BEYOND THE PILOT PROJECT: A REVIEW OF THE DIFFUSION OF ECOLOGICAL SANITATION TOILETS

by

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ABSTRACT

Over 2.6 billion people lack safe sanitation. EcoSan toilets are an affordable technology that, used appropriately, minimize environmental and health problems associated with waterborne sewerage and pit latrines. A challenge for population health is how to encourage widespread adoption, known as diffusion or scale-up. This paper employs Diffusion of Innovations constructs to illuminate EcoSan toilet adoption factors in diverse settings. EcoSan toilets were found in 55 countries. Experiences in seven countries are compared. Findings include: a tendency for greater proliferation in federally-driven sanitation programs; successes in surmounting traditional disgust with excreta; a relationship between utilization and follow-up; and the importance of user acceptance before attempting to routinize construction. Included is a theoretical framework of EcoSan diffusion as a two-tiered, parallel innovation-decision making process, where the decisions of implementers and administrators and intended beneficiaries overlap and interact. Maximizing adoption from both groups is key for scaling up pilots to nations.

Keywords: Ecological Sanitation, Diffusion of Innovations, Scale-up, Dry Toilet, Diarrhoeal Disease, Agricultural Reuse

Subject Terms: Sanitation, Water Supply, Public Health, International Development

DEDICATION

To the people of Nsolomba village in Malawi.

Though Malawi does not formally grace these pages, I assure you that every page is marked by it.

I hope and pray that someday, fruit from this work will return to you and multiply one-hundred fold.

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ABBREVIATIONS

CITA	Centro de Innovación Tecnológica (Mexican NGO)
EcoSan	Ecological Sanitation
EcoSanRes	Ecological Sanitation Research Programme (Swedish)
ESAC	Espacio de Salud (Mexican NGO)
GTASC	Grupo de Technologia Alternativa (Mexican private organization)
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH
NGO	Non-governmental organization
ROSA	Resource-Oriented Sanitation concepts for peri-urban areas in Africa
SANDEC	Department of Water and Sanitation in Developing Countries at the Swiss Federal Institute of Aquatic Science and Technology (Eawag)
SIDA	Swedish International Development Cooperation Agency
SWT WSP	South-Western Towns Water and Sanitation Program (Uganda)
UDDT	Urine-diverting dehydration toilet
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization

GLOSSARY

Adoption	A decision to make full use of an innovation as the best course of action available (Rogers, 2003).
Agenda-setting	The first stage of organizational adoption process, when the problem is defined that creates a perceived need for an innovation (Rogers, 2003).
Arborloo	A compost toilet with a portable superstructure with no urine diversion, covering a shallow pit that fills in after approximately one year. The superstructure is then moved and a tree planted in the filled pit (Jackson, 2005).
Change Agent	An individual who influences clients' innovation-decisions in a direction deemed desirable by a change agency (Rogers, 2003).
Clarifying	The fourth stage of the organizational adoption process, where the innovation is put into more widespread use in an organization, so that the new idea gradually becomes clearer to the organization's members (Rogers, 2003).
Compatibility	The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters (Rogers, 2003).
Complexity	The degree to which an innovation is perceived as difficult to understand and use (Rogers, 2003).
Compost Toilet	A toilet that that kills pathogens in human excreta via the heat generated from bacterial digestion of the vault contents.
Dehydration Toilet	A toilet that kills pathogens in human excreta through the process of desiccation.
Diffusion	The process in which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003).

Dry toilet	A toilet that does not use water to carry away excreta.
Ecological Sanitation (EcoSan)	A sanitation approach that treats human excreta as a resource, based on pollution prevention, human excreta sanitization, and safe reuse of excreta for agricultural purposes (Winblad et al., 2004).
EcoSan Toilet	Any dry toilet whereby human excreta are sanitized by dehydration or composting for the purposes of safe handling during agricultural reuse.
Fossa Alterna	A compost toilet with two permanent pits and a portable superstructure. When one pit is full the superstructure is moved to the other (Jackson, 2005).
Implementation	That which occurs when an individual puts an innovation to use (Rogers, 2003).
Innovation	An idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 2003).
Innovation-Decision Process	The process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision (Rogers, 2003).
Match Decision	The organizational or administrative decision to adopt a particular innovation as a solution to a perceived problem identified by an organization.
Matching	The second stage of the organizational adoption process, where the problem from the organization's agenda is fit with an innovation, and this match is planned and designed (Rogers, 2003).
Night Soil	Expression that refers to human faeces used as fertilizer
Observability	The degree to which the results of an innovation are visible to others (Rogers, 2003).
Opinion Leadership	The degree to which an individual is able to influence other individuals' attitudes or overt behaviour informally in a desired way with relative frequency (Rogers, 2003).

Persuasion	That which takes place when an individual forms a favourable or unfavourable attitude toward an innovation (Rogers, 2003).
Redefining/ restructuring	The third stage of the organizational adoption process, where the innovation is re-invented to meet the organization's needs, while the organization's structure is modified to fit the innovation (Rogers, 2003).
Relative Advantage	The degree to which an innovation is perceived as better than the idea it supersedes (Rogers, 2003).
Routinizing	The fifth and final stage of the organizational adoption process, where an innovation has become incorporated into the regular activities of the organization and has lost its separate identity (Rogers, 2003).
Scaling-up	Introducing an innovation to a larger population that has been previously tested on a limited basis.
Social Marketing	The design, implementation, and control of programs calculated to influence the acceptability of social ideas and involving considerations of product planning, pricing, communication, distribution, and marketing research (Kotler & Zaltman, 1971).
Skyloo	A dehydration toilet in a permanent structure that requires periodic (6-12 months) emptying of the receptacle and transportation to a composting site (Jackson, 2005).
Trialability	The degree to which an innovation may be experimented with on a limited basis (Rogers, 2003).
Urine Diverting (UD) Toilet	A toilet that separates urine from faeces during toilet use.

1: INTRODUCTION

The year 2008 was declared by the United Nations as the International Year of Sanitation, to address what has been called the "global sanitation crisis" (Black & Fawcett, 2008). Ecological sanitation (EcoSan) toilets are seen by a growing number of scholars and opinion leaders as a sustainable, ecologically sound solution to this crisis, as well as a tool in food security and poverty alleviation. This paper describes the current state of global EcoSan diffusion, focusing on experiences in seven countries, and provides recommendations to implementing agencies on how to encourage scale-up beyond the pilot project.

1.1 The Global Sanitation Crisis

More than 2.6 billion people lack a way to urinate and defecate safely (WHO/UNICEF, 2006). Two billion more are expected to join them within 20 years (Langergraber & Müllegger, 2005). The lack of adequate sanitation not only poses inconvenience, but comes with high human, economic, and environmental costs.

Poor sanitation kills. Poor water and sanitation leads to numerous waterborne diseases which are passed through faecal-oral transmission (Prüss, Kay, Fewtrell, & Bartram, 2002). Diarrhoeal diseases cause 17% of approximately 10 million annual deaths globally among children under five (Bryce, Boschi-Pinto, Shibuya, Black, & WHO Child Health Epidemiology Reference Group, 2005). Poor water, hygiene, and sanitation account for 3.7%, or 54 million, of global losses in Disability Adjusted Life Years (Boutayeb, 2006). The ripple effects of recurrent and largely preventable illnesses upon family life and communities cannot be fully quantified.

Poor sanitation poses staggering economic costs to developing economies. In one study, the World Bank determined that the combined financial and economic cost of poor sanitation to the four countries of Cambodia, Indonesia, the Philippines, and Vietnam are $11 billion USD per year (Hutton, Rodriguez, Napitupulu, Thang, & Kov, 2008). Based

on a life expectancy of 73 years, the 2006 economic costs to Africa of cholera alone were $156 million USD (Kirigia et al., 2009). Globally, a cost-benefit analysis showed that $7.3 billion USD in health-related expenditures would be avoided through the provision of adequate sanitation (Boutayeb, 2006).

Poor sanitation degrades the environment. Besides faecal contamination of point water sources that occurs from open defecation and latrine leakage, 85% of waste from households connected to a waterborne sewerage system globally is discharged into waterways without undergoing primary or secondary treatment (Bos et al., 2004). This leads to eutrophication (macronutrient enrichment) of the waterways, which spurs the growth of aquatic plant life, thereby reducing the amount of available oxygen for other aquatic life (Díaz, 2001). The consequences of eutrophication include loss of fisheries and biodiversity, and alteration of food webs (Ibid). In addition, failure to recycle nutrients from human excreta increases the need for chemical fertilizers, which also lead to eutrophication of waterways, releases greenhouse gases, and reduces soil fertility over time (Drinkwater & Wagoner, 1998).

Waterborne sanitation is not feasible in many countries. On average, flush toilets consume between 60 and 100 litres of water per day (Gleick, 1996). It is estimated that 54 countries, with a combined population of 4 billion people, will experience water scarcity (<1000 m^3 annually per person) or water stress (<1700 m^3 annually per person) by 2050 (Hinrichsen, Robey, & Upadhyay, 1997). In summary, the "porcelain standard" (Harper & Halestrap, 2001) of the flush toilet, to which the majority of those desiring a toilet aspire, is an unsustainable sanitation system for a growing number of communities around the world.

1.2 EcoSan: The Global Sanitation Solution?

Ecological Sanitation (EcoSan) is a sanitation approach that considers human excreta to be a resource and seeks to return to the soil valuable macronutrients in excreta which are otherwise lost to waterways (Esrey, 2001). An ecological sanitation system may employ one or many technologies that work together to reduce water consumption, protect water sources from faecal contamination, and recover nutrients from human urine

and feces. Particular technologies that are considered part of EcoSan systems include rainwater harvesting, greywater collection and reuse, biogas digestion for energy production, composting or digestion of organic waste, and composting or dehydration toilets (Langergraber & Müllegger, 2005). Proper implementation of EcoSan has many benefits, including ground and surface water contamination prevention, soil degradation prevention, and optimization of nutrient and water resources (Werner, Otterpohl, & Jönsson, 2003). In addition to these direct benefits, indirect benefits include increased food production, reduced malnutrition, and increased savings for farmers not having to invest in chemical fertilizers.

2: RESEARCH PURPOSE

Despite the many benefits of EcoSan and the growing realization of the environmental impact of waterborne sanitation, diffusion of EcoSan technology and practices at both the community and national levels has been limited. Many case reports about EcoSan toilet projects have been presented at conferences that summarize project experiences and lessons learned at the community and national levels. Examination of individual projects reveals many similarities in approach (e.g., participation by intended beneficiaries, promotion efforts) and barriers to user acceptance. The presence of similar projects in countries with such differential levels of progress in scaling-up EcoSan construction leads to the question of what factors contribute to the rate of toilet construction at a national level. To this point, there has been no comprehensive global review in the peer-reviewed literature that has attempted to describe and recommend strategies for scaling up, or going beyond EcoSan toilet pilot projects, in low and middle-income settings. Therefore, the purpose of this project is to integrate global experiences from EcoSan toilet promotion efforts and provide a set of lessons from which project planners can draw information to optimize the likelihood of EcoSan diffusion.

The principal research questions are:

- What are key factors in gaining community acceptance of EcoSan technology?
- What factors are associated with an early decision at an organizational level to adopt EcoSan as a sanitation strategy?
- What factors lead to scaling-up EcoSan construction and toilet adoption?

3: LITERATURE REVIEW

Before comparing and discussing EcoSan toilet diffusion, it is first necessary to understand some finer details of EcoSan toilet technology, how scholars understand technology transfer and the processes underlying widespread adoption of innovations, and the psychosocial determinants of sanitation choices.

3.1 Ecological Sanitation

As previously described, ecological sanitation is a sanitation approach that places priority upon environmental protection and macronutrient recycling. EcoSan systems can consist of one or many technologies implemented at a household or community-level. The focus of this project is on EcoSan toilets and their associated hygiene practices required for safe reuse of human excreta.

3.1.1 EcoSan Toilets

For the purposes of this research project, an EcoSan toilet is defined as any dry (non-water using) toilet whereby human excreta are sanitized by dehydration or composting to ensure safe handling during agricultural reuse. Toilets connected to biogas digesters for energy generation are also classified under the category of ecological sanitation, but are not included for the purposes of this project since they are an add-on technology separate from the toilet itself.

Toilets that function on the process of dehydration (often called UDDTs for urine-diverting dehydration toilet) collect, store, and treat urine and faeces separately so that faeces dry out and pathogens die faster (Esrey, 2001; Peasey, 2000). These toilets are built aboveground and drying agents are added to the faecal vault after defecation. Design can be modified to accommodate preferences for sitting or squatting. In sit-down models, the toilet bowl has a physical separator. Urine is collected in front of the separator and flows to a container or soak pit, while faeces falls behind the separator and into the

storage vault below. For squat-toilet models, separate holes are designated for urination and defecation. A third hole for anal cleansing water may also be added if desired. Additional design modifications may include urinal installation for men and solar-heating and ventilation of faecal storage vaults to accelerate pathogen die-off. Examples of dehydration toilets include, but are not limited to, the Vietnamese dry toilet, the Mexican dry ecological toilet, the South African urine diversion dry toilet, the Ethiopian EcoSan toilet, the El Salvadorian Tecpan solar heated toilet, and the African Skyloo (Jackson, 2005; Peasey, 2000).

Composting toilets do not separate urine and faeces. The combined excreta are aerobically digested by bacteria, worms and other organisms to produce compost (Esrey, 2001; Peasey, 2000). Composting toilets may be above or belowground and are available in sitting or squatting models. Examples of composting toilets include the African Arborloo and Fossa Alterna, and the Mexican SIRDO (Jackson, 2005; Peasey, 2000).

It should be noted that sometimes toilets referred to as compost toilets are actually dehydration toilets. There are two reasons for this common error. First, composting as a secondary treatment of dehydrated excreta is commonly practiced. Secondly, toilets that are designed to be compost toilets sometimes do not reach appropriate temperatures, and while not intended, the primary method of disinfection is in fact dehydration (Redlinger, Graham, Corella-Barud, & Avitia, 2001).

3.1.2 Sanitization for Agricultural Reuse

Improper utilization of EcoSan toilets poses personal and public health risks. Typical raw sewage contains numerous bacteria, intestinal helminths, protozoa, and enteric viruses (Kamizoulis, 2008). Both urine and faeces contain pathogens, though the pathogens in urine that are of public health concern are most often derived from faecal cross-contamination (Schönning & Stenström, 2004). Particular attention must be paid to climate when deciding how excreta are to be sanitized and for how long they must be stored (Austin, 2001; Peasey, 2000). The key to excreta sanitization is to maintain conditions unfavourable for microbiological growth for a suitable period of time (Austin, 2001). A number of factors may be manipulated to cause unfavourable conditions for

microbial growth. They include raising the temperature above 40°C, raising the pH to at least 9.0, adding ammonia, drying the excreta, irradiating the excreta with sunlight, and encouraging microbial competition from non-pathogenic bacteria through aeration and the addition of organic matter, as enteric bacteria are generally anaerobic and have different nutritional requirements (Schönning & Stenström, 2004).

Dehydrated Excreta

In dehydration toilets, urine and faeces are managed separately. As faecal cross-contamination of urine occurs, urine as well as faeces must undergo treatment before agricultural reuse. The Swedish recommendations for urine fertilization of crops for raw consumption is storage for six months and application to crops at least one month prior to consumption (Schönning & Stenström, 2004). For faeces, recommendations vary according to temperature and humidity. The minimum storage time required for faeces is dependent entirely upon how hot and dry the excreta can be maintained. At ambient temperatures, helminth eggs can survive in soil for years (Ibid). Tests in different climates recommend 18 months (no secondary sun drying) and 12 months (with sun drying) in climates with average temperatures between 17-20°C, and 10-12 months (no sun drying) and 8-10 months (with sun drying) in climates with average daily temperatures between 28-30°C (Austin, 2001). Hotter temperature of the faeces pile may be achieved through solar-heating (Peasey, 2000). Storage time of faeces is shortened by drying and increasing pH. The addition of an alkaline material (ash, lime, etc) in sufficient quantities after defecation dries and increases pH.

Composted excreta

Composting toilets use heat inactivation to achieve pathogen die-off (Schönning & Stenström, 2004). The addition of an amendment, such as sawdust or straw, is recommended to ensure proper aeration of the compost pile, which is necessary for the growth of aerobic bacteria that generate heat and out-compete enteric pathogens (Ibid). In an ideal setting, enough heat is generated from aerobic digestion from competing microorganisms to reach temperatures exceeding 50°C in the compost pile. Microbial inactivation under these conditions takes only weeks to a few months (Ibid). However,

repeated experiences from around the world have shown that the necessary ventilation and heat conditions are rarely achieved in applied settings. Thus, given the level of control and expertise required to maintain ideal conditions, the EcoSanRes Guidelines question the effectiveness of composting as a primary sanitization method at the household level, and recommend composting as a secondary treatment method (Ibid).

3.1.3 Transfer of Appropriate Technologies

EcoSan toilets are affordable, and if used appropriately have substantial health, environmental, and economic benefits. These benefits cannot be reaped if toilets are not built and subsequently utilized. The principles underpinning the scaling-up of any given EcoSan project are thus not unlike the scaling-up of any appropriate technology.

Everett Roger's Diffusion of Innovations Theory, which first appeared in 1962 and is available in book format, is a framework to explain how new ideas or technologies diffuse through a society (Rogers, 2003). The rate of diffusion of any particular innovation varies by several main clusters of influence: the nature of promotion of the innovation, perceived attributes of an innovation, characteristics of adopters, contextual factors, and the innovation-decision process.

3.1.3.1 Promotion

Although promotion of public health and environmental innovations can occur in an organic, grassroots way (e.g., by innovators and early adopters internal to a community), they are more typically fostered by specific, external agents. A *change agent* is "an individual who influences clients' innovation-decisions in a direction deemed desirable by a change agency" (p.473). Change agents use *communication channels*, or means of relaying a message, to promote an innovation. Mass media can reach a large audience rapidly to introduce knowledge and change weakly held attitudes. Interpersonal methods, which involve the interaction of two or more individuals, are generally more useful in persuading people with stronger opinions to adopt an innovation. Cosmopolite channels, which are nearly ubiquitous in EcoSan projects, link receivers with information sources outside their immediate social system, and can be either mass media or interpersonal (e.g., visits to neighbouring communities). In localite

channels, which attempt to use the social system itself as a network for promotion, the involvement of opinion leaders can be particularly important. *Opinion leadership* is "the degree to which an individual is able to influence other individuals' attitudes or overt behaviour informally in a desired way with relative frequency" (p.475). Opinion leaders are often members of the social system, whereas change agents are usually external, though this is not always the case. Hence, the credibility of the change agent and perceived source of the information can be critical to the acceptance of an innovation.

3.1.3.2 Perceived Attributes of an Innovation

Diffusion of Innovations research has found five key attributes of innovations that influence how quickly an innovation is adopted in a social system (p.219-266). The first and often strongest predictor of more rapid adoption is greater perceived *relative advantage* compared to the technology or idea the innovation is replacing. For this reason, innovations that prevent some undesirable future event often diffuse more slowly than innovations with immediate benefits. This can be counteracted through incentives, though incentives may also change the identity of the individuals adopting the innovation by attracting people interested only in the incentive, and not in the innovation itself. Secondly, innovations that are *compatible* with the values held by the intended beneficiaries are often adopted at a higher rate. Sometimes even making the name of an innovation more compatible with local values can cause an innovation to diffuse more rapidly. *Complexity* of the innovation is how well the innovation is understood in how it works and how to use it. *Trialability* is the ability for intended beneficiaries to test an innovation on a limited-basis. Innovations that do not require a large upfront investment or allow potential adoptees to revert to previous behaviour tend to be adopted more rapidly. Finally, *observability* is how visible the results of an innovation are by those who have not yet adopted in a social system.

3.1.3.3 Nature of Social System and Other Contextual Considerations

Different social systems have different norms and hierarchical structures that characterize them. The norms and structure of a system affect how quickly innovations are able to diffuse (by how many people make up the decision-making unit), how

innovations are perceived (by the reputation and popularity of the change agent or agency), and at what level of innovation-decision can be made (whether by the authorities, implementing agencies, or intended beneficiaries). Social norms related to sanitation are discussed in Section 3.1.4.

3.1.3.4 Innovation-Decision Process

The innovation-decision process is "the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision" (p.475). While individuals form the decision-making unit in authoritative and collective decisions, Rogers also describes the innovation-decision process for entire organizations. An *organization* is "a stable system of individuals who work together to achieve common goals through a hierarchy of ranks and a division of labour" (p.404). The innovation-decision process for organizations is composed of *agenda-setting*, *matching*, *redefining/restructuring*, *clarifying*, and *routinizing* (p.421). These terms are defined in the Glossary. Of note is the match decision, which occurs between the matching and redefining/restructuring stages. The organizational innovation-decision process becomes important later in this paper in understanding why EcoSan is more widely accepted in some countries than others. Less is known about the complexities of adoption of an innovation above the level of organizations (i.e., the scaling-up of a useful program, process, or technology in a country or across many countries).

3.1.4 Determinants of Sanitation Choices

All EcoSan projects occur in social systems with pre-existing traditions and attitudes towards sanitation and human excreta. Tanner wrote that every society has a "social excreting policy" (cited in Avvannavar & Mani, 2008). Culture and religion, socioeconomic status, and environment all influence how people choose to eliminate excreta.

3.1.4.1 Culture and Religious Practices

People are generally uncomfortable with discussing the issue of human excrement in detail (Rosenquist, 2005). In an adaptation of Maslow's hierarchy of needs, it has been proposed that self-actualization in relation to sanitation is the "need for denial" – to treat excreta as though it does not exist (Ibid). Societies differ in their level of disgust, each falling somewhere on the spectrum from faecophobic (handling excreta is unacceptable) to faecophilic (handling excreta is acceptable) (Winblad et al., 2004).

Religion has a significant influence on attitudes towards excreta. Muslim and Hindu societies are often faecophobic. In Islam, coming into contact with urine and faeces disqualifies a person from praying (Nawab, Nyborg, Esser, & Jenssen, 2006). Muslims also frequently practice anal cleansing with water after defecation. Many Hindu societies also cleanse with water, and follow specific purification procedures before and after defecation (Avvannavar & Mani, 2008). One must account for anal cleansing with water in toilet design. Some African societies that practice witchcraft, sometimes alongside other religious systems, believe excreta can be used for curses (Ibid). By contrast, Buddhists believe that excrement is just one of many earthly resources and are often faecophilic (Ibid). In Christian societies, attitudes towards excreta are likely influenced more by secular traditions rather than religion, as little mention of excreta is made in the Bible (Ibid).

There are other sanitation-related behaviours that seem to be rooted in secular-derived cultural norms, though it is sometimes difficult to define where religion ends and culture begins. One clear example of a culturally-linked behaviour is constant toilet flushing by Japanese women, who fear being heard while urinating or defecating. This behaviour became so prevalent that a toilet capable of emitting flushing noises was designed to meet client needs while conserving water (Rosenquist, 2005).

Gender relations are a very important aspect of culture that influences sanitation preference. In two studies in Pakistan and India, women of all ages desired to have a toilet in the home because social norms, which deem it shameful for a woman to be seen defecating, have caused women to adjust their eating habits accordingly in order to defecate secretly in the very early morning or evening (Calvert, 2003; Nawab et al.,

2006). One project in Uganda reported that pregnant women were prohibited from using toilets for fear of losing the pregnancy (Kaggwa, Kiwanuka, Okia, Bagambe, & Kanyesigye, 2003; Victoria, 2007). Perhaps most significant of all is the fact that repeated experiences from around the globe have shown that women bear the labour of maintaining and caring for toilets, which means carrying water for flushing and cleansing as well as potentially coming into contact with excreta during routine maintenance.

3.1.4.2 Socioeconomic Status

The socioeconomic status of a family and a society determines what sanitation options are available to households. In developing societies, toilets (especially flush toilets) are often status-conferring (Harper & Halestrap, 2001). The more a toilet appears like a white porcelain flush toilet, the higher status it is perceived to give (Rosenquist, 2005). The association of toilets with status and modernity, together with the observation that people desire toilets for reasons other than health (e.g., privacy, convenience, safety, home improvement) has spurred discussion among sanitation experts that sanitation would be better diffused through social marketing rather than health promotion (Avvannavar & Mani, 2008; R. Holden, Terreblanche, & Müller, 2003; Rosenquist, 2005). The status-conferring power of a technology is not static, however, as it decreases as the technology becomes more prevalent (Rogers, 2003).

3.1.4.3 Environment

Sanitation choices are affected by both the natural and built environments. Climate, water availability, and soil conditions not only affect but also restrict sanitation options. For example, some decision-makers and NGOs turn to EcoSan because rocky soil or a high water table prohibits the digging of pit latrines. A lack of water resources can also be a cue to action to construct dry toilets. Concerning the built environment, dense human settlements restrict the space available for toilet construction. Urban planning also affects the ease with which centralized sewerage systems may be constructed. Furthermore, urbanization can make people unaccustomed to open defecation upon return to rural regions (Jenkins & Curtis, 2005).

4: METHODS

4.1.1 Study Design

Factors in global EcoSan diffusion are explored using a case-study approach with countries as the unit of analysis. Case studies were considered the best way to achieve the depth required to understand the intricacies of adoption patterns. Project reports from various countries were assessed through a Diffusion of Innovations theoretical lens. From these reports, themes were identified and countries illustrating these themes were selected for deeper study. The countries selected were China, Uganda, Mexico, South Africa, Mozambique, Nepal, and India.

Countries were selected instead of projects or regions for two reasons. First, the purpose of this paper is to understand the factors that lead to widespread diffusion of EcoSan toilets. Project-level details undoubtedly affect the success of an individual project, however one must focus on a larger unit to capture the diffusion pathway outside, rather than inside, project communities. Second, the project reports that were used as data for this paper have already done a thorough job at outlining lessons learned at the project level.

4.1.2 Literature Search

Data were drawn from a mixture of sources. Peer-reviewed literature was identified by searching the Web of Science, JSTOR, Medline PubMed, and Global Health search databases using the terms: *ecological sanitation, environmental sanitation, Arborloo, Skyloo, Fossa Alterna, humanure,* and *human manure.* This search yielded mostly background articles on ecological sanitation, as well as analyses done on its cost-effectiveness and sustainability in discrete, local settings. No reviews on widespread adoption or scale-up of EcoSan toilet technology were identified during this search.

The bulk of the literature on EcoSan project experiences came from proceedings of various conferences and symposiums, or through project data sheets. Through

performing an internet search using the terms *ecological sanitation*, *EcoSan*, and *eco-sanitation*, the following conferences were identified: 1st International Symposium: EcoSan - Closing the Loop in Wastewater Management and Sanitation, 2000, Bonn, Germany; 1st International Conference on Ecological Sanitation, Nanning China, 2001; 2nd International Symposium: EcoSan – Closing the Loop, 2003, Lübeck, Germany; 3rd International Conference on Ecological Sanitation, 2005, Durban, South Africa; DWA-BMZ-GTZ EcoSan Symposium: New Sanitation Concepts - International Project Experiences and Dissemination Strategies, 2006, Eschborn, Germany; Dry Toilet; and International Conference on Sustainable Sanitation: Eco-Cities and Eco-Villages, 2007, Dongsheng, China.

Once the first reading of the acquired literature was performed, another internet search was performed using the names of countries of particular interest and the original search terms previously mentioned. During the course of the search, a link was discovered on the website of the Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ) to a document containing a catalogue of information on all global EcoSan projects, to the knowledge of the GTZ team as of June 15, 2009. Links to project websites and reports were drawn from this global database, and additional internet searches were performed using specific project titles.

4.1.3 Case Study Selection

In total, 55 countries have reported EcoSan toilet projects. Since an underlying motivation of this research is to accelerate the rate at which those currently lacking adequate sanitation gain access to appropriate, sustainable sanitation facilities, case study selection was limited to low or middle-income countries. From this list of countries, China, Uganda, South Africa, Mexico, Mozambique, Nepal, and India were selected. In general, countries were selected to illustrate various stages of collective adoption. China, Uganda, South Africa, and Mexico were chosen specifically because they are examples of countries with large-scale EcoSan projects. Mozambique and Nepal were chosen because of their high toilet utilization rates. Finally, India was chosen because despite many years of vigorous effort, EcoSan has not been scaled-up despite the presence of many small projects.

4.1.4 Data Analysis

Analysis of the data focused on constructs from Diffusion of Innovations theory, namely adoption rate, perceived attributes of EcoSan toilets, change agents, promotion methods, and innovation-decision processes. Qualitative analysis was used to draw out factors that influence EcoSan diffusion from the case studies. Quantitative analysis was used to describe the current global EcoSan situation.

Qualitative analysis was performed in stages. In the first stage, open coding of the case studies was performed, to inductively search for common themes and the range of variation between cases. Special attention was paid to project process, the identity of project administrators, characteristics and reactions of the intended beneficiaries, technological and environmental barriers, financing issues, gender issues, and diffusion patterns. From this process, the seven case study countries were identified. During the second stage, data were entered into a matrix built upon the principles of Diffusion of Innovations Theory. Countries were then compared along theoretical constructs, which included the identities of the EcoSan change agents, the level of adoption decision, the characteristics of the intended beneficiaries, and the perception of EcoSan toilets with regards to relative advantage, compatibility, complexity, trialability, and observability. In terms of perceptions of EcoSan toilets by intended beneficiaries, care was taken to distinguish between reported perceptions and authors' speculations.

Quantitative analysis of the number and proportion of persons served by EcoSan toilets was performed using estimates of numbers served according to the GTZ global database. Case reports that did not appear to be captured by the GTZ database were included by multiplying the number of household and communal latrines by the estimated number of users. With the exception of Nepal, where household size was estimated to be 6 based on the 2008 WaterAid Nepal report (Tuladhar et al., 2008), the household estimates from the GTZ global database (3 for Asia, 4 for Africa and Latin America) were used for internal consistency. Unless otherwise stated in the case report, the estimate of people served by school toilets used was 200. Note that only completed EcoSan projects featuring dry toilet technology were included in this analysis.

5: RESULTS

5.1 Global Overview of EcoSan Toilet Promotion

The review of published and grey literature turned up documentation of modern EcoSan toilets in 55 countries, listed in the Appendix (Brandberg, 2003; Bregnhøj, Eilersen, von Krauss, & Backlund, 2003; Buren, McMichael, Cáceres, & Cáceres, 1984; CREPA, 2009; Galbiati, da Silva, Affonso, & Paulo, 2007; GTZ EcoSan Team, 2009). One can see in Figure 1 that time is an important factor in the diffusion of EcoSan toilets, as is the case with any technology, though there are also clearly examples where time has less influence. The leader in the number of persons served by EcoSan toilets at 2.2 million in 11 years is China, which does not appear alongside other select countries in the figure below since its scale is so large.

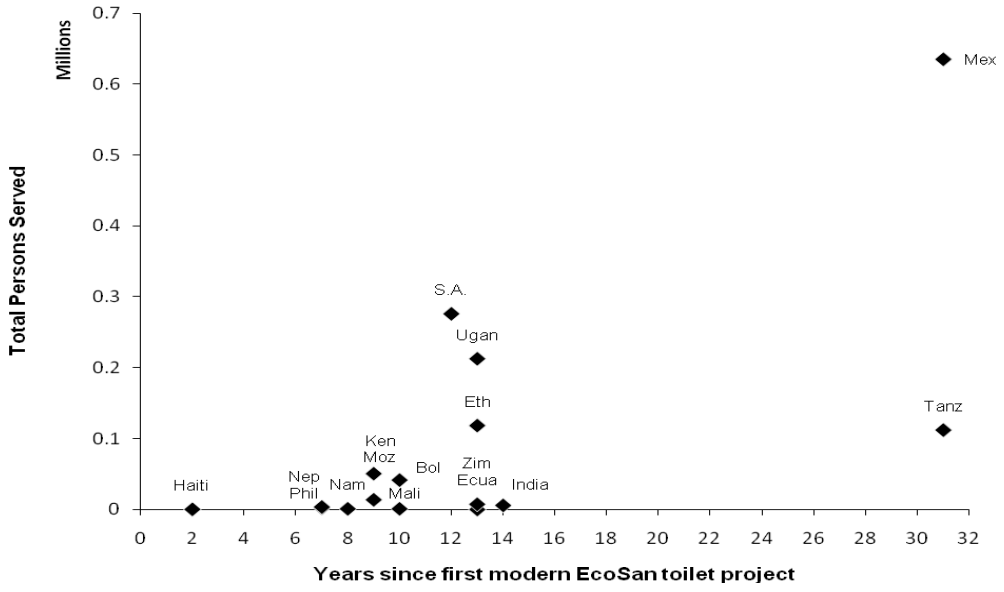

Figure 1. Total persons served against time for select EcoSan countries (excluding China)[1]

[1] Country Abbreviations. Bol: Bolivia, Ecua: Ecuador, Eth: Ethiopia, Ken: Kenya, Moz: Mozambique, Nam: Namibia, Nep: Nepal, Phil: the Philippines, S.A.: South Africa, Tanz: Tanzania, Ugan: Uganda, Zim: Zimbabwe

When population is taken into account (Figure 2), the current world leader in the proportion of people served is Uganda. Bolivia moves higher in rank while China falls in rank due to its large population, and the other countries seem to maintain their relative positions from Figure 1. Still, one can see that the proportion of populations served in all countries is very low, with Uganda leading at a mere 0.79%. This figure however represents a very high coverage of seven of Uganda's southwestern districts (Victoria, 2007). It should be noted that Rwanda was excluded from this graph, since reports of over 800,000 persons served by urine-diversion toilets could not be verified, even through personal communication with in-country representatives. If the project in Bulera, Rwanda was completed according to project plan, Rwanda would lead in proportion of population served, at an astounding 9.6% (GTZ EcoSan Team, 2009).

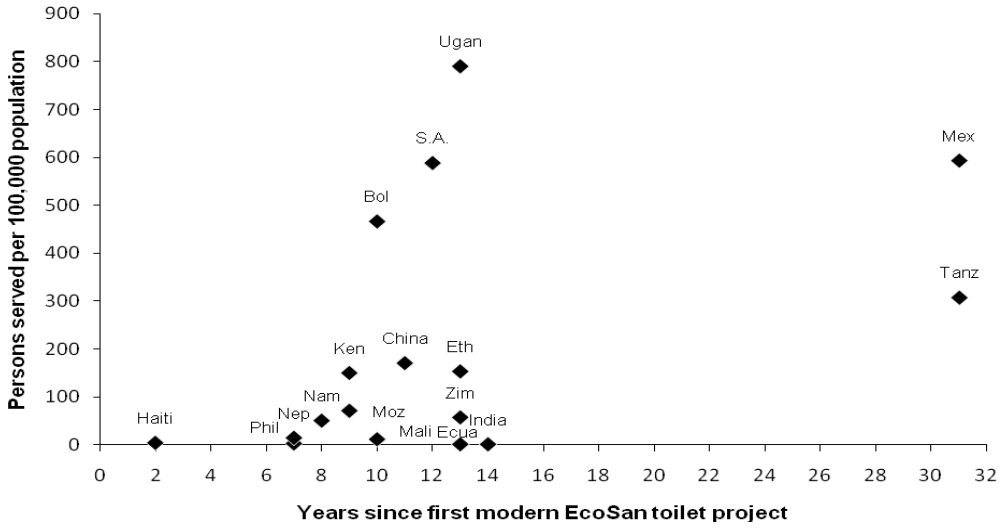

Figure 2. Persons served per 100,000 population versus time for select EcoSan countries (including China)

5.2 Case Studies

Out of 55 countries, China, Uganda, South Africa, Mexico, Mozambique, Nepal, and India are included as case studies. Each case study contains a country profile and brief summary of the country's diffusion pathway and unique features. Rationale behind country selection is included in Chapter 4 (Methods). According to the World Bank

country classification system, Mozambique, Nepal, and Uganda are low-income economies, China and India are lower-middle-income economies, and Mexico and South Africa are upper-middle-income economies. Another factor to consider in terms of country-level wealth is how the wealth is distributed between members of a population. The indicator of wealth distribution is the Gini coefficient, where a value of zero indicates wealth is equally distributed and 100 indicates the wealth is concentrated into the hands of a single person. The 2008 Human Development Report shows that with the exception of India with a Gini coefficient of 36.8, all other countries have a Gini of at least 45, with the highest being 57.8 in South Africa. Thus, wealth is least equally distributed in South Africa. As seen in Table 1, countries differ greatly in persons served by EcoSan, the rate of toilet construction, and geographical patterns of adoption.

Table 1. Comparison of adoption rates and distributions by country

Country	Persons Served per Year (n Years)	Geographic Distribution
China	184,967 (12)	Highly concentrated efforts in 17/22 provinces
Mexico	20,484 (31)	Hot spots of varying size dispersed in 17/31 states
Uganda	17,722 (12)	Highly concentrated efforts in southwestern districts
South Africa	16,675 (12)	Highly concentrated efforts dispersed in 5/9 provinces
Mozambique	1,524 (9)	Small hot spots in 2/10 regions
Nepal	515 (7)	Largely localized to one peri-urban area
India	418 (14)	Small projects dispersed in 7/28 states

5.2.1 China

In Chinese, "sanitation" literally translates as "protection-life" (Rusong, 2001). The first pilot project in 1997, funded by UNICEF and SIDA, consisted of 70 UDDTs built in a village in Guanxi province by the Ministry of Health in cooperation with the Guanxi Public Health Campaign Committee, the Institute of Environmental Health and Engineering (IEHE), and the Jui San Society (a major political party). Two other pilot projects in Jilin and Shanxi provinces also began in 1997 (Mi & Liu, n.d.). Only one year later in 1998, 10,000 UDDTs in 200 eco-villages had been built in Guanxi. In five short years, this number grew to over 685,000 in 17 provinces (Jurga, Schlick, Klingel,

Werner, & Bracken, 2005). This rapid expansion is due in large part to the efforts of the Jui San Society, a major political party in China, to put sanitation and EcoSan on the national agenda. Jurga writes, "The government, under pressure from rural improvement targets, have seen that ecological sanitation is a hygienic solution that performs well…As top-down decision making processes prevail in China, implementation can proceed extremely quickly once decision makers are convinced" (Jurga et al., 2005)." Now EcoSan is an integral part of China's rural development and poverty reduction plan (Mi & Liu, n.d.), and is considered "the Chinese standard for rural latrine construction" (Jurga et al., 2005).

Country Profile 1. EcoSan Summary for China

Construction & Utilization:	
First Toilet Built (Year)	1997
Total Persons Served	2,219,605 persons (total), 170.2 persons per 100,000
Toilet Model(s)	UDDT
Toilet Utilization	Variable; Kunming 64%, Dianchi basin villages 0.002-40%, other locations not reported
Excreta Utilization	Not reported
Geographic Profile:	
Confirmed Locations	Multiple "EcoSan towns and villages" in 17 of 22 provinces
Level(s) of Implementation	Household/apartment, public
Human Settlements	Majority rural towns and villages
Client Characteristics:	
Attitude Towards Excreta	Faecophilic, high view of organic fertilizer
Anal Cleansing Method(s)	Paper
Promotion Efforts:	
Initiator(s)	Ministry of Health, Guanxi Public Health Campaign Committee, UNICEF, SIDA
Partners	Jui San Society, IEHE, Kunming Institute of Environmental Science, Yunnan Academy of Science; Swiss agencies, Red Cross, Plan, ReSource, GTZ, Plan International
Channels & Methods	Television, radio, newspaper, model households and villages, training courses
Subsidy	33% (cost, cement, toilet pan) Guanxi, 44-50% Shaanxi

As expected across such a large geographical area, toilet acceptance is variable. UDDTs have been promoted through local television, radio, newspapers, community visits to model villages, and village health and hygiene education (Mi & Liu, n.d.). In

Guanxi, where demand has exceeded funds available, villages decide on a sanitation system and the leader submits a proposal and financial plan to the country government (Jurga et al., 2005). In Kunming, SANDEC and two Chinese educational institutions set up a study tour of Guanxi and then proceeded to build five model toilets (Werner et al., 2006) in January 2004. After monitoring their social acceptance, a larger number of toilets were started near Kunming and completed by the end of the summer in the same year. In the early stages, toilet usage was only 40%. This increased to 64% at the end of three months (Werner et al., 2006). Reasons for not using toilets included the lack of choice in toilet model, urine pipe blockages, and worry about complexity of operation. The government of Kunming approved the project and planned for the construction of 100,000 more UDDTs around the Dianchi basin, 53,989 of which were completed by the end of 2006. An assessment of toilet usage in these basin villages revealed that the utilization rates ranged from 0.002-40% (Liu & Yang, 2007). A separate project in Shaanxi executed by Plan appeared to be more successful (Kumar, 2008). This project too proceeded remarkably quickly from pilot (May/June 2005) to scale-up (July 2005). Though the report did not report percentage utilization, user acceptance of UDDTs was reported to be very high, a result that Plan attributes to its participatory approach (needs assessment, planning, design, execution), the low price of UDDTs compared to other toilets, the simplicity of the UDDT, and the project subsidy (44% in 2008).

People in China largely accept excreta reuse. Many communities actively used night soil prior to project involvement (Kumar, 2008). In contrast to other countries (with the exception of Nepal) which often report low excreta utilization, Chinese EcoSan promoters must instead convince UDDT owners to wait to harvest faecal fertilizer until it is safe to do so.

5.2.2 Mexico

Peasey writes that Mexico has been called the “dry sanitation capital of the world” (Peasey, 2000). The first record of construction of toilets functioning on EcoSan principles was by a for-profit Mexican NGO, Grupo de Technologia Alternativa (Alternative Technology Group), in 1978 (Ibid). Since that time, at least 235,000 EcoSan toilets, and possibly many more, have been built in at least 17 Mexican states.

Country Profile 2. EcoSan Summary for Mexico

Construction & Utilization:	
First Toilet Built (Year)	1978
Persons Served	635,000 persons (total), 593.4 persons per 100,000
Toilet Model(s)	UDDT, Solar-heated composting toilet (SIRDO), some prefabricated and some self-constructed
Toilet Utilization	12% in 1991 project, 2003 study reported high user satisfaction at most study sites
Excreta Utilization	Not explicitly stated but seems low, 2003 study says projects often neglected reuse aspect
Geographic Profile:	
Confirmed Locations	1 federal district and 17 of 31 states
Level(s) of Implementation	Households, public, institutional, schools
Human Settlements	Peri-urban and rural
Client Characteristics:	
Attitude Towards Excreta	Not reported
Anal Cleansing Method(s)	Paper
Promotion Efforts:	
Initiator(s)	GTASC
Partners	Government (national, state, local), National Water Commission, REDSECO, ESAC, CITA, MexiSan marketing; UNDP, EcoSanRes, SANDEC, ReSource
Channels & Methods	Demonstration centre, operation & maintenance training, "liquid-gold" microenterprises
Subsidy	Not reported

Few of these many EcoSan projects are documented in detail. Case studies from the 1990s showed utilization rates in pilot projects ranging 10-67% (Peasey, 2000). One small project showed that utilization could increase to 100% when pre-fabricated fibreglass models were offered over toilets made from locally available materials. In terms of excreta reuse, project presentations generally have not reported utilization rates, though one analysis stated that end-product use management was often neglected in EcoSan projects (Cordova & Knuth, 2003). The same analysis reported that user satisfaction with EcoSan toilets was high in most study sites but that "user satisfaction and acceptance of the technology can be increased by improved convenience and aesthetics, operation and end-product management support services, and economic incentives" (Ibid).

Mexico has a diverse set of EcoSan change agencies, including the Mexican National Water Commission, state governments, international funding and technical assistance organizations (e.g., UN agencies, EcoSanRes, SANDEC), non-profit local and international NGOs (e.g., ESAC, CITA headed by Cesar Anorve), marketing agencies, and for-profit NGOs and enterprises. Peasey writes that the interest of governments, NGOs, and commercial companies has grown out of a "slow realism of the disadvantages of conventional excreta management systems" (Peasey, 2000). Some of these organizations have moved very quickly, such as the Oaxaca state government together with a businessman that built 15,000 toilets in 1994, and the GTASC partnership with the Mexican government which reportedly built 1,000 SIRDO composting toilets per month in 2000 (Ibid). Others move more slowly, such as ESAC and CITA. CITA's perspective is that "large scale sanitation programs are doomed to fail from the beginning, since it is difficult to set up large-scale programs to convince populations to assume responsibility for the correct usage of their newly installed dry toilets. Programs must slowly install dry toilets in households keen to adopt this technology" (Ibid). Thus, CITA responds to client requests, rather than engaging in active solicitation. As of 2000, CITA had built 1,337 toilets in 17 states.

One notable project for which more information is available is the Tepoztlán, Morelos project serving a population of 35,000, which began implementation in 2004 (Sawyer, 2007). Promotion of this project has included demonstration toilet centres, capacity building workshops, employing youth promoters and partnering with community groups, participatory methods (PHAST methodology), social marketing, "liquid-gold" (urine-harvesting) microenterprises, and urine-harvesting prototype displays. Users report high satisfaction with the toilets, saying that they are a "logical solution" because they do not smell or use water. People also find urine to be a "natural" and "organic" fertilizer. Yet Sawyer cautions that "dry toilets require a large investment for potential users who may not be totally convinced of the comparative advantages of EcoSan", principally with regards to their convenience and cleanliness (Sawyer et al., 2006).

5.2.3 Uganda

EcoSan toilets were officially introduced in Uganda in 1997 by the Ugandan-led South-Western Towns Water & Sanitation Project (SWT WSP). EcoSan was chosen by the Government of Uganda, funded bilaterally by the Government of Austria, as one technological solution for poor geological conditions, such as collapsing or rocky soils and high water tables (Jackson, 2005). The project covers seven of 56 districts, with most toilets being built in rural growth centres (Victoria, 2007).

Country Profile 3. EcoSan Summary for Uganda

Construction & Utilization:	
First Toilet Built (Year)	1997
Total Persons Served	212,665 persons (total), 790.6 persons per 100,000
Toilet Model(s)	Skyloo (UDDT), compost toilets
Toilet Utilization	Not reported explicitly, re-visited toilets are functioning and copying has occurred, rejection in one shoreline village
Excreta Utilization	Not promoted, only 4 of >500 households in SW project, asking for emptying service
Geographic Profile:	
Confirmed Locations	11 of 80 districts, projected 30 towns by 2009
Level(s) of Implementation	Households, schools, public
Human Settlements	Urban and rural
Client Characteristics:	
Attitude Towards Excreta	Some faecophobic, others with experience planting bananas and trees on used latrine pits
Anal Cleansing Method(s)	Water (prominent) and paper
Promotion Efforts:	
Initiator(s)	Governments of Uganda and Austria
Partners	National Water & Sewerage Corporation, Uganda Fisheries & Fish Conservation Association, local masons; World Bank, IMWM, WASTE Netherlands, ROSA, GTZ
Channels & Methods	Charity walks, village drama, demonstration toilets and gardens
Subsidy	73-90%

Experiences from SWT WSP and seminars with EcoSan experts such as Uno Winblad led the government to establish the EcoSan National Advisory Committee in 2001 and incorporate EcoSan toilets as part of Uganda's national sanitation strategy (Tushabe, Müllegger, & Knapp, 2003). The strategic objectives included capacity building for EcoSan promoters, building private sector capacity for service delivery, and

community sensitization towards excreta reuse. Other EcoSan projects included the Lake Victoria Environmental Management Project (LVEMP) in 1997 (11 Lake Victoria shoreline districts led by the National Water and Sewerage Corporation in partnership with Uganda Fisheries and Fish Conservation Association funded by the World Bank), a 2006-2009 project in Kitgum town in Northern Uganda led by ROSA, and a peri-urban Kampala project implemented by the Kampala City Council and funded by SIDA (Kaggwa et al., 2003; G. Langergraber, 2008; Minze, n.d.).

It is hard to say how successful the projects have been on a national level. Two towns from the SWT WSP were reported to have functioning toilets during inspection visits one year after construction, and excreta reuse was observed, though some also requested a vault-emptying service (Victoria, 2007). In addition, 52 privately financed spontaneous toilet copies have been documented (Jackson, 2005). Another report alluded to slow acceptance and scepticism of clients, as well as the continuation of unfilled pit latrine usage after toilet construction (Nyiraneza & Hoellhuber, 2001). A report from one Lake Victoria site illustrated how a lack of adequate operation and maintenance education and follow-up led to the near failure of a communal EcoSan toilet project due to mixing of excreta with wash water (Kaggwa et al., 2003). The peri-urban project in Kampala, which was prompted by ongoing cholera outbreaks, seems to have enjoyed success, with a small study determining that 82.5% prefer EcoSan toilets to other options, and that users are reusing excreta (Minze, n.d.). Of note however was that only 33% of toilets were observed to be odourless, indicating a need for educational refreshment.

Promotional efforts are listed in the profile table. Reflections on EcoSan promotion presented by the Ministry of Lands, Water, and Environment have highlighted the need to intensify public sensitisation and promotion efforts, use subsidies with caution, ensure adequate monitoring in the first year of operation, and the utility of using local masons as change agents (Tushabe et al., 2003). Of particular note is the fact that the SWT WSP program included an explicit policy statement which said that 100% of citizens would have access to adequate sanitation, with a pit latrine having a cement slab as the minimum requirement (Victoria, 2007).

5.2.4 South Africa

South Africa has taken a pro-active stance on sanitation from the start. The 1996 Bill of Rights (Chapter 2, Section 27.1b) states that access to sufficient food and safe water is a human right. The first EcoSan pilot project, initiated by the Council for Scientific and Industrial Research (CSIR) and funded by the Eastern Cape Appropriate Technology Unit (ECATU) followed soon after in Mthatha (formerly Umtata), Eastern Cape province in 1997 (Holden & Austin, 1999). At this point, the Department of Water Affairs and Forestry (DWAF) from Northern Cape Province and the Mvula Trust (a South African NGO) became involved. Progress past the pilot was delayed because of logistical and financial barriers in importing the five pedestal moulds ordered from Mexico. Permission was later granted for the moulds to be reproduced in South Africa by Cesar Anorve of CITA in Mexico.

Around that same time, a local woman named Maritjie Meyer in Namaqualand, Northern Cape Province saw pictures of Cesar Anorve's bathroom in Mexico and installed a UDDT in her own home, which was part of a brand new social housing unit (Holden et al., 2003). Her influence was sufficient to convince her fellow residents, and later the National Sanitation Operations Manager of the Mvula Trust to follow suit. This urban toilet installation ended up being instrumental in spreading EcoSan in Northern Cape. In 2000, the provincial premier, Manne Dipico, publicly committed to eliminate 25,000 bucket toilets and replace them with flush toilets. UDDTs were seen as second class technology by the premier and other local councillors. To convince the government otherwise, the premier and other officials were invited to behold the success of UDDTs in Namaqualand. The visit was successful, and funds were allocated to promote EcoSan in Northern Cape. Many more politicians and international visitors, as well as television crews, were invited later that year to the house belonging to the operations manager of Mvula Trust in Johannesburg where a UDDT had been installed.

Country Profile 4. EcoSan Summary for South Africa

Construction & Utilization:	
First Toilet Built (Year)	1997
Total Persons Served	200,100 persons (total), 426.6 persons per 100,000
Toilet Model(s)	UDDT
Toilet Utilization	Accepted in Eastern Cape Province, growing dissatisfaction in Northern Cape province, low demand in Kwazulu-Natal
Excreta Utilization	Very limited (not promoted), faeces burned or disposed in fields, urine led to soak-pit
Geographic Profile:	
Confirmed Locations	6 of 9 provinces
Level(s) of Implementation	Mostly households
Human Settlements	Peri-urban and rural
Client Characteristics:	
Attitude Towards Excreta	Faecophobic, recognize value but majority unwilling
Anal Cleansing Method(s)	Paper
Promotion Efforts:	
Initiator(s)	Council for Scientific and Industrial Research
Partners	Mvula Trust (NGO), Department of Water Affairs & Forestry, provincial governments, ECATU
Channels & Methods	Social marketing (safety, security, privacy, quality, etc), television, invitation to provincial premier to attend festival, installation of UDDT in urban government official's home, garden competition
Subsidy	Initially partial, now fully subsidized

In 2001, DWAF published the "White Paper on Basic Household Sanitation", which included EcoSan as a part of South Africa's National Sanitation Programme. The programme initially offered heavy subsidies to poor households lacking on-site water to install dry EcoSan toilets, but now offers fully financed toilets. Furthermore, in Northern Cape municipalities desiring to build waterborne sewerage are denied capital funds from the province unless they can prove that it can be financially sustained. As of 2005, 15,000 of the 25,000 bucket toilets had been converted to UDDTs, and more UDDTs have been built in Northern Cape (Jackson, 2005). Over 50,000 of 155,000 planned units have been built in the Durban municipality of eThekwini in Kwazulu-Natal province, as a preventive strategy for avoiding logistical challenges associated with emptying the 100,000 pit latrines (Duncker, Matsebe, & Moilwa, 2007). EcoSan toilets have also been

built in North West Province, Western Cape Province, Limpopo Province, and Gauteng Province (Ibid).

While EcoSan has enjoyed remarkable popularity among decision-makers, user satisfaction has been less so, with the exception of Eastern Cape (Duncker et al., 2007). In Northern Cape, where toilets were initially accepted because they met expectations of privacy, dignity, safety, convenience, and permanence, users reported dissatisfaction due to frequently blocked urine pipes and the desire to revert to using pit toilets. When people in a neighbourhood near eThekwini were asked about UDDTs, they responded that from what they had seen, they did not desire one in their own home. It seems that dissatisfaction in both cases is linked to design flaws and technical problems.

5.2.5 Mozambique

EcoSan efforts in Mozambique have largely been spearheaded by a partnership between a British NGO named WaterAid, acting on behalf of the Department of Water and Sanitation (DWS), and a local NGO called ESTAMOS. The concept was introduced to two small peri-urban towns in Niassa Province in March 2000, following the SanPlat Ventilated Improved Pit Latrine program delivered by the government that ended prematurely due to a lack of donor funds (dos Santos & Breslin, 2001). Linchinga and Madimba had a high coverage of pit latrines, yet the population was experiencing problems with odour, flies, space constraints, and slab collapse. Despite the fact that the majority of intended beneficiaries practice Islam, people were more accepting than expected of the reuse concepts of EcoSan, largely because they already engaged in agricultural reuse (Ibid).

ESTAMOS employed social marketing techniques and participatory methods, making use of local radio, demonstration latrines, drama and weekend festivals, agricultural demonstration plots, sending village representatives to nearby EcoSan projects, and meetings with chiefs, government leaders, and client representatives. By 2003, the project had spread to other towns in Niassa, and 430 toilets (mostly Fossa Alternas) had been constructed. In the first year, demand rose from zero to 595 formal applications for toilets to the district government (Breslin, 2001), a number that has since

increased to 2,500, helped greatly by fear reduction among neighbours upon seeing excreta from earlier models (Jackson, 2005). It would thus appear that the number of toilets is constrained more by capacity than by demand.

Country Profile 5. EcoSan Summary for Mozambique

Construction & Utilization:	
First Toilet Built (Year)	2000
Persons Served	13,716 persons (total), 70.7 persons per 100,000
Toilet Model(s)	Fossa Alterna, Arborloo (very few)
Toilet Utilization	1 village reported 100%, others not reported
Excreta Utilization	Some find idea "too new", others see good for agriculture, demand increased after first opening
Geographic Profile:	
Confirmed Locations	2 of 10 provinces
Level(s) of Implementation	Households, schools
Human Settlements	Peri-urban and rural
Client Characteristics:	
Attitude Towards Excreta	Initially faecophobic, though some planted on old pits
Anal Cleansing Method(s)	Water (prominent) and paper
Promotion Efforts:	
Initiator(s)	DWS & WaterAid
Partners	Government (national, provincial, municipal), ESTAMOS; Austrian Development Cooperation, Italian Development Cooperation, UNICEF, Red Cross, Rotary Club
Channels & Methods	Radio, demonstration toilets (opinion leaders) and gardens, community visits, festival weekends
Subsidy	Materials (plastic, cement, bricks)

The other location where EcoSan has been observed is the Programme for rural Water Supply and Sanitation in Sofala province. This project, funded by the Austrian Development Cooperation and executed by the DWS and the Provincial Directorate for Public Works and Cooperation, began construction of 245 household, five primary school, ten public, and two rural health post squatting Skyloos (UDDTs) in 2001 (Fogde & GTZ EcoSan Team, 2007). The project was conceived in response to a sanitation crisis among a population of 4,000 displaced by floods in 2000. A unique approach of this project is the use of local agricultural extension workers in supervising excreta reuse. Local artisans were also trained in construction. Other projects reported in Sofala

included efforts by the Red Cross, Rotary Club, UNICEF, and the Italian Development Cooperation.

The Niassa project conducted a thorough evaluation of EcoSan acceptability, practices, and safety of the biosolids in 2002 (Van der Meulen, Moe, & Breslin, 2003). Interestingly, they found that 41% of recipients did not choose their own latrine design. Authors speculate that the choice in these cases was made by the chief or village leader. Of those who did choose their latrines, attractiveness (19%) and design (17%) were the most commonly cited reasons, with health (5.7%) and fertilizer (1.4%) ranking much lower. Only 18% reported they would have built a toilet without assistance (advice and material). Ninety-eight percent of users and 80% of neighbours expressed satisfaction with EcoSan. Eleven percent of users thought the pits would fill up too quickly. Regarding hygiene and sanitization, 83% of users reported using ash and soil after defecation, and 91% of toilets had handwashing stations with evidence of use. The physical parameters of the biosolids, however, revealed mean temperatures and pH values that were too low and moisture content that was too high, which led authors to suggest longer storage times.

5.2.6 Nepal

Nepal has a long history of night soil utilization. Modern EcoSan however was introduced via a Nepalese research-based NGO (Environmental and Public Health Organization, ENPHO), which learned about EcoSan from a SIDA training course in 2001. ENPHO organized an EcoSan talk for water sector stakeholders in January 2002 (Mandahar, Shrestha, Schlick, Räth, & Werner, 2006), after which EcoSan became part of the National Sanitation Campaign (motivated by health and hygiene concerns), which had previously set a goal of constructing 80,000 new permanent (i.e. flush) toilets (Lamichhane, 2007).

The Department of Water Supply and Sewerage (DWSS) and a private company organized a pilot in Siddhipur (peri-urban Kathmandu), and installed ten UDDTs in households of varying socioeconomic status (Tuladhar et al., 2008). Around the same time, ENPHO, funded by WaterAid, conducted a pilot in a neighbouring peri-urban

settlement named Khokana. Considerable effort was made to promote EcoSan to decision-makers, with the installation of a UDDT by an ENPHO member in his modern urban home, and the organization of demonstration tours and educational sessions for policymakers and NGO officials (Shrestha, Shrestha, Paudel, Shrestha, & Manandhar, 2005). These preliminary experiences led to a multiplication of EcoSan construction projects, with partners from UN agencies, Practical Action Nepal, the Red Cross, and other Nepalese local NGOs (LUMINATI, CIUD, NEWAH, SOPHEN). Between 2002 and 2006, 517 EcoSan toilets in total were constructed, of which 487 were in operation (Tuladhar et al., 2008). Ninety-three percent of these are located in Kathmandu valley, Bagmati zone, while the other 7% are in the zones of Bheri, Gandaki, Kosi, Lumbini, and Narayani. The projects did not report their community promotion efforts in detail, though the use of small subsidies is documented (Rajbahandari, 2008).

Country Profile 6. EcoSan Summary for Nepal

Construction & Utilization:	
First Toilet Built (Year)	2002
Persons Served	3,602 persons (total), 14.2 persons per 100,000
Toilet Model(s)	UDDT
Toilet Utilization	94%
Excreta Utilization	High faeces usage, 37% use urine correctly
Geographic Profile:	
Confirmed Locations	6 of 14 zones (93% in Kathmandu valley, Bagmati zone)
Level(s) of Implementation	Households
Human Settlements	Majority peri-urban
Client Characteristics:	
Attitude Towards Excreta	87% without EcoSan toilet say valuable as fertilizer, mix urine with compost because accustomed to solid fertilizer
Anal Cleansing Method(s)	Water
Promotion Efforts:	
Initiator(s)	DWSS and D-Net; ENPHO and WaterAid
Partners	LUMINATI, CIUD, NEWAH, SOPHEN, UN agencies, Practical Action Nepal, Red Cross, Plan, WHO
Channels & Methods	Demo tours and education for policymakers and NGOs, community demonstrations
Subsidy	Yes

WaterAid Nepal conducted a study on the perspectives and practices of EcoSan users and their neighbours (Tuladhar et al., 2008). EcoSan was overwhelmingly popular with survey respondents: 98% of respondents without an EcoSan toilet felt positively about their neighbours' toilets, and only 1% of users reported dissatisfaction. In stark contrast to many other countries, the top cited reason for desiring a UDDT was fertilizer (86%), followed by simply desiring a toilet (72%). Thirty-five percent and 23% also cited water conservation and environmental protection, respectively. Permanency was also mentioned. It appears that fertilizer has great economic value among survey respondents. This was determined to be slightly detrimental to EcoSan diffusion in non-agricultural areas, since many lacked agricultural fields. Like China, the major concern of EcoSan promoters was not encouraging reuse, but rather convincing users to store excreta for the appropriate time before use. Only 18% of respondents stored faeces from the vaults for more than 4 months, though 54% did report letting faeces dry in the sun prior to application as a soil conditioner.

5.2.7 India

The first recorded EcoSan project was a toilet demonstration centre in the Ladakhi Himalayan community of Leh in 1986 (Panesar, Schlick, Räth, & Werner, 2006). The purpose of the project was to raise awareness of the sustainability of traditional sanitation practice. This effort is not considered the starting point of EcoSan in India for the purposes of this project because the community is very culturally distinct and geographically isolated, and the project was intended only for the Leh community.

Thus, a community-organized compost toilet pilot in Pulluvila, Punalur in 1995 is considered the starting point for EcoSan in India (Calvert, 2003). Prior to the project, the women in the village planned and built a community latrine, laying out clear responsibilities and user fees, to address the shame of open defecation. Due to a high water table, the latrine failed. Paul Calvert of EcoSolutions listened to the women's concerns and organized workshops to choose a suitable technology and modify it to their needs. Calvert started with seven toilets to allow the women to see the transformed excreta after a year had passed. The desired reaction was achieved (an example of the importance of observability), and the women organized a Hygiene Awareness Team to

teach hygiene and promote EcoSan through street dramas. As of 2003, 250 toilets had been built.

Country Profile 7. EcoSan Summary for India

Construction & Utilization:	
First Toilet Built (Year)	1995
Persons Served	5,850 persons (total), 0.53 persons per 100,000
Toilet Model(s)	UDDT, compost toilets
Toilet Utilization	Not reported
Excreta Utilization	Not reported for households, examples of collection and institutional reuse, some projects use faeces for biogas
Geographic Profile:	
Number of Locations	7 of 28 states, 1 of 7 union territories
Level(s)of Implementation	Households, communal, school, institutional
Human Settlements	Town and rural
Client Characteristics:	
Attitude Towards Excreta	Cultural taboo against urine reuse
Anal Cleansing Method(s)	Water
Promotion Efforts:	
Initiator(s)	Paul Calvert (EcoSolutions)
Partners	SCOPE Trichy, Mythri, EcoSan Services Foundation, Navsarjan Trust, Indian Water Works Association; UNICEF, UNDP, SIDA, WASTE Netherlands, BORDA Germany, GTZ, Seecon Switzerland, EcoSanRes, ACTS, UMB Norway
Channels & Methods	Community and official visits to EcoSan sites, peer education
Subsidy	Not reported

More efforts followed. Soon after a communal toilet project in Bangalore by ACTS-Ministries and Seecon (Heeb & Gnanakan, 2003; Werner & Rüd, 2007), Calvert conducted an Ecological Sanitation Awareness Raising tour across ten states to introduce the concept of eco-towns, cities, and villages to more than 400 senior government officials (Calvert, 2003). In 2004, the Innovative Ecological Sanitation Network of India (IESNI), a network of many of the EcoSan partners listed above, was founded. As of 2006, the IESNI had plans for larger-scale projects, however they had not yet been carried out. Thus on a household construction level, besides rather small projects or projects in institutions (Singh, 2003), the most concentrated efforts to bring EcoSan to the

underserved have occurred in Tamil Nadu, led by an Indian NGO called SCOPE Trichy (SCOPE, 2009). SCOPE has constructed over 1,000 UDDTs and compost toilets, including 138 household toilets in Sevanthilingapuram, the first eco-village in India. Later projects drew upon cross-visits to earlier project sites to demonstrate the effectiveness of EcoSan, both to prospective communities and to NGO delegates and government officials. In addition to holding training workshops, SCOPE has employed some unique promotional tools, such as a toilet beauty contest in the Tsunami-affected village of Kameshwaram.

5.3 Comparative Analysis

Countries were compared according to all theoretical constructs in Diffusion of Innovations Theory. While details of project experiences are stated in Section 5.2, not every promotional method and change agent identity is described in detail in this section. Rather this section summarizes overall country experiences, giving particular attention to early pilot projects, and highlights the emergence of important themes through noting remarkable similarities and differences, according to the theoretical constructs. It should be noted that this analysis is limited by the availability of data. Every effort was made to trace the diffusion trail in each country by seeking as many project reports as were available, although one must be aware that some perceptions and communication channels may not have been reported. Table 2 on the next page contains a concise summary of the observations noted in the forthcoming narrative.

Table 2. Comparison of user perceptions, promotional efforts, and decision processes by country

Constructs	China	Mexico	Uganda	South Africa	Mozambique	Nepal	India
Perceived Advantages:							
1. Status	-	-	-	Y	Y	-	-
2. Privacy	-	-	-	Y	-	-	Y
3. Convenience	Y	-	Y	Y	Y	-	Y
4. Permanence	-	-	Y	Y	Y	-	-
5. Hygienic	Y	-	Y	-	Y	-	Y
6. Odourless	Y	-	-	Y	Y	-	-
7. No insects	Y	-	-	-	Y	-	-
8. Agricultural benefit	-	-	Y	-	Y	Y	-
9. Safety/security	Y	-	-	Y	Y	-	Y
10. More affordable	Y	-	Y	-	-	-	-
11. Environment/water use	Y	-	-	-	-	Y	-
12. Economic benefit	-	-	-		Y	Y	-
Perceived Disadvantages:							
1. Blockage of urine pipes	Y	Y	-	Y	-	-	-
2. Breaking traditions	N	-	-	-	-	-	-
3. Low status	-	-	-	-	-	-	-
4. Requires extra work	N	Y	-	-	-	-	-
Compatibility:							
Previously reused excreta	Y	N	Y	N	Y	Y	N
Anal cleansing with water	N	N	Y	N	Y	Y	Y
Complexity: Easy to manage/understand	N	-	N	-	Y	-	-
Observability: Demand increase after first year	-	-	-	-	Y	-	Y
Trialability: Can try first in another location	Y	Y	Y	-	Y	Y	Y
Communication Channels:							
Mass media	Y	-	Y	Y	Y	-	-
Interpersonal	Y	Y	Y	Y	Y	-	-
Change Agents:							
National actors involved in first pilot	Y	Y	Y	Y	Y	Y	N
Federal government involved in first pilot	Y	N	Y	Y	Y	Y	N
Federal government involved since first pilot	Y	Y	Y	Y	Y	Y	N
National NGOs involved	-	Y	-	Y	Y	Y	Y
International NGOs involved	Y	N	Y	-	Y	Y	Y
Entrepreneurs/for-profit sector involved	Y	Y	-	Y	-	-	-
Use of local/peer promoters	-	-	Y	-	Y	-	Y
Decision Process:							
EcoSan part of national sanitation strategy	Y	N	Y	Y	-	Y	N
Most beneficiaries choose model preference	N	Y	N	N	Y	N	-
Individuals/groups submit applications for toilets	Y	Y	-	-	Y	-	-

Y denotes countries where reported; *N* denotes countries where opposite was reported; -- denotes countries where no mention was made

5.3.1 Perceived Attributes of EcoSan

Nearly every EcoSan project report (with the exception of reports on Mexican experiences) has demonstrated the importance of how intended beneficiaries perceive EcoSan toilets (particularly reuse of human excreta). Findings by country according to the five perceived attributes in the Diffusion of Innovations framework are summarized in Table 2.

In terms of perceived *relative advantages* of EcoSan, intended beneficiaries in case study countries responded similarly when asked why they chose or preferred their toilet to other options. EcoSan toilets were often status conferring, evidenced by responses such as "modern", "attractive", or "urban". Also in agreement with the literature was the common response of the toilets being private and convenient. Permanence was a major theme among responses, as well as cleanliness, the absence of odour and flies, and lower maintenance costs. Less common, with the notable exceptions of Nepal and Mozambique, were the benefits of having fertilizer to use or sell, and the positive influence of EcoSan on health.

EcoSan toilets require acceptance of not only the technology but also associated practices, which if not properly explained are not easy to understand. Thus, *complexity* is high in the absence of adequate education and training. Indeed, follow-up monitoring increased utilization in areas where urine treatment was not well understood. Due to lack of availability of data regarding proper sanitization practices (with the exception of Mozambique and Nepal), it is difficult to say how important this attribute is on a country-level.

Issues in *compatibility* included whether people are faecophobic, preference for squatting or sitting while using the toilet, and taking anal cleansing with water into account. In terms of the latter two issues, these are easily rectified by proper design, and hence are more important on a pilot project level. Regarding attitudes towards excreta, one might attribute China's success to the fact that people are traditionally faecophilic. However, this does not explain the user acceptability of EcoSan in places like Mozambique, but only whether the concept is accepted before or after intended

beneficiaries see the transformed excreta. In Mozambique and India, concerns about handling human excreta diminished rapidly in certain projects when intended beneficiaries saw the transformed faeces for themselves. In contrast, reuse has not increased greatly in South Africa. Thus, it is possible for *observability* to overcome compatibility issues in handling of excreta, though further study would be required to understand why this is not always the case. Concerning *trialability*, people generally have the opportunity to try toilets in demonstration centres or households. It is much more difficult for intended beneficiaries to try a personal model on a limited basis, however, since EcoSan toilets require up-front investment. This is the same across all countries.

Here, a return to the construct of relative advantage is necessary. Relative advantages in the eyes of EcoSan implementing agencies (which often included federal governments) were very different from those perceived by users and intended beneficiaries. Intended beneficiaries often adopted EcoSan toilets for reasons other than health, as mentioned above. This is consistent with observations by EcoSan project implementers and researchers (see Holden, 2001; Wegelin-Schuringa, 2000). Contrastingly, it was observed that governments in those countries with national sanitation policies that include EcoSan (China, Uganda, South Africa, and Nepal) are motivated by the need to provide adequate sanitation in order to improve health. Their specific cues to action vary. According to Jurga and colleagues (2005), China adopted EcoSan to meet rural improvement targets. Uganda adopted EcoSan as a sanitation solution for areas with poor geological conditions, such as rocky soils or high water tables (Jackson, 2005). South Africa turned to EcoSan as a low-cost solution to avoid future costs incurred through emptying pit latrines, a service provided by the government free of charge (Ibid). Nepal's National Sanitation Campaign grew out of governmental concerns over health and hygiene (Lamichhane, 2007). The implication is that EcoSan must be packaged differently in policy advocacy than in community promotion.

5.3.2 Social System

According to the World Bank country classification system, Mozambique, Nepal, and Uganda are low-income economies, China and India are lower-middle-income economies, and Mexico and South Africa are upper-middle-income economies. The 2008 Human Development Report shows that with the exception of India with a Gini coefficient of 36.8, all other countries have a Gini of at least 45, with the highest being 57.8 in South Africa. There does not appear to be a trend between Gini coefficient and the extent of EcoSan diffusion, though it is notable that Mozambique and Nepal trail in construction and are both low-income economies.

Socially speaking, countries differ in other ways than wealth distribution. For example, some areas of a country might have practiced open defecation before EcoSan introduction, while others in the same country had pit latrines. Given the unavailability of data, this and other social norms could not be compared on a country-level. One variable of interest that can be compared is the prevalence of anal cleansing with water (refer to Table 2). While it is possible that anal cleansing with water is practiced in all case study countries, it was recorded as a major practice in the reviewed project reports for Uganda, Mozambique, Nepal, and India (being nearly universal in the latter two countries). There does not appear to be a relationship at the country-level between EcoSan diffusion and anal cleansing with water, though collectively the reports show that it is important at the project-level if toilets are not tailored to take anal cleansing into account.

5.3.3 Promotion & Process

5.3.3.1 Communication Channels

Mass media promotion of EcoSan, either via television or radio, was reported in China, Uganda, South Africa, and Mozambique. It is unclear whether mass media was used in Mexico, though likely since social marketing has been documented. Interpersonal channels, via face-to-face sensitization and education, were reported in every country. Cosmopolite channels were also used in every country, as change agents were always external to client communities, with the exception of one community in South Africa that had a local champion who saw pictures of EcoSan from Mexico. Client visitation to

demonstration toilets, sometimes within project communities or in a neighbouring community, was also reported in every country. Visitation to demonstration toilets by government and NGO workers was also reported, though only in South Africa, Nepal, and India. Both South Africa and Nepal had a case of an EcoSan toilet being built in a modern urban home belonging to a member of the change agency. Notable cases of localite channels were the use of masons as change agents and peer agricultural extension workers as excreta reuse supervisors in Uganda. Chiefs were also instrumental in Mozambique for persuading neighbouring communities to try EcoSan (Breslin, 2001).

5.3.3.2 Change Agents

How the information source of an innovation is perceived and what capacity that agency has to implement or convince others to implement that innovation can be very important to the adoption or rejection of an innovation itself by intended beneficiaries. Furthermore, change agents vary in their geographical coverage and spheres of influence. As EcoSan toilets were subsidized in every case study examined, the identity of the change agent also affects what kind of a subsidy can be offered. In general, change agents can be from the country or from outside the country where EcoSan is promoted, belong to a government department or ministry, or belong to a national or international non-governmental organization.

In-Country versus International Agents

Any innovation can be introduced by a person inside the system (in this case the country) or outside the system. The terms used here are in-country and international actors, respectively. In-country actors may be local community members, representatives of national NGOs, or in-country government officials. International actors range from representatives of international NGOs to government officials from other countries. In all case study countries except for India, EcoSan was initiated by in-country actors, which may or may not have been partnered with international actors. According to the information available, in-country actors were the primary stakeholder in the first documented pilot projects in China, Uganda, Mexico, South Africa, Mozambique, and Nepal. In Uganda, the first project was a collaboration with the government of Austria,

and in Mozambique with a British NGO called WaterAid. China's early projects were funded by SIDA and UNICEF. In India, in contrast to the other countries, the 1995 pilot was conceived and implemented by Paul Calvert of EcoSolutions. In every country, international partners became involved soon after, most significantly as funding agencies.

Government as Agents

Governments of all levels, from federal to municipal, are involved in EcoSan in all the case study countries. Their role as change agents can consist of simply requesting proposals and providing funding for EcoSan projects, all the way to funding and sending government-employed promoters into intervention communities. Of note are the countries in which the federal government (at least in large part) initiated the first EcoSan projects, namely China, Uganda, and South Africa. Federal governments incorporated EcoSan into national sanitation policies or programs in China, Uganda, South Africa, and Nepal. In Mozambique, where the government became involved upon the advice of WaterAid, a demand-driven sanitation approach was adopted by Niassa province, and the districts respond to applications for EcoSan toilets. Local and state governments in Mexico have been behind the projects where large numbers of EcoSan toilets have been built at one time. Though India recorded great efforts to involve government officials, government as a primary change agent was not observed in the body of reports available.

China however was unique in its government involvement. A major national political party (Jui San Society) placed EcoSan on the national agenda. The first implementing agencies were the Chinese Ministry of Health from the federal government, and the Guanxi Public Health Campaign Committee from the provincial government. It seems that, with the exception of funding from UNICEF and SIDA, there was very little initial involvement of NGOs until later in the diffusion process, and even then, not to the same degree as many other countries globally.

Non-Governmental Organizations as Agents

Non-governmental organizations can be for-profit or non-profit. When NGOs act as change agents, they are generally involved in ground-level promotion and implementation of EcoSan projects. Sometimes, especially in the case of international

NGOs, they can act in an advising capacity to government or other NGOs, as is the case with WaterAid in Nepal.

NGOs initiated the first EcoSan pilots in Mexico and Nepal. The two organizations are quite different. The GTASC in Mexico was a for-profit organization. In Nepal, the organization was a non-profit organization that immediately sought government support after attending an EcoSan workshop in Sweden.

Following the initial pilot, NGOs continued to be instrumental in EcoSan implementation in all countries. Five countries (Uganda, Mozambique, Nepal, India, and China to a lesser extent) have multiple NGOs working around the country. In South Africa the Mvula Trust seems to be the most dominant NGO in EcoSan initiatives. Mexico, which seems to be the most entrepreneurial (for example, Oaxaca state partnered with a businessman), is the only country to report the use of a marketing organization for promotion (Sawyer, 2007).

5.3.3.3 Innovation-Decision Level and Process

In China, Uganda, South Africa, and Nepal, governments took ownership of EcoSan efforts early during diffusion. The political decision-makers selected UDDTs as their primary promotional model, and proceeded to sell the UDDT idea to people in target areas, meaning model choice is authoritative, and the decision to participate is optional. The exception is a project implemented by Plan in Shaanxi province in China, which involved participation by intended beneficiaries in model selection (Kumar, 2008).

Decision-making has been much more individualized in Mozambique. ESTAMOS, on behalf of the federal government and under the direction of WaterAid, has openly promoted three toilet models, two of which are composting toilets (the Arborloo and the Fossa Alterna) and the other a UDDT (the Skyloo). The Fossa Alterna is the overwhelming model of choice. The Arborloo was rejected because it is a temporary toilet, and users fear running out of space for future toilets (Jackson, 2005). It is unclear why the Skyloo lags in popularity behind the Fossa Alterna. What is most notable about Mozambique is its demand-driven sanitation policy, where clients must submit formal applications to district offices for subsidies for toilet construction (Breslin,

2001). Perhaps due to a lack of adequate resources, construction has fallen behind the burgeoning demand.

Though government has not been a key player in India, due to the communal nature of many of the planned EcoSan projects, model choice has been decided upon by the planning network of organizations. In household level projects, it is unclear at what level model choice took place.

Mexico appears to have decentralized sanitation to the local and state levels, though there is record of involvement by the National Water Commission. Nevertheless, with Mexico's diverse set of stakeholders and apparent state leadership in sanitation, one cannot label the innovation-decision process on a nation-wide scale. It is not clear whether construction sites, such as in Oaxaca state and Tepoztlán, leave model choice to beneficiaries or to the implementing agencies. In the regions served by CITA, a non-profit NGO, individuals decide on their toilet model, as CITA's approach is demand-responsive.

In summary, the cases of China, Uganda, and South Africa clearly demonstrate the importance of political commitment in toilet construction. It is expected that Nepal, given more time, will mirror experiences in these three countries, as its decision pathway has been similar, though current toilet construction has been largely concentrated in the Kathmandu valley. In Mozambique, diffusion has been slower. As construction has fallen behind demand, the presence of an implementing agency with sufficient funds and capacity to meet demand becomes critical. These case studies also show that the reach of decision-making bodies affects the speed of EcoSan diffusion. In China, Uganda, and South Africa, federal governments are the main promoters of EcoSan. This is not the case in Mexico and India, where there has been little or no recorded federal involvement, respectively. In Mexico EcoSan is mostly promoted by partnerships between local and state governments and private (non-profit and for-profit) stakeholders. In India, the stakeholders are primarily national and international NGOs. Diffusion in India has been negligible but wider in Mexico, where EcoSan has a 31-year history.

6: DISCUSSION

6.1 Understanding EcoSan Diffusion

Through comparative analysis of key Diffusion of Innovations constructs, it would seem that initial scale-up largely depends on having a strong change agent with the decision-making power and capacity to fund and handle logistical demand for EcoSan toilet construction. Intended beneficiaries are most often made aware through cosmopolite communication channels, and mass media was used in the leading countries (China, Uganda, South Africa, and possibly Mexico). Decisions made by intended beneficiaries are affected most by perceived relative advantage over other sanitation options, and observability of transformed excreta, especially in faecophobic communities. With regards to EcoSan in particular, grassroots strategies, such as projects in Mozambique using participatory methodology, demonstrate the importance of user acceptance in ensuring high community-level toilet utilization and excreta reuse. And yet, this analysis has clearly demonstrated that toilet construction tends to progress at a faster rate when governments adopt the toilets as a sanitation strategy. This might convey that user acceptance is not important. Yet the author suggests that the reason construction depends on government involvement is the fact that sanitation is a system with considerable capital costs (especially for waterborne sewerage). The author also suggests, based on recent observations of discontinuance and low utilization in certain areas of China and South Africa where a top-down approach to EcoSan promotion has been practiced, that scale-up cannot proceed indefinitely, and that user acceptance is key to sustaining the diffusion of EcoSan until it becomes the normative choice in toilet design.

6.1.1 Parallel Decision-Making

Theoretically, it is helpful to visualize EcoSan scale-up as the exchange between two non-mutually exclusive parallel processes, referred by Diffusion of Innovations theory as individual and organizational innovation-decisions. The case studies suggest

that diffusion beyond pilot villages depends on both the acceptability of EcoSan to intended beneficiaries as well as the support from whatever entity within a region of a country has both the capacity and the authority to make EcoSan toilets available on a larger-scale. To grasp the interplay between individual and political sanitation decisions, the following model is proposed. The model is illustrated in Figure 3. Terms are defined in the glossary.

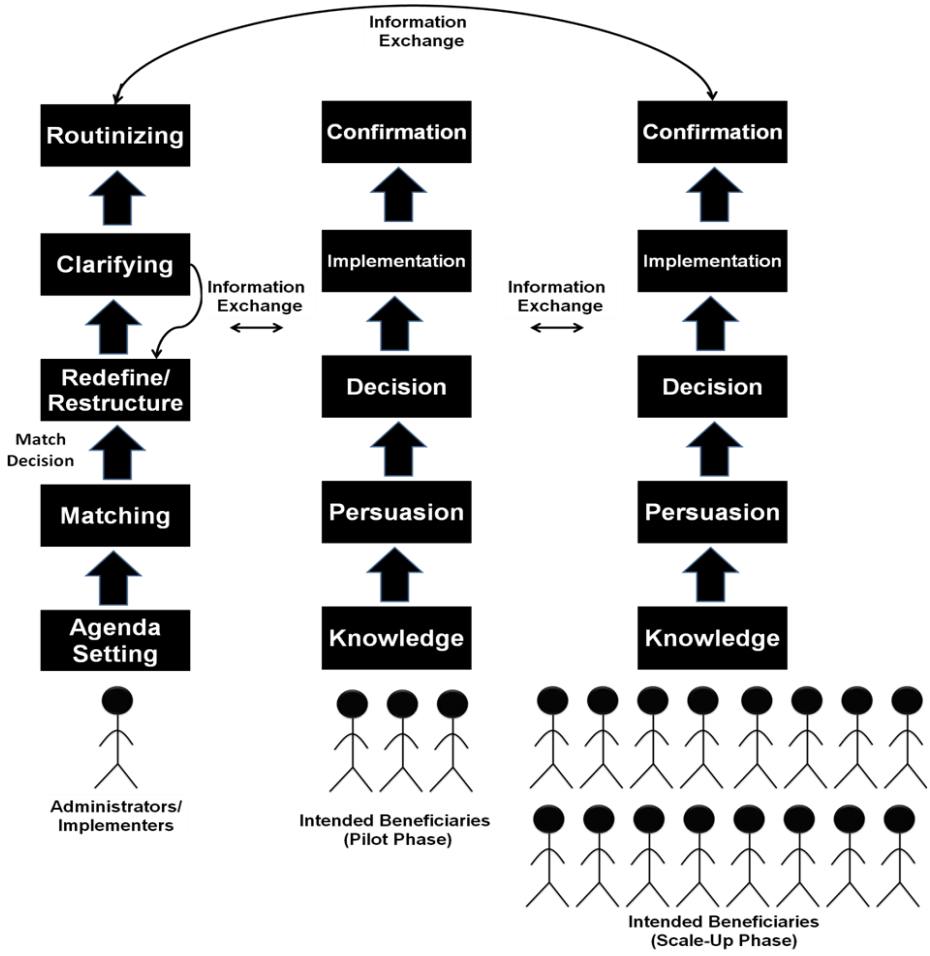

Figure 3. Parallel Decision Model

In this model, the decisions of administrative bodies and implementing organizations (which include government and NGOs) and intended beneficiaries overlap and interact. When a decision is made by administrators, the intended beneficiaries can cooperate (adopt) or not cooperate (reject) the decision. The decisions of the intended

beneficiaries shape decisions made by the administration about which technology to promote through partnership, demonstration, expressing model preferences, or outright rejection.

The organizational innovation-decision process (agenda-setting, matching, redefining and restructuring, clarifying, and routinizing) may or may not include intended beneficiaries in prioritizing sanitation as a problem (agenda-setting) and identifying EcoSan as a potential solution (matching), however intended beneficiaries always have influence after the match decision (the administrative decision to implement EcoSan) is made. Intended beneficiaries help administrators see what modifications need to be made to toilet design (redefining), require time to decide whether or not the toilets are acceptable by the majority of the beneficiaries (clarifying), and depending on their toilet utilization, show administrators whether EcoSan toilets should be scaled up even further (routinization). The model also depicts knowledge exchange between small projects and larger projects over time, demonstrating the increasing interconnectedness of decisions and ripple effects of experiences in past projects on current and future decisions.

6.1.2 Illustrating Parallel Decision Pathways in the Case Studies

Every country is unique in its parallel decision pathway. However, certain inferences can be made upon comparing countries by whether match decisions are driven by demand by intended beneficiaries, or whether acceptance by intended beneficiaries is driven by the administrative decision.

Federal governments first chose EcoSan toilets in China, Uganda, and South Africa, all of which are global leaders in absolute numbers served by EcoSan. In all these countries, UDDTs were selected (in most project locations) by the administration and promoted as the single EcoSan option, sometimes alongside pit latrines. China differs from Uganda and South Africa in two primary ways. First, people in China are generally not faecophobic. Secondly, instead of offering EcoSan on an individual basis, change agencies marketed EcoSan and solicited village-level applications for construction projects (collective decision). Another unique feature about China is that EcoSan was put on the national agenda by a political party, rather than an aid agency (Uganda) or a

provincial government department (South Africa). While the absolute number of toilets constructed is high in all three countries, large projects in China and South Africa have encountered low toilet utilization by community members, often due to blockage of urine pipes. Interestingly, the governments of Uganda and South Africa both chose UDDTs solely as a sanitation, and not a food security strategy, and hence promotion did not focus on excreta reuse. As such, it is not a surprise that reuse is uncommon in these countries, though more common in Uganda as the concept of reuse is not completely new as it is in South Africa.

Nepal has followed the pattern of China, Uganda, and South Africa. Two features distinguish Nepal, however. First is that the administration has largely focused on one geographic area (as in the case of Tanzania which was not featured in this project). Second, member acceptance, as evidenced by toilet and excreta utilization, is remarkably high. As EcoSan is quite new, there has not yet been a chance for diffusion of EcoSan on a larger scale. Time may be the restraining factor, though one must also consider what effect focusing on peri-urban rather than rural areas might have in terms of space and how that relates to speed of construction.

Though a federal department was involved in EcoSan from the start in Mozambique, the demand-driven approach has made decision-making less top-down than the previous four cases. Pilot projects were carried out by a local NGO acting on behalf of the government, which was advised by the international NGO, WaterAid. User acceptance was very high and demand soared. Despite government support and high user acceptance, diffusion has been much slower. Diffusion has likely been constrained by construction capacity, though it is unknown for sure what factor is behind the capacity issues (e.g., funds, hierarchical structure, human resources, etc).

The last two cases, India and Mexico, have more fragmented EcoSan administrative bodies. In India, where diffusion has been limited, EcoSan is primarily administered by a network of NGOs and donors. Some initial pilots included intended beneficiaries in the planning stages, however given the fact that many upcoming projects are planned for institutions rather than households, community involvement has not been significant to this point. Possible reasons for the limited scale-up are cultural taboos

against urine, the presence of so many change agencies with different funding sources and no single overseeing body (i.e. government), and low member involvement in the restructuring and redefining decision process.

In Mexico, which is one of the top countries in terms of number of people served by EcoSan, the burden of sanitation seems to have fallen to a mixture of stakeholders (NGOs, private enterprises, and government), with government players being mostly at the state and local levels. Without data reporting on user acceptance, it is difficult to know how diffusion has been affected by decisions of intended beneficiaries. When considering Mexico as a whole, one might conclude that it is in its clarifying stage of the decision process, though EcoSan has been routinized in certain hot spots. A lack of administrative linkages between states helps to explain why Mexico has not rapidly progressed towards regional saturation as has been seen in China, Uganda, and South Africa.

6.2 Limitations

The primary constraint of this analysis is the unavailability of complete, universal, up-to-date project reports. The majority of reports analyzed were published in or before 2005, and were not consistent as to which indicators were reported. Secondly, the choice of number of persons served by EcoSan toilets as an indicator, while a better indicator than number of toilets (since some reports do not specify if toilets are household or communal toilets), is prone to numeric inflation in cases where EcoSan toilets were used to meet a temporary need, such as a community festival or religious pilgrimage. A third limitation is that the fact that a toilet has been constructed does not mean it is being used. The toilet may not be accepted by its intended beneficiaries, and even if the toilet is used, it does not mean excreta are being re-used. Finally, using countries as units of analysis does not capture the heterogeneity of populations within countries, as they relate to sanitation practices.

6.3 Conclusions

Scaling-up EcoSan toilet adoption is dependent on parallel innovation-decision making processes, where the decisions of administrators and implementers and intended beneficiaries interact and overlap. Strong, early support from federal decision-making bodies, as seen in China, Uganda, and South Africa, is associated with a faster rate of toilet construction. Where leaders have influenced large-scale construction of EcoSan toilets, toilet utilization is variable, and excreta reuse has depended on local attitudes toward handling excreta, highlighting the need for ongoing attention to user preferences and education for operation and maintenance to normalize EcoSan concepts and practices. Where EcoSan is embraced by users but promoted by a change agent with less capacity to meet demands, diffusion is more limited. Project-level examples of acceptance of excreta reuse in Mozambique and India shows that diffusion is not necessarily linked to whether a society is faecophobic. When change agents do not have decision-making power over a sufficiently large geographic area, as is the case in Mexico and India, diffusion appears to occur much more slowly. In summary, scale-up is aided by the presence of a large administrative body with the capacity to build EcoSan toilets, while community acceptance plays an important role in toilet utilization and the sustainability of the technology after construction is complete.

7: RECOMMENDATIONS FOR RESEARCH & PRACTICE

From this analysis a number of recommendations for future research, as well as lessons for EcoSan project planners may be drawn.

7.1 Research Recommendations

A number of questions regarding EcoSan and scale-up still need to be answered. They include:

- How might EcoSan scale-up be accelerated in countries with low administrative absorptive capacity for increasing toilet demand?
- What toilet subsidization schemes are more likely to spur EcoSan toilet demand?
- What financing mechanisms are most cost-effective for large-scale EcoSan projects?
- How can participatory methods best be incorporated into government-driven EcoSan projects?
- What motivates high adherence to proper excreta sanitization and storage practices by intended beneficiaries?
- What is the most effective and least costly way to monitor toilet utilization and excreta sanitization practices in the first year of follow-up after toilet construction?

7.2 Implications for Practice

7.2.1 Successful EcoSan Promotion Must Aim at Two Levels

EcoSan diffusion depends on both acceptance by intended beneficiaries and administrative capacity and commitment. Observations from case studies show a

tendency for faster construction if efforts are led by large, previously existing entities, where formal structures for accepting and responding to applications for toilets are already in place. The implication is that EcoSan education and promotion must be directed both at intended beneficiaries, as well as organizations or institutions with the ability to support EcoSan on a larger scale. Administrators are more likely to respond to benefits related to health, the cost-savings of EcoSan, and ease of construction. Conversely, intended beneficiaries are more likely to adopt for reasons such as convenience, privacy, and status, though promoters need to be observant and employ culturally-relevant promotional messages. Once administrators are convinced, promotion must not neglect future users, who may discontinue use after toilets are built if their desires are not taken into account.

7.2.2 Disapproving Attitudes about Use of Excreta Not Insurmountable

Socially held faecophobic attitudes towards excreta are not insurmountable barriers to adoption of EcoSan toilets. Ideas of how to circumvent rejection based on handling excreta from case reports include instituting a collection service strategy (Tushabe et al., 2003), or collecting excreta to be transported to biogas plants for energy generation (Werner & Rüd, 2007). The sub-text to this conclusion is that EcoSan toilets may only be accepted as a sanitation solution. This means that in the true sense of ecological sanitation (closing the nutrient loop), countries such as Uganda and South Africa, have not adopted ecological sanitation, but rather the urine-diversion dehydration toilet.

7.2.3 Observability Spurs Demand

Toilet and excreta utilization have varied widely. Administrators must ensure ample time is given by change agents to allow intended beneficiaries to see transformed excreta for themselves and see reuse and maintenance carried out. Projects that progress too quickly are in danger of suffering from low utilization, either because of fears and concerns about operation, maintenance, and reuse, or due to design flaws (such as blocked urine pipes) that go unnoticed until after many toilets have been built. Otherwise,

change agents will encounter enforced negative opinions towards EcoSan that may not be subject to further persuasion.

7.2.4 Follow-Up Can Avoid Discontinuance

Case reports in China, Uganda, and South Africa, as well as in countries not featured in this analysis (such as the Philippines) have all stressed the importance to extend follow-up beyond the construction of the toilets. In this way, design errors (whether technical or social in that they ignore an important compatibility issue), and confusion regarding operational and maintenance practices, can be clarified and reinforced. This has been shown to increase utilization even after initial discontinuance by EcoSan owners (Kaggwa et al., 2003; Victoria, 2007).

7.2.5 Sanitization and Reuse Practices are Largely Not Reported

As a technology aimed at improving public health and food security, it was surprising to find that case reports often do not report on human behaviour (i.e., utilization and sanitization of excreta). Given the risks of handling human excreta that are associated with EcoSan (Austin, 2001), it is imperative for implementing agencies to ensure sanitization practices are effective in local climate conditions, and to regularly monitor the adherence to these practices and the pathogenic profile of excreta. An interim strategy to fulfil this need might include spurring university partnerships to provide human resources through field internships, however in the long-term research should be conducted to develop low-cost, appropriate technologies that can be put into the hands of local communities trained in EcoSan operation and maintenance. While this lesson is not directly related to diffusion of EcoSan, it does relate to the relative advantage perceived by intended beneficiaries. If users are sick more often, others are less likely to adopt. Most of all, promoting toilets without the necessary hygiene behaviours that EcoSan necessitates can make EcoSan an innovation that does more harm than good, which is an innovation one would rather not see diffused. This would be a tragic loss, given the tremendous benefits proper management of EcoSan confers.

APPENDIX

List of Countries with EcoSan Toilets

Afghanistan
Angola
Armenia
Australia
Austria
Benin
Bolivia
Botswana
Brazil
Bulgaria
Burkina Faso
China
Cote D'Ivoire
Denmark
Ecuador
El Salvador
Ethiopia
Finland
Germany
Ghana
Guatamala
Guinea
Guinea Bissau
Haiti
India
Kenya
Kosovo
Kyrgyzstan
Malawi
Mali
Mexico
Mongolia
Morocco
Mozambique
Namibia
Nepal
Netherlands
Niger
Palestine
Peru
Philippines
Romania
Rwanda
South Africa
Sri Lanka
Sweden
Switzerland
Tanzania
Thailand
Togo
Uganda
Ukraine
United States
Uzbekistan
Vietnam
Zambia
Zimbabwe

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