea of using the treated feces in agriculture. After seeing and handling the dehydrated feces for the first time when his feces chamber was opened, one owner reported that his opinion of the practice had changed and he was now willing to use the soil conditioner in his fields.

A local Imam was amongst the first individuals in the village to install a UDDT and reported that he had initially received sharp criticism from some members of the community for doing so. However, the Imam reportedly made a logical argument with dissenters, saying:

> '...they are just defecating in open places. What about the feces? Where are those going? Then I analyzed and realized those are going in the field. Those are coming back to the foods. Those are coming back to the water. So, if this not going directly to the field, [UDDTs] are just processing it, treating it, disinfecting it, then this is the better idea.' (Interview 016, page 1, lines 18-23)

The non-monetary values of the UDDTs appear to be most important to users in Amarak. A sense of pride in the toilet and a perceived improvement in social standing within the community were commonly mentioned in interviews. The toilet was also linked with a decrease in the instances of diarrheal illness in one household, though improved hygiene behaviors likely contributed on this front. One villager indicated that the toilet had led to a greater sense of self-sufficiency for her family, as they were now able to grow a larger portion of their own vegetables.

Prior to the installation of the UDDTs several of the households in Amarak practiced open defecation. The women of these families, who now felt comfortable using the toilet during the daytime, held the UDDT in especially high regard.

Embeddedness at the Community Level

Most respondents agreed that the initially negative attitudes regarding the reuse of excreta had largely abated and that impressions of the practice were becoming increasingly favorable. Most felt that continued exposure to the practice, recognition of the increased crop productivity and the continued presence of NGO workers in the area have been critical in changing opinions. The local Imam, who installed a UDDT at his own home, feels that social barriers in the community persist, but are in the process of eroding. Most respondents indicated that the community interest in installing UDDTs had increased over the course of the intervention, noting financing limitations, rather than socio-cultural or religious barriers, as the primary impediments.

9.0 Discussion: Differential Patterns of Embedding

A review of the previous section shows that the process of socially embedding innovative sanitation technologies has progressed quite differently in each of the case study areas. The following section analyzes various factors that have contributed to these differential patterns of embedding at both the household and community levels.

9.1 Exogenous and Endogenous Factors

The successful embedding of UDDT technology in Bangladesh requires a significant transition in the behavioral and socio-cultural attitudes of the actors involved. Loorbach and Rotmans (2006) have established that various elements of such a transition, especially cultural change, are autonomous process that cannot be controlled by external management decisions. The entire process is, however, subject to influence through steering and coordination of various efforts (Loorbach & Rotmans 2006). These external influences, which occur as part of an NGOs educational outreach, training and monitoring programs, are exogenous factors that can steer the direction the of the cultural changes that ultimately result in the embedding of the sanitation technology at the household and community levels. The degree to which the technology becomes embedded, however, ultimately depends on a variety of endogenous factors inherent to the contextual dynamics of the intervention area.

This study attempts to distinguish between factors that can be directly controlled by external authorities and those that can merely be steered within the community. The following discussion highlights aspects that are perceived to have exerted influence on how UDDT systems have become embedded at the household and community level, and how different NGO implementation models and variable socio-cultural factors identified within the communities have affected the embedding of the technology.

9.2 Site Selection

The high construction costs and relative obscurity of UDDT technologies in Bangladesh largely prevent installation of the toilets without external support. The role of providing the financial support and technical guidance in the construction of these innovative sanitation solutions has primarily been filled by NGOs. Wider proliferation of these toilets does not appear to be feasible in the foreseeable future without these critical support mechanisms. However, the resources available to NGOs involved in the sanitation sector are quite limited. It is imperative that each UDDT intervention undertaken achieve a degree of success, as, in the eyes of prospective beneficiaries, project failure is more likely to be seen as a reflection of the weakness of the applied technology rather than a failure of the NGO to effectively integrate the technology into the local context.

The selection of a site for a UDDT intervention is an exogenous factor that can be controlled by the NGO and should be recognized as one of the critical factors in embedding innovative sanitation technologies in Bangladesh. Socio-cultural, religious and economic contexts vary widely across the country, and are even more pronounced in the transition from rural to urban settlement typologies. This study has not determined that certain contexts are inherently impervious to embedding UDDT sanitation technologies. Rather, it highlights the importance of adjusting the UDDT design and the implementation model to most appropriately account for the local context.

Agricultural Linkages

The case studies in which UDDT technology has been most successfully embedded at both the household and community level have all had strong agricultural linkages. In most instances, local economies were primarily based on cultivation of crops. While the association of UDDT systems and agriculture is obvious, the affect on the process of socially embedding the technology in the local fabric is profound. At the household level, the primary justification for the UDDT's installation was to produce excreta fertilizers and offset chemical fertilizer expenditures. These households were more likely to be willing to financially contribute to the installation of the toilet, and

ultimately accept the toilet as a fundamental aspect of their livelihood. While negative attitudes regarding the reuse of the excreta generally persisted in these households for some time following the toilet's installation, these attitudes invariably abated with the continued use of the fertilizer, resulting in the transition from chemically fertilized fields to organically produced crops.

Agricultural linkages have been observed to be even more important to the embedding of UDDTs at the community level. Educational outreach and training programs instituted by NGOs cannot reach every member of a community, and consequently socio-cultural barriers tend to persist in the community for a greater duration than in the household. The primary route of exposure to the technology and reuse ideology for most members of the community is through direct observation of the toilet and the beneficial effects of the excreta fertilizers. A majority of respondents in this study recognized that community attitudes relating to the reuse of excreta began to shift when they observed the increased crop production of those individuals using excreta fertilizers. In most cases, the economic benefit of the use of excreta seemed to be a stronger motivator than any pre-conceived social or religious stigmas. One respondent commented that when '… I used [excreta fertilizers] for the first time, and the production is higher, grow higher level, at this time the religious barrier is over. Production is the answer to the religious people' (Interview 038, page 3, lines 30-31).

While Bangladesh as a whole is a primarily agrarian society (Jayaraman 2006), not all communities have strong agricultural linkages. In the instance of the peri-urban village of Pobonkul, the UDDT technology had become embedded at the household level fairly quickly, despite the fact that none of the UDDT users received their primary incomes from agriculture and only two of the four households owned any arable land. The excreta fertilizers were, however, widely appreciated as a beneficial asset in the kitchen gardens maintained by each of the households in this case study area. This is evidence that even small-scale horticulture can be a sufficient incentive for individuals to reformulate attitudes towards the reuse of excreta.

Other Factors

Additional contextually dependent factors could also contribute to the embedding of the UDDT technology on the household and community scale, though the results of this study are less conclusive. In a few instances, the technology was introduced in villages that had well-established practices of using vermicompost in agriculture. It appears that members of these villages acknowledged the potential benefit of the excreta fertilizers more rapidly, and that associated practices were more readily accepted at the community level.

Religious beliefs may also play a significant role in the embedding of the UDDT technology. This research did not identify any specific religious objections to the reuse of excreta fertilizers in any of the predominantly Muslim communities that served as case studies for this research. However, it is widely believed amongst sanitation practitioners in Bangladesh that Bangladeshi Hindu communities are not accepting of the reuse of excreta in agriculture (Interview with Ranajit Das on Aug 18 2011; Interview with Monirul Alam on Aug 28 2011). Despite the fact that respondents from several Hindu households reported no specific objections to using the excreta fertilizers, none of them actively participated in the practice. However, a number of confounding factors prevent drawing any substantive conclusions related to Hindu communities and willingness to use excreta fertilizers. Further investigation should be undertaken to gain a more comprehensive understanding of religious barriers to the proliferation of UDDT systems in Hindu communities.

9.3 Establishing the UDDT as Valuable Asset

There appears to be a direct correlation between identifying the UDDT as an economically productive asset and the social embeddedness of the technology at both the household and community levels. While the creation of an inherent value for the UDDT is primarily an endogenous process, it can be influenced by certain NGO activities. Creating an environment in which both monetary and non-monetary values of the toilet can be fully realized may contribute significantly to the degree to which the technology will become socially embedded in the local context.

Monetary Value

The appraisal of the UDDT as an economically productive asset was the most common method in which users identified the toilet as valuable. This value primarily related to the ability to decrease long-term chemical fertilizer expenditures and increase crop productivity, resulting in a larger volume of produce reaching the market and while minimizing production costs. To a lesser degree, respondents also noted that increased productivity of their kitchen gardens resulted in improved food security, and reduced the household's food expenditures. Inevitably, an inherent monetary value of the toilet will be realized in those contexts in which agriculture is the primary mode of subsistence. Once UDDTs begin to produce urine fertilizer and fully dehydrated fecal manure, the valuation will occur as an autonomous process, with little or no steering required by external actors.

While the previous section highlights the importance of agricultural linkages in the local community, it should be noted that such linkages are not necessarily preconditions to creating a clear monetary value for the technology. In contexts such as the urban slum or isolated island villages like Jelepara, where there are no direct linkages to agriculture, external support becomes the critical element in creating perceptions of the toilet as a productive asset. The ability to create a market for the fertilizer can supplant the economic boon that has been identified in agrarian localities, with direct cash returns for the excreta fertilizers being more readily apparent, and perhaps an even greater incentive, than increased crop production. In such instances the monetary value would be easily recognized and universally appreciated.

Of course, creating a market for excreta fertilizers in a society that is either unaware or averse to such practices is more easily said than done. Potential buyers of the fertilizer would first need to be convinced of the acceptability of the practice themselves, and may also consider whether their consumers would find the practice objectionable. A marketable excreta based product could also be subject to considerably more stringent government regulations than have otherwise been encountered, and it may be well beyond the capacity of a local NGO to show that the product is acceptable within the existing regulatory framework. It could be argued

that the creation of a market for excreta based fertilizers requires embedding of the reuse ideology at the macro-level, which is beyond the scope of this study. Early attempts to sell the fertilizers in the Comilla District have shown that creation of a market is possible; whether the results of such of a small trial can be replicated on a wider scale remains to be seen.

Attempts to introduce UDDT technology to localities with limited agricultural linkages are ambitious, and must be undertaken with an informed understanding of what will ultimately be required from the support agency to successfully embed the technology in the local context. The model successfully implemented in agricultural areas cannot be directly applied to these locales. Instead, support mechanisms related to the marketing of the excreta may need to continue for the lifespan of the toilets, with cost recovery occurring only when, and if, a regular market for the products has been secured.

Non-Monetary Values

The perceived non-monetary value of the toilet appear to be less context dependent than the monetary values. Respondents in all case study areas reported that UDDTs were widely regarded as superior sanitary systems than any of the available conventional sanitation solutions. This is significant in that even those members of the family not actively participating in agricultural activities have still developed a deep appreciation of the toilet. Furthermore, women were most likely to identify improved menstrual hygiene management and increased privacy and security as primary benefits of the toilet.

While the non-monetary valuation of the toilet is an excellent indicator of the embeddedness of the UDDT technology, it is somewhat limited as an analytical tool in assessing the degree to which the ecosan ideology has been accepted within the local context. While the UDDT's effective confinement of feces allows for better public health outcomes than other conventional sanitation solutions, the UDDT is not economically feasible if treated solely as a sanitation solution. With installation costs generally amounting to eight times that of a ring-slab latrine, it is quite likely that greater contributions can be made to public health by installing eight conventional

sanitary toilets than a single UDDT. The practicality of installing UDDT systems is, therefore, dependent on the recycling of nutrients in human excreta. Though contributing to the process of embedding the sanitation technology, the importance of the non-monetary valuation of the UDDT should not necessarily be over-estimated.

9.4 Implementation Model

The implementation model for a UDDT intervention is an exogenous factor that is controlled exclusively by the supporting agency. It is the primary means by which an NGO can steer the endogenous factors encountered in the intervention. Though the implementation model employed by NGOs involved in UDDT interventions in this study was fairly consistent, several elements are worth discussing here.

Educational Outreach, Training and Monitoring

The behavioral adjustment to the UDDT system does not appear to have been a significant barrier in any of the case studies assessed in this study. In most instances, respondents reported becoming habituated to the toilet's operational requirements after approximately one month of continuous use. Though respondents reported frequent misuse during the habituation phase, none of the toilets fell into disuse as a result. This success can largely be attributed to the training and monitoring programs implemented by the responsible NGOs. Daily visits to the UDDTs by NGO monitoring officers in the first several months after the toilets installation allow the consequences of misuse to be mitigated and provide an opportunity to teach users about simple solutions to common operations and maintenance issues encountered with the UDDTs. The habituation phase to the UDDTs can be seen as critical to embedding the technology, not only because it is when the bulk of the behavioral adjustment takes place, but also because it provides a practical training in UDDT operation and maintenance procedures that will be critical to the toilets sustainability following the termination of the NGO monitoring program.

The monitoring programs implemented by the various NGOs have been successful and appear to be integral to the eventual embedding of the sanitation technology. Though educational outreach programs are essential in stimulating initial interest in

UDDTs, they are generally not a sufficient means to wholly shift attitudes regarding the acceptability of excreta reuse. Educational outreach appears to be less important to the embedding process than practical experience using the excreta based fertilizers. An effective monitoring program is important in providing the encouragement that may be required for families to actually follow through with the use of the excreta products.

It was widely noted throughout all of the case study areas that, prior to the first application of the manure, the use of the treated feces in agriculture was regarded with some skepticism. However, upon opening the fecal chamber and handling the fecal compost for the first time, opinions began to shift (Figure 13). One respondent, whose feces chamber was opened for the first time in the hours before the interview said that '…before opening this, I had a negative image. But after opening this, and touching by different people, I have got a dramatic change' (Interview 020, page 2, lines 28-29). Generally, negative attitudes continued to wane with increased use of the fertilizer.

Figure 13: Opening the Feces Chamber
Owners of a UDDT in the Amarak village are encouraged to handle fecal soil conditioner by SPACE field staff after opening their feces chamber for the first time. (Photo: A. Guadagni)

It is important that the monitoring program continue for a minimum of one year following the UDDTs installation, or until the unit has produced the first batch of fecal soil conditioner. Certain disease causing vectors, notably parasitic ova, have been identified in manure that has dehydrated for the prescribed six-month period, and a reinforcement of safe handling procedures should be conducted immediately prior to the opening of feces chamber. This study corroborates the results of other studies that found that monitoring programs have the greatest effect in the first year following a toilet's installation (Azad-uz-zaman [undated].

Financing Schemes

The single largest variable in implementation models of the various NGOs related to financing mechanisms. The majority of projects relied on cost-sharing methodology, with user contribution ranging between 25% and 50% of the total installation cost. In these instances, beneficiaries signed a contract that stipulated the terms of repayment to the NGO, as well as a commitment from the toilet's owners mandating that they would use the toilet as prescribed. After having used the toilet for a period of time, the majority of respondents indicated that they thought their financial contribution was a sound investment, and many reported that they would be willing and able to contribute a significantly higher amount to a subsequent installation[25].

Two UDDT interventions assessed as part of this research did not require financial contributions from users and installed the toilets with solely NGO financing. The reasons behind this financing decision were considerably different. One of the responsible NGOs felt that it was unlikely to generate substantial interest in an untested sanitation technology while asking for user contributions, while the other financed the toilets in entirety as per an existing arrangement with their donor organization. In these instances, users entered into what Neupane (2010) refers to as a *mental contract* with the support organization, detailing the owners commitment to use the toilet as their primary means of sanitation.

[25] Users were asked if they would want to construct another UDDT if they moved to another village. If they answered in the affirmative, they were then questioned as to how much they would be willing to contribute to the installation of this UDDT.

It is generally accepted in the development discourse that user contribution to infrastructure projects fosters a sense of ownership in the users, contributing to the longevity and sustainability of the project. However, this study did not identify any discernible difference in the patterns of socially embedding the UDDT technology directly attributable to a user's financial contribution to the toilet's construction. In general, those aspects that can be seen as indicative of a sense of ownership among users, namely maintenance and appreciation of the system, proved to be quite similar amongst toilets installed with cost-sharing mechanisms and those that were solely donor financed.

UDDT technology is somewhat unique within the sanitation sector in this regard. Many other basic services that are merely 'given away' tend to be neglected by the users and rapidly fall into disrepair. A sanitation intervention that implemented conventional technologies would likely not be as successful if donor financed. The success of the donor financed UDDTs in this study can likely be attributed to the fact that the toilets were quickly established as an economically productive asset for the household, one that could not be realized if it was not properly maintained or if improper use prevented the effective dehydration of the feces. The perception of the UDDT as an economically productive asset appears to contribute significantly towards the embedding of the technology at the household level; once embedded the household is likely to feel a sense of ownership towards the system.

9.5 Exposure to UDDT Technology

Perhaps the greatest influence on embedding the UDDT technology at the community level comes as a result of the exposure to the sanitation systems. Limited NGO resources and low community wide interest in the initial phase of an intervention prevent educational outreach programs from reaching a wider audience. The primary factor involved in shifting community perceptions more favorably towards UDDT technology tends to be the acknowledgement of the benefit of the excreta fertilizers, which generally occurs as an endogenous process resulting from the use of the products. Two factors have been identified as contributing most significantly increasing the community's exposure to the UDDT systems, namely duration and saturation.

Duration

Though it seems a rather obvious supposition that UDDT systems should become more socially embedded at both the household and community level with the passage of time, this study has shown that the continued experience with the toilet is amongst the most critical factors in embedding the technology. The transition to the use of UDDTs is neither simple nor quick, and requires significant behavioral changes for its users and wider attitudinal changes from both the users and the communities in which they are installed. That the systems have become more embedded as households continue to utilize them is an encouraging indication that the perceived benefits of the sanitation and nutrient recovery system outweigh any difficulties encountered in the transition to the technology.

Initial hesitation towards the agricultural application of treated excreta was almost universally encountered in this study. Attitudes generally did not begin to shift until the fertilizer had been applied to fields and increased crop growth had been realized. Respondents who's UDDTs had been in continuous use the longest tended to be the most accepting and seemed to incorporate the practice most seamlessly into their daily lives. With sufficient use of the UDDTs, a transition was observed in the fundamental way in which the products were perceived: users tended to view the products as fertilizer first, and as excreta second. One respondent from the Comilla District neatly summarized the general attitude of UDDT users in the region, saying 'I have no disgusting concept. It is not a disgusting thing. It is fertilizer; it has to be used in the field' (Interview 039, page 2, lines 11-12).

Not surprisingly, the community's acceptance of the UDDTs also increased with time. Those communities in which UDDTs had been installed for the longest tended to display the greatest desire for the proliferation of the technology in the area. Users in these areas were also less likely to feel stigmatized regarding their use of the excreta fertilizers. This is largely a result of the community wide recognition of the quality of the organic fertilizers and greater instances of interaction with the users.

Saturation

There also appeared to be a correlation between the saturation of UDDTs in a given area and the embeddedness of the technology at the community level. Respondents in those villages with a higher UDDT system to household ratios tended to report a lesser degree of stigmatization and greater desire within the community for the proliferation of the technology. This, again, can likely be attributed to increased exposure to the technology on a community wide basis.

Saturation also effected the embedding of the UDDT technology on the household level. The installation of the toilets within a village creates a *de facto* subset of UDDT users within the community. Members of such a subset are more likely to find critical support mechanisms and less likely to feel stigmatized by the community as a whole.

Unlike duration, however, NGO involvement in the interventions makes the saturation of UDDT technology in a given area a primarily exogenous factor. None of the case study areas assessed as part of this research had UDDTs installed in more than one-sixth of the households in the village. It is likely that patterns of embedding the sanitation would occur more rapidly and effectively if a greater degree of saturation were sought.

10.0 Conclusions

The aim of this study was to identify the mechanisms by which and variable influences on the process of socially embedding urine diversion dry toilet (UDDT) technology in various contexts in Bangladesh. It also sought to determine a set of qualitative indicators that can be used to effectively assess the degree to which the sanitation technology has become embedded in the socio-cultural fabric of a given locality. The study attempts to add depth to the discussion of socially embedding innovative sanitation technologies, which is particularly deficient in the developing world.

A number of case study areas were selected based on certain criteria set forth in the research design. The case studies were selected to be widely representative of different settlement typologies and environmental contexts in Bangladesh. Care was also taken to select case study areas that represent different implementation models employed by various NGOs and different temporal arrangements in the data set. The variability of the selected case study areas serves to address the likelihood that different socio-cultural attitudes regarding the reuse of excreta may exist across Bangladesh, and to adjust for the unpredictability of extraneous factors that could potentially affect the process of socially embedding new sanitation technologies at the local level.

A series of qualitative interviews were conducted with users of UDDT systems in each of the case study areas and from sanitation experts working in the field of UDDT and conventional sanitation interventions. These interviews were than analyzed using a thematic analysis methodology. The analytical results were then applied to a quantitative indicator set developed for this study, to determine the degree to which social embedding has occurred in each of the case study areas. The differential patterns of embedding were then examined to identify which factors most affected the process of embedding the sanitation technology at both the household and community levels.

10.1 Summary of Findings

The results of this study indicate that the proposed qualitative indicator set developed as part of this research is can be an effective analytical tool for assessing the social embeddedness of urine diversion dry toilets. Furthermore, various social, contextual and managerial influences have been shown to affect the process of embedding, as observed in the case study areas.

The degree to which UDDT systems have become embedded in the local context and the factors that influence the process are quite varied in the case study areas. In general, the NGO implementation model of the UDDT intervention has considerable influence on the eventual embedding of the sanitation technology. Selection of an appropriate site for the intervention is essential, and should include an assessment of the predominant economic modalities and religious influences identified within the local socio-cultural context. Implementation models should be adjusted to on a case-by-case basis to account for these differences. Agricultural linkages within the community have been shown to be important embedding the UDDT technology and creating acceptance of the ecosan ideology of nutrient recovery and reuse. However, perceived benefit associated with these linkages can likely be supplanted in non-agrarian localities by creating a viable market for the excreta fertilizers.

NGOs in Bangladesh implemented two financing models in UDDT interventions, cost-sharing and donor financing. The financing model employed in the intervention does not appear to have significant influence on the degree to which the toilet ultimately becomes embedded in the local context. Other factors, notably the perceived value of the UDDT, have been shown to be more significant in creating a sense of ownership of the toilets, which is thought to be crucial to their sustainability.

Creating perceptions of the UDDT as an economically productive asset in perhaps the most critical element in embedding the sanitation technology at both the household and community levels. This value was most commonly recognized as a decrease in the household's regular fertilizer expenditures and increased crop production. However, respondents also indicated that increased productivity of their kitchen gardens lead to a decrease in food costs and increased food security. The process of

creating a clear monetary valuation of the toilet is an autonomous process that requires little or no external steering in agrarian economies. Establishing value in areas with no agricultural linkages will require additional NGO support.

Socially embedding of an innovative sanitation technology is a dynamic process and cannot be expected to occur rapidly. Unless other confounding factors dominate, the process of embedding progresses with time. Increased saturation of UDDT units also appears to contribute to the rapidity of the embedding process, as a higher ratio of UDDT users to households provides a stronger *de facto* support mechanism for UDDT users and provides a wider degree of exposure to the sanitation technology for the community at large.

10.2 Looking Forward

The present rate of proliferation of UDDTs in Bangladesh is rather slow. This can be primarily attributed to two factors: unfamiliarity with the technology and the high cost of installation. If UDDT systems are to play a more significant role in providing improved sanitation and contributing to fertilizer production in Bangladesh, both of these issues will have to be addressed. This study has primarily evaluated the social issues related to the introduction of UDDT technology in Bangladesh, and has concluded that with an increase in the number of units installed in a given area and continued exposure to the technology, a community will become more accepting of the technology. With that in mind, it is reasonable to conclude that a community in which the ecosan ideology is already firmly embedded will require less external technical support for the future installation of UDDTs.

The financing issue remains problematic. Several Bangladeshi NGOs involved in ecosan interventions have developed variable UDDT designs that significantly reduce the cost associated with the dual-chambered, brick and mortar structures most commonly constructed (see Practical Action 2010a; Practical Action 2010b; JADE 2011; Uddin 2011). Even these minimalist models, however, generally require construction costs well beyond the means of most of the population and remain several times more expensive than ring-slab latrines. Until innovative technological designs, such as prefabricated plastic pans and chambers, are developed, financing of

UDDT construction will likely be dependent on external subsidy. Innovative financing schemes should be developed and inherent value of the excreta fertilizers should be emphasized in educational outreach programs as a primary mechanism of cost recovery at the household level.

The current model for the distribution of UDDTs employed by NGOs working in Bangladesh calls for a small number of toilets to be installed in a larger number of villages. None of the villages assessed as part of this study had more than 17% of their households equipped with UDDTs. This methodology has obvious benefits: it allows an NGO a wider range of influence throughout the country, is likely to decrease the cost and increase the efficiency of subsequent phases of the UDDT interventions, and can be seen as a more equitable model for selecting aid beneficiaries.

However, a greater saturation of UDDTs in a village would present interesting opportunities for research of the technology, as well as distinct benefits with regards to prospects for financing the toilets. The construction of an 'ecovillage', with virtually 100% coverage of ecosan toilets and the incorporation of more holistic solid waste management systems, would allow researchers to assess the true benefits to human health and the environment associated with the use of UDDTs. Diarrheal disease is still widely reported amongst users of UDDTs in Bangladesh, even amongst those individuals who are regularly practicing proper hygienic behaviors. This may be, in many instances, due to migration of fecal pathogens from unsanitary toilets in the areas or by open defecation practiced by other members of the community. Actual improvements to public health outcomes associated with the installation of UDDTs cannot be adequately assessed until no such possibilities for cross-contamination exist. Furthermore, as knowledge related to UDDT systems progresses through a community, implementation costs associated with socialization to the systems and creation of formidable institutional arrangements, such as well trained local masons, are likely to minimized, allowing an increase in the share of NGO funds available the installation of UDDT hardware.

Finally, integration of UDDT technology into the urban sanitation infrastructure appears to be particularly challenging. While the efforts of NGOs in Bangladesh to

reach the urban poor with this innovative technology are laudable, whether it can be established as a viable sanitation alternative remains to be seen. The creation of functioning markets for excreta fertilizers has proven to be a daunting task in many contexts around the globe, and the situation in Bangladesh's urban areas will likely be no different. Experience has shown that small-scale success does not necessarily translate to large-scale practicality, as wider use of the fertilizer could lead to increased regulation of the products, potentially limiting the possibilities for cost recovery. However, these NGO attempts to integrate excreta ferilizers with existing organic composting operations in the slum settlement show promise. A true assessment of the viability of an excreta based fertilizer market can only be made when a more regular supply of the fertilizer is available; this, of course, cannot be achieved until more UDDTs have been built.

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Appendix I: Interview Questionnaire Template

Date:	Latrine No.:	Interview No.:

General Interview Information

Time	Translator:	Interview Location:
Interview begin: _____ Interview end: _____		

Temperature:	Meteorological Conditions:	Humidity:

Respondent Demographic Information

Gender:	Age:	Head of Household?

Residency Information

Length of Residence in Dhaka:	Length of Residence at Current Location:	Number of Residents in Household:

General Sanitation System Information

Improved Sanitation: (Y/N)	Sanitation System Design:	Number of Households Using Toilet:	Number of Individuals Using Toilet:	Number of Children Using Toilet:

NOTES:

Appendix II: Diagnostic Survey Template

Date:	
Location:	
Latrine No.:	
Interview No(s).:	

NGO:

Observations Regarding Condition of Toilet						
Parameter	Very Good	Good	Normal	Bad	Very Bad	Notes
Condition of Above Ground Structure:						
Condition of feces chamber and slab						
Condition of Urine collection / leach pit and hosing						
Entrance to toilet						
General Cleanliness						
Anal cleansing water drain / leach pit and hosing						

Appendix III: Distribution of Interviews

UDDTs Assessed and Interviews Conducted by NGO Intervention

Responsible NGO	Number of UDDTs Assessed	Number of Interviews Conducted
BARD / JADE	11	14
BASA / Practical Action	5	5
DSK	7	14
SPACE	14	19
Total	37	52

Number of Interview by Case Study Area

Case Study Area	Number of Interviews Conducted
Raicho, Hatigara and Joypur South	14
Jelepara	7
Bhashantek	3
Pajulia	5
Behakyor and Pobonkul	11
Shamta and Tengra	6
Amarak	6
Total	52

UDDTs Assessed and Interviews Conducted by Installation Date

Year of Installation	Number of Toilets Assessed	Number of Interviews Conducted
2005	7	9
2006	0	0
2007	0	0
2008	11	15
2009	2	2
2010	9	12
2011	8	14
Total	37	52

Appendix IV: List of Expert Interviews

Interview Date	Name	Organization	Job Title
8/18/11	Mr. Ranajit Das	DSK	Head of WatSan Program
8/20/11	Ms. Rabeya Khanam Ms. Munmun Khanam Ms. Mushfiqua Musharref	DSK	Project Manager Assistant Engineer Training Officer
8/23/11	Mr. Abdus Salam Mr. Md. Zillur Rahman Mr. Md. Fayzur Rahman	SPACE	Training Coordinator Agricultural Expert Resource and Documentation Officer
8/23/11	Mr. Ranajit Das	DSK	Head of WatSan Program
8/28/11	Mr. Monirul Alam	UNICEF	Water and Environmental Sanitation Officer
8/29/11	Mr. Azahar Pramantik	SPACE	President and Chief Officer
9/4/11	Mr. Asraful Islam Ms. Naju Najira Ms. Raju Rubina	SPACE	Unit Manager Community Worker Community Worker
9/6/11	Mr. Shajahan Monbal	SPACE	Unit Manager
9/8/11	Mr. Sirajul Islam Mr. AKM Rafiqul Islam Mr. Bimal Kanti Kuri Mr. Mian Md. Morshed	BASA	Director Project Coordinator Senior Program Coordinator Program Development Officer
9/8/11	Mr. Rafiul Islam	Practical Action	Senior Monitoring Officer
9/12/11	Ms. Farhana Rahman	BASA	Assistant Project Officer
9/13/11	Mr. Md. Abdul Kadir	DSK	Unit Manager
9/14/11	Mr.Faruque Hussain	ICDDR,B	Researcher
9/15/11	Dr. Shishir Kumar Munshi	BARD	Deputy Director - Agriculture Extension, Agriculture and Environment Division
9/15/11	Dr. Masudul Chowdhury	BARD	Joint Director
9/16/11	Mr. Abdullah al Mamun	BARD	Deputy Director
9/17/11	Mr. Md. Alauddin Alom	JADE	Training Officer
9/19/11	Mr. Dhanadip Chakma	SPACE	Field Engineer
9/19/11	Mr. Sajib Dewan	Green Hill	Community Development Organizer
9/21/11	Mr. Zahidul Mamun	Concern Universal	Head, Health Unit
9/21/11	Mr. Md. Ali	Oxfam	Researcher
9/24/11	Mr. Md. Abdul Kahleque Mr.Nayeemur Rahman Mr. S.M. Prarul Islam	Practical Action	Community Development Officer Monitoring Officer Technical Officer

Appendix V: Summary of Indicators

Level	Qualitative Indicator	Primary Factors	Secondary Factors
Household	Change in User Routine	Change in toilet behaviors Change in agricultural practices Use of fertilizers	Understanding of proper fertilizer use
	Percieved Value of UDDT	Willingness to pay Reduction in fertilizer costs Non-monetary values	Perceptions of improved household health Improved social status
	User Satisfaction	Perception of community attitudes Ease of use	Percieved stigmatization Sense of pride
	Gender Specific Issues	Menstrual hygiene management Improved privacy Improved security	Improved comfort Toilet can be used at both day and night Advocates proliferation of UDDTs
Community	Community Acceptance of Excreta Reuse	Percieved stigmatization of users Developing market for excreta fertilizers	Consumption of produce grown with excreta fertilizers
	Desire for Proliferation of UDDTs in Community	Community wants more UDDTs installed	Willininngness to pay Participation in planning process