DIFFUSION OF INNOVATION: GIS TECHNOLOGY ADOPTION BY COASTAL GEORGIA ENVIRONMENTAL HEALTH DEPARTMENTS

by

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(Under the Direction of DIANA KING)

ABSTRACT

According to Rogers (2003, p. 11), “Diffusion is the process by which an innovation is communicated through certain channels over a period of time among members of a social system”. The University of Georgia Marine Extension Service embarked on a Clean Water Act 319 (h) grant funded project that involved the inventory and GIS mapping of all relevant septic systems (OSDS) and well heads in proximity of state waters of coastal Georgia. Coastal Health District Environmental Health Managers and Inspectors were trained on a GIS mapping and database process innovation, the OSDS project procedure. Through results of an administered survey and observed behavior, the Diffusion of Innovation was found to be on a late majority level. It is my hope that this study will add to the body of research about Diffusion of Innovation with GIS technology and local governments by identifying attributes of the knowledge attitude and behavior of adoption.

INDEX WORDS: Coastal Georgia, Diffusion of Innovation, Environmental Health, Geographic Information System, Nonpoint Source Pollution, Technology Adoption, Water Quality

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

Background and Setting

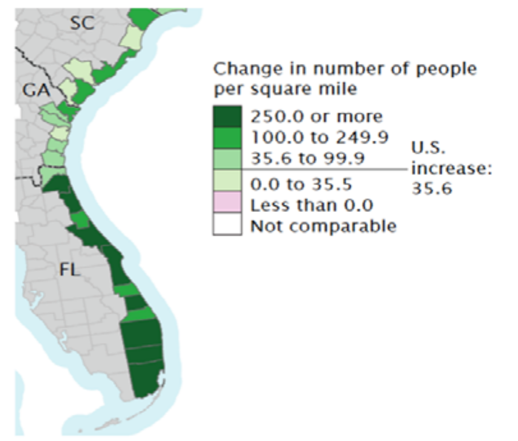

Figure 1.1 Change in Population Density for Coastline Counties 1960 to 2008. Courtesy of the U.S. Census Bureau

The population boom in coastal areas is increasing in magnitude. According to the U.S. Census Bureau in 2011, nearly 100 million people live along the U.S. coast on only 18% of the nation's land mass. The population has more than doubled since 1960 when 47 million people inhabited the coast line (Figure 1.1). Coastal populations are projected to steadily increase and coastal Georgia is not immune to this trend, as this area is one of the fastest growing in the state.

A major challenge for environmental health organizations is the issue of water pollution. Exponential growth in urban areas is changing the water quality throughout the world. The U.S. is in the forefront of this issue. With growth, comes the need to build. Continuing urban sprawl has put land disturbance issues in the forefront. These issues are brought on by population growth, erosion, sedimentation, stormwater runoff and wastewater treatment system failure. Other than population growth, all the other issues have one thing in common. They are types of nonpoint source pollution. "Unlike pollution from industrial plants, nonpoint source pollution is caused by rainfall or snowmelt moving through the ground carrying away natural and human-made pollutants and depositing them into lakes, rivers, wetlands, coastal waters and underground sources such as drinking water" (U.S. EPA, 1994). "Major sources of nonpoint pollution can include storm drain runoff, wildlife, runoff of pesticides, fertilizers, and herbicides from agricultural fields, residential lawns and golf courses, as well as fecal contamination from faulty on-site disposal systems" (Walker, Payne & Cotton, 2003, p. 1).

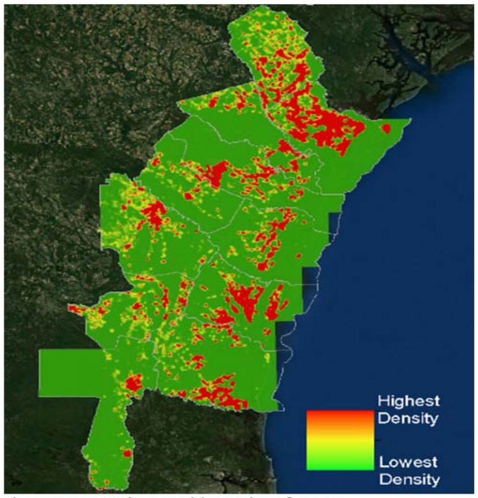

Figure 1.2 Parcel Centroid Density of OSDS.
Courtesy of the Southern Georgia Regional Commission

The approach to tackle these issues in Georgia is mostly done on a regional level per individual watershed. However, these regional strategic plans are not necessarily ideal for managing nonpoint source pollution on Georgia's delicate coastline. All of the watersheds have a hydrological connection to the coast. Therefore, the water pollutants from Atlanta and other piedmont regions potentially end up in one place, downstream, in coastal Georgia. Coastal Georgia's nonpoint source pollution must be managed on a much more stringent level due to this factor.

Most of Georgia's counties have limited public sewage treatment infrastructure and rely heavily on individual septic tank systems or onsite septic disposal systems (OSDS) to handle human sewage production. Figure 1.2 shows the density of septic systems geo-located in coastal Georgia. OSDS refers to an individual septic tank and drain field on a homeowner's property. These systems can be a major threat to water quality, especially along coastal areas if not monitored and maintained. "Concerns have been raised that combined output from densely packed on-site wastewater treatment systems may exceed the natural ability of soils to receive and purify the wastewater before it reaches groundwater or adjacent surface water" (CSREES, 2004, p. 3).

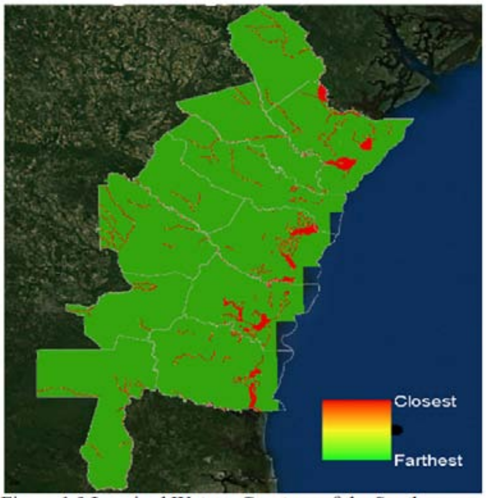

Figure 1.3 Impaired Waters. Courtesy of the Southern Georgia Regional Commission and the Georgia Department of Natural Resource

Fecal contamination of Georgia's coastal waters has periodically increased in recent years. From time to time water bodies are closed due to high levels of bacteria. "Of Georgia's 20 estuarine areas, 19 are closed to shellfish harvesting. Ten of these areas are closed due to fecal contamination from nonpoint sources" (Georgia Department of Natural Resources, 1998, p. 67). This supports a McIntosh County shellfish study conducted by The University of Georgia Marine Extension Service. "Impacts of fecal pollution can result in closure of shellfish growing areas curtailing of oyster and clam harvesting, closure of clam farms, and closure of public swimming beaches" (Walker, Payne & Cotton, 2003, p. 1). Figure 1.3 shows state water bodies in coastal Georgia that periodically have met or exceeded the total maximum daily load of pollutants at time of water sampling.

Development trends are resulting in increased installation of OSDS. Most often municipality officials are reluctant to "hard pipe" a new development for municipal wastewater, due to the possibility of overloading the city/county wastewater treatment infrastructure. In areas where this is an option for the city, in some cases the property owner or developer often cannot afford the hard pipe permit fee. As a result, there is a rapid increase in the number of OSDS installations.

If a homeowner maintenance schedule is not implemented, OSDS have a great potential to become dysfunctional after a short period of time. The threat of dysfunctional OSDS makes it very important to periodically inspect and prevent nonpoint source pollution, particularly in the areas of tidal wetlands, a highly productive biological nursery and ecosystem that is the predominant coastal boundary system. A procedure to adequately track and monitor OSDS is a major priority. However, local public health offices often lack the resources to conduct proper surveys of the soil types in certain portions of the counties to determine if the area can safely support OSDS. With this lack of information, improper systems are sometimes installed. Areas of rural or remote portions of counties within close proximity of state waters where dysfunctional OSDS are prone to occur are real threats to public health. Most counties have outdated paper files on septic systems and have only used the state mandated Garrison Enterprises, Inc. database since 2008. Therefore, no historical septic system data prior to 2008 is found in a computer database that can be geo-referenced.

As a requirement of the NOAA/U.S. EPA mandated Coastal Management and Statewide Nonpoint Source Programs, Georgia must develop a comprehensive Coastal NPS Management Program. The Coastal NPS Program is intended to implement a wide variety of management measures designed to control and prevent nonpoint source pollution from impacting the critical coastal environment. In an effort to lift conditions attached to the 2002 conditional Coastal Nonpoint Source Program approval, a primary partnership was developed between The University of Georgia Marine Extension Service (MAREX), the Coastal Health District and Local Health Departments, the Southern Georgia Regional Commission (SGRC) and the Georgia Environmental Protection Division's Coastal Nonpoint Source Program. The primary step in this initiative was to put a process in place to inspect, geo-locate and inventory all relevant existing OSDS and water wells, where present.

The OSDS Project Procedure Overview

The location of all relevant existing OSDS and wells were recorded with a handheld Global Positioning System (GPS) unit to provide the geo-location within the proximity of marshlands or other waters of the state in the coastal region counties of Bryan, Camden, Chatham, Glynn, Effingham, Liberty, Long and McIntosh. Phase I of this project which includes Bryan, Effingham, Liberty and Long counties has been completed. Phase II, which includes Camden, Chatham, Glynn and McIntosh counties is in mid project. The initiative has produced GIS maps and analysis of the OSDS and wells utilizing the SGRC's geo-referenced WelSTROM database which are all web accessible for better public health planning. The database provides a standardized method of recording all current and future OSDS installations for the eight counties of the Coastal Health District.

MAREX and the SGRC developed the GIS technology process and trained health inspectors from each county, whose duties would be to locate, inspect and provide GPS data on OSDS and well positions. Each office received a Trimble Juno SB GPS unit and a Garmin eTrex (GPS) unit with appropriate training and details on the field work including maps, how to track progress and use the WelSTROM database. The Trimble Juno unit was used to gather historical field data whereas; the Garmin eTrex unit was used to collect geo-location data for incoming or new septic system permits. Each county environmental health office conducted a survey to geo-locate and inspect OSDS and well locations within proximity of marshlands or other state waters in Bryan, Camden, Chatham, Glynn, Effingham, Liberty, Long and McIntosh counties. During each site visit, the inspector would geo-locate the septic system and well head, if present. All geo-located and inspected OSDS were evaluated on whether the area had signs or characteristics that would lead an environmental health professional to conclude that the site could potentially lead to a dysfunctional system.

Data Collection Procedure

Each county was provided an individualized strategy on how to best accomplish their field work. Each county was given maps detailing areas of concern from high pollution susceptibility areas to low susceptibility areas. This was used so that each county could plan their mapping routes accordingly. A media campaign was set in motion by MAREX prior to field data collection activities to bring about public awareness. The media campaign consisted of a press release, county commissioners meetings, a TV public service announcement and door hanger canvassing.

Figure 1.4 OSDS Data Collection in Liberty County. Courtesy of the Southern Georgia Regional Commission

During each county survey, the collected GPS positions were transferred from the Trimble Juno SB handheld GPS unit to a county health department computer equipped with the Trimble GPS software interface. On a monthly basis, the GPS data coordinates were sent via email from the county environmental health department to the SGRC. Once the data was cleared for accuracy, the data was then uploaded into the WelSTROM tracking website and database (Figure 1.4). At this stage, permit information is linked from the state mandated Garrison Enterprises, Inc. database to the coordinates taken by each county. Even after project funding expires, each county will maintain access to the WelSTROM septic and well database/map website and project map database website.

Project Outcome

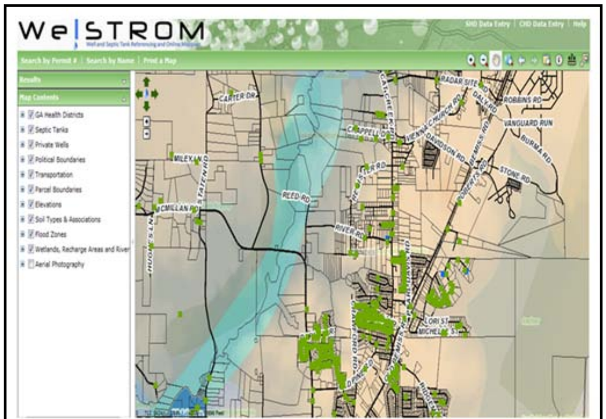
Figure 1.5 The WelSTROM Septic & Well Database. Courtesy of the Southern Georgia Regional Commission

The WelSTROM database was designed by the Southern Georgia Regional Commission and is used for the housing of well and septic tank reference data, accompanied by a GIS component (Figure 1.5). Individual county health departments are able to enter and edit new or existing well and septic permits within this database as it works in conjunction with the state contracted Garrison Enterprises, Inc. non-GIS database. Health Department personnel are able to search for data by numerous query options such as permit number, permit year, last name, address and type of septic system. The health department employee can view OSDS permit data within many geography layers including: Floodplain, National Wetlands Inventory, State Soil Geographic Data, Pollution Susceptibility, Geologic Substrates, Ground Water Recharge Zones and Licensed Shellfish Bed. A host of variables needed for public health planning in the form of tools are established inside this map site. There are tools that may be used to calculate distances as well as analyze surrounding structures, roads, water bodies and parcels.

This initiative specifically addressed Georgia's requirement to develop a federally-approved Coastal Nonpoint Source Management Program. The work focused on the federal conditions that apply to individual septic systems and the protection of aquatic resources. Phase I of this initiative was successful and accomplished the inspection and GIS inventory of onsite septic disposal systems (2,345) and wells (334) in relevant, high priority areas adjacent to state waters. The project created the first GIS inventory system of septic systems and wells in the 11 county GA EPD's NPS region. The technical process put in place improved collection and verification of OSDS position locations followed by data entry into the Department of Community Health's mandatory statewide Garrison Database. It also assisted with the development of GIS mapping capacity (WelSTROM) to improve local and state management of septic systems and wells. The geo-location and inspection of OSDS and wells for all of the coastal counties provides vital information for resource managers. Upon approval of the Coastal Health District, the compiled information can be shared and would provide urban and rural county municipal officials or planners with powerful new tools that will assist them in protecting and preserving coastal natural resources, as well as public health.

Statement of the Problem

Now that this process is in place, will the health departments see the importance of the process and continue to use the procedure in their day to day work? Is this innovation sustainable over time?

Purpose of the Study

The purpose of this study was to evaluate the knowledge, attitude and behavior regarding the longevity of the OSDS project procedure by the Coastal Health District's Environmental Health Mangers and Inspectors. The objectives were to:

1. Describe the environmental health department participants by demographics
2. Determine the OSDS project procedure adoption rate among environmental health department participants regarding Voluntariness, Relative Advantage, Compatibility, Image, Norms, Complexity, Result Demonstrability, Observability & Trialability.

Limitations of Study

The information gathered for this study includes only Environmental Health Managers & Inspectors of the eight Coastal Health District counties (Phase I & II) of Bryan, Camden, Chatham, Effingham, Glynn Liberty, Long and McIntosh. The Coastal Health District Phase I counties of Bryan, Effingham, Liberty and Long have completed their project as of September 30, 2010, which was a 24-month project. At the time of study, the Phase II counties of Camden, Chatham, Glynn and McIntosh were in the 10 month stage of the 30 month project period. An extra 6 months was added to Phase II due to size and scope of field work and analysis.

Basic Assumption of Study

The data analyzed in this study will be a vital assessment used by MAREX, GA EPD and NOAA/EPA to determine the overall quality of the project, specifically this information will help identify areas in need of improvement regarding the adoption of the technology process as this initiative moves forward to other health districts. It is assumed that the Coastal Health District was truthful regarding their knowledge, attitude and behavior as it pertained to the longevity of the OSDS project procedure.

Significance of Study

The population on the coast of Georgia is growing at an alarming rate, which increases the demand on OSDS for wastewater treatment. Soil and groundwater limitations are a primary concern for human and marine ecosystem health. Utilizing GIS technology by way of geo-locating and inspecting these systems is paramount in protecting coastal water quality. Other coastal states have implemented projects with health organizations in reducing the impact of potential water quality pollution due to OSDS in regards to NOAA/EPA findings and conditions. Currently, there are other ongoing coastal environmental GIS technology process funded by

Clean Water Act 319 (h) grants on water quality issues associated with OSDS in Florida, South Carolina and North Carolina. Along with these scientific studies, this social science study will give perspective on the attitude, knowledge and behavior of environmental health professionals regarding coastal water quality issues and the longevity of the OSDS project procedure. Using Diffusion of Innovations as the theoretical foundation, this study will provide information useful in understanding the process by which the OSDS project procedure was communicated over time among the participants in the Coastal Health District.

Definition of Terms

Biological Oxygen Demand (BOD) – indicates the necessary amount of oxygen in the water that will support the life in a given body of water. Low BOD can result in fish kills and growth of weed species.

Bohicket-Casper soil type - these soils are on broad level tidal flats bordering the Atlantic Ocean; less than 3 feet above mean sea level and extending 5 to 15 miles inland along some of the larger rivers. These soils have poor draining properties with both very slow runoff and very slow permeability characteristics.

Diffusion of Innovation – theory that explains the rate a technology is adopted or rejected by the end user.

Flood Plain – This is data that is derived from the Federal Emergency Management Agency (FEMA). Flood hazard areas are classified as having a 1% annual chance of flood and are also referred to as the base flood or 100-year flood plain or 0.2% annual chance of flood, also known as the 500-year flood plain.

Geographic Information System (GIS) - is a system designed to capture, store, analyze, manage and present all types of geographically referenced data.

Geographic Positioning System (GPS) – is a satellite system that provides location and time data of geo-referenced coordinates on Earth. This system was created and is maintained by the United States government. Anyone with a GPS receiver can access the information.

Geologic Substrates –This data is derived by the GA EPD. These substrates refer to different layers of organic matter beneath the surface soil.

Groundwater Recharge – This data is derived from the GA EPD. Groundwater Recharge is a hydrologic process where water percolates through soil by making the transformation from surface water to groundwater.

Hydrology – the study of the movement, distribution and quality of water.

Hydromodification – environmental changes in water bodies that curb nonpoint source pollution activity.

National Wetland Inventory -This data is derived by the U.S. Fish & Wildlife Service. These conservation maps show wetland areas in the U.S. through geo-referenced information.

Nonpoint Source Pollution – is a term that describes pollution which cannot be traced back to a single origin such as stormwater runoff and failed septic systems.

On-site Disposal Systems (OSDS) – A typical septic system has four main components: a pipe from home, a septic tank, a drainfield, and the soil.

Point Source Pollution – is a single traceable source of air, soil or water pollution.

Pollution Susceptibility - The Georgia Geologic Survey has developed a map that shows susceptibility of the water table in regards to possible pollution activities. These map areas are graded as low, average, or higher susceptibility to pollution.

Statistical Package for the Social Science (SPSS) - is an IBM computer program used for survey and statistical analysis.

Soil Types - The Natural Resources Conservation Service (NRCS) has archived soil textures regarding different mineral makeup as well as grouping the soils according significance in sand, silt and clay.

CHAPTER 2

REVIEW OF LITERATURE

The literature review will include three areas: (1) Impacts of Dysfunctional OSDS on Coastal Water Quality, (2) GIS Technology and Public Health and (3) Diffusion of Innovation and GIS Technology Adoption

Impact of Dysfunctional OSDS on Coastal Water Quality

It has become clear that nonpoint source pollution has become a major driver in the worlds increasing battle with failing water quality standards. The sources of nonpoint source pollution must be controlled and monitored in order to produce and maintain healthy water quality levels. There are many mechanisms that help control nonpoint source pollution, such as best management practices for hydromodification, and low impact land development applications. These applications take the shape of hydrolic and topographic characteristics and vegetative cover or buffers to name a few. “EPA estimates indicate that approximately 15% of the waters in the U.S. fail to meet quality standards because of nonpoint sources, while an additional 35% are degraded by a combination of discharges from point and nonpoint sources” (Litwin & Donnigan, 1978, p. 2348). Developing coastlines are fragile areas that can be easily compromised by pollution activity. Coastal ecosystems are under increasing stress from a variety of human activities that cause nonpoint source pollution, which significantly alters the environment.

OSDS have great consequences on health and the environment. These systems have a high rate of being dysfunctional if not maintained through a pump schedule. Georgia Department of Community Health Homeowner's Manual (2008, p. 5) recommends 3-5 years in between cleanings. Many homeowners are not aware of this and never have their system pumped. Therefore, OSDS becomes dysfunctional, leaking potentially hazardous bacteria and nitrogen into the groundwater table. OSDS have traditionally been thought of as having a high rate of failure, due to poor design and construction for coastal soils. A typical septic system consists of a tank and drainfield. "Settled solids in septic tanks undergo some decomposition, but they never completely go away. Consequently, sludge volume is always increasing. The tank is used to hold solids as the drainfield is designed to disperse the effluent into the soil column" (CSREES, 2004, p. 1).

Dysfunctional septic systems can leach harmful pathogens and nitrogen into surface and ground water. "Disease-causing microorganisms or "pathogens" are found in impaired waterways. These pathogens can be bacteria that cause cholera and typhoid-fever, protozoa that cause dysentery, viruses that cause polio and hepatitis and helminths such as roundworm and tapeworm" (Vendrell & Atiles, 2003, p. 1).

Bacterial contamination by means of dysfunctional OSDS is a real threat to coastal Georgia water quality. Bacteria, to be more specific, fecal coliforms are associated with harboring potentially deadly strains of viruses. Increased nutrient loading from leaking OSDS, specifically nitrogen, is another threat to water quality. In a study conducted in Sarasota County, Florida, five of the six watersheds sampled were classified as high OSDS density areas. "All five watersheds tested positive for fecal pollution. Eleven stations (representing six watersheds) were intensively sampled for microbial indicators of fecal pollution (fecal coliform bacteria, enterococci, Clostridium perfringens and coliphage) and the human enteric pathogens, Cryptosporidium, Giardia and enteroviruses during the summer rainy season" (Lipp, Farrah &

Rose, 2001, p. 292). In addition to bacterial pathogens, there are also potential health problems associated with high nitrate levels in ground and surface water. “High nitrate levels can cause a condition called methemoglobinemia or blue babysyndrome. Babies under six months of age, older people, pregnant women, people with low stomach acidity, and people who lack certain enzymes can develop methemoglobinemia. Symptoms include a bluish tint to the skin, headaches, dizziness, weakness and difficulty breathing” (Gaskins, Vendrell & Atiles, 2003, p. 2).

Another issue with nitrogen is that it acts as a fertilizer to algal species. When nitrogen levels exceed their limit in water bodies, the algal plant growth increases. Since algae take in more dissolved oxygen than they give off, this depletes the dissolved oxygen level in the water column, therefore affecting the biological oxygen demand (BOD). Once the algal plants bloom, they begin to die off. This organic matter falls to the bottom of the water body floor where bacteria further breaks down the nutrients. Bacteria consume oxygen during this process, which further depletes the dissolved oxygen content. Last, but not least, some of these harmful algal blooms (HABs) have blooms that give of a neurotoxin in the form of a red shaded pollen. This is what is known as a “red tide”. These red tides kill fish and other marine species. This is also devastating to the tourism and the seafood industry. “Harmful algal blooms (HABs) are periodically found in the waters of almost every US coastal state. Notable toxic algae include those responsible for “red tides” caused by blooms of dinoflagellates including the species *Gymnodinium breve* and the flesh eating organism, *Pfiesteria piscicida* that has plagued coastal North Carolina and Maryland” (Luttenberg, Sellner, Anderson & Turgeon, 2000, p. 47).

Nitrogen discharge from OSDS poses the greatest threat to water quality.

"Vertical distance of septic tank infiltration system from the water table, septic system design and siting remain the key components in minimizing potential impacts from OSDS for control of both pathogens and nutrients. The most comprehensive information connecting nutrient contributions from OSDS to surface water quality was the study conducted on Buttermilk Bay in Massachusetts where 74% of nitrogen to the bay was attributed to onsite disposal systems" (Harris, 1995, p. 262).

GIS Technology and Public Health

Geographic Information System (GIS) is an application tool that allows a person to create and analyze information in the form of a map. This is vastly important in determining the relationship between nonpoint source pollution activities and the corresponding geographic locations. There are two basic user options associated with GIS: manage and edit data through functions within a map overview and performing analyses on the data within a map. GIS technology ultimately leads to answering the question, "Where is the location in reference to the potential issue at hand?"

Table 2.1 Elements of a GIS. (Chan & Williamson, 1999, p. 273)

Elements of a GIS

Elements of a GIS	Scope of each element
Data	all accessible data, both geographical and attribute, required to meet the geographical information needs, identified or latent.
Information technology	all computer hardware, software (including applications) and the associated communication technology required to meet the geographical information needs, identified or latent.
Standards	all agreed practices required to facilitate the sharing of the other four components of a GIS.
People with GIS expertise	all knowledge, skills, procedures, and systems, technical or otherwise, acquired by people involved, for the smooth functioning of the GIS.
Organizational setting	all the operating environments, technical, political, or financial, created by the interaction among stakeholders, in which the GIS is to function.

A geographic information system is comprised of geographical data, information technology (computer hardware and software), a standardized method, a group of people with expertise in GIS and an organizational setting to accept the GIS technology (Table 2.1). Local governments began to explore the use of GIS technology in the early 1990’s. “A national survey in 1997 of a sample of 200 cities and counties concluded that use of GIS technology in at least one department of local government had increased from 20% of jurisdictions in 1990 to a predicted 87% by the end of 1997” (Richards, Croner, Rushton, Brown & Fowler, 1999, p. 3). The National Association of County and City Health Officials (NACCHO) reports that interest in GIS technology has increased during the 1990s, but many local public health departments still do not have the software, hardware, or trained staff that would enable them to apply GIS technology (Richards et al., 1999, p. 3).

GIS is both the software and hardware through which digital geo-referenced data can be displayed and analyzed. GIS is an extraordinary field tool of public health.

> “GIS is capable of supporting the collection, storage, retrieval and statistical manipulation of spatially-referenced observations and events. In the years ahead, GIS will have a profound impact on public health strategies involving surveillance, risk assessment, analysis, and the control and prevention of human disease” (Croner, Sperling & Broome, 1996, p. 1961).

GIS mapping is important to determining water quality status. GIS as well as regression modeling techniques were used to evaluate relationships between land use and fecal pollution in Murrells Inlet, a small, urbanized, high-salinity estuary located between Myrtle Beach and Georgetown, SC. “GIS techniques were used to identify and calculate land use and spatial variables to be used in a regression model. The results of the regression analysis indicated that proximity to areas with septic tanks and rainfall runoff from urbanized areas are important predictors of fecal coliform densities in the estuary” (Kelsey, Porter, Scott, Neet & White, 2004, p. 201).

GIS is becoming a standard practice in monitoring public health. This information can be analyzed and transferred to other decision making parties at a very fast pace. “Information technology has become critical to public health practice and management. First, geography is a near-universal link for sorting and integrating records from multiple information systems into a more coherent whole. Second, modern GIS systems provide a format that allows the quick response needed for public health decision making. Third, GIS facilitates policy development” (Yasnoff & Sondik, 1999, p. ix).

Health departments are using GIS to identify potential impacts of dysfunctional OSDS. “GIS can spatially represent site characteristics and hydrological responses with mapped features. A GIS system can help describe the suitability of a site to locate a septic-system and assess the potential for nitrate pollution of groundwater from that location” (Stark, Nuckols & Rada, 1999, p. 15). The University of Georgia Marine Extension Service and the McIntosh County Environmental Health Department conducted a GIS study in McIntosh County, Georgia to locate and inspect OSDS. This was the original pilot/feasibility study for the Phase I OSDS project. During this study, 1,056 septic tanks adjacent to the coastal waters or salt marsh in McIntosh County were mapped by GIS technology. This study found 53 OSDS were found visually dysfunctional; 100 septic tanks were found within one foot of a state water body; and 11 were found between 1 and 25 feet of a body of water. Georgia State Law requires a minimum distance of 50 feet from a body of water and proper placement of a septic tank (Walker, Cotton & Payne, 2003, p. 22).

> "The combination of the shallow coastal water table and prevalent sandy soil (esp. Bohicket-Caper-Water soil type) indicated that most (63%) of the tanks were found in areas of high pollution susceptibility. Likewise, 75% of the septic tanks in McIntosh County occur in the 100 year floodplain. Eighteen percent of the septic tanks occur within water recharge areas" (Walker, Cotton & Payne, 2003, p. ii).

Diffusion of Innovation and GIS Technology Adoption

Rogers (2003, p. 11) defines Diffusion of Innovation as a "process by which an innovation is communicated through certain channels over time among the members of a social system". "Applying this to diffusion of GIS technology, we can view local governments as members of a larger social system (e.g., all public organizations in a state or in the U.S.), as well as social systems in themselves" (Budic, 1994, p. 286). Thus, the two possible levels for analyzing GIS diffusion are:

1. Macro-level diffusion among local governments, as they decide to acquire GIS technology
2. Micro-level diffusion within local governments, after they purchase the technology and face "the beginning of an often prolonged process of diffusion within the organization" (Budic, 1994, p. 286).

Micro-level diffusion is the focus of this thesis. The strategy that was followed was, "Big Bang". "The Big Bang strategy is defined as, instant changeover with simultaneous technological and organizational change; involves great risk; requires substantial planning, preparation for change and extra funding, centrally managed, creates stressful conditions, suitable for applications that need "critical mass" of users" (Eason, 1988, p. 159).

For this study, Diffusion of Innovation explains the adoption of a new GIS technology process by environmental health departments under a grant funded initiative. Five qualities of an innovation must be met in order for a process to properly diffuse and actually lead to adoption. According to Rogers, these five qualities of an innovation determine between 49 and 87 percent of the variation in rate of adoption of new products. These five qualities of an innovation make a valid evaluation guide. These qualities can help determine strengths and weaknesses when improving either products or behaviors.

Five Qualities of Diffusion of Innovation (Rogers, 2003 p. 15)

1) Relative Advantage - degree to which an innovation is perceived as better than the idea it supersedes by the participants.
2) Compatibility – degree to which an innovation is perceived as being consistent with the values, past experiences, and needs of potential adopters. An idea that is incompatible with their values, norms or practices will not be adopted as rapidly as an innovation that is compatible.
3) Complexity - degree to which an innovation is perceived as difficult to use or understand. New ideas that are simpler to understand adopted more rapidly than innovations that require the adopter to develop new skills and understand.
4) Trialability - degree to which an innovation can be experimented with on a limited basis. An innovation that is trialable represents less uncertainty to the individual who is considering it.
5) Observability – degree to which results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt.

The population for diffusing an innovation can be broken down into five different segments, based on their rate of adoption of an innovation: innovators, early adopters, early majorities, late majorities and laggards (Figure 2.1).

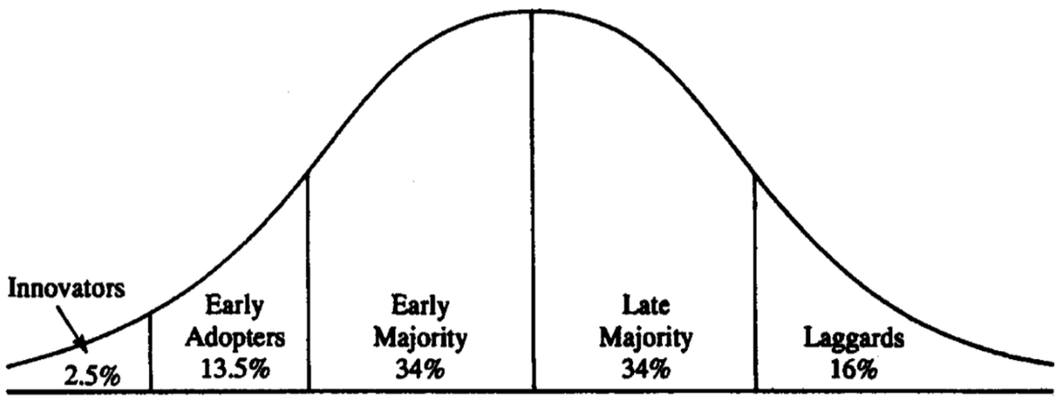

Figure 2.1 Adopter Categorization on the Basis of Innovativeness. (Rogers, 2003, p. 281)

Adopter Categories (Rogers, 2003, p. 282)

Innovator: Venturesome

Venturesomeness is almost an obsession with innovators. Their interest in new ideas leads them out of a circle of peer networks and into more cosmopolite social relationships.

Early Adopters: Respect

The early adopter is respected by his or her peers, and is the embodiment of successful, discrete use of new ideas. The early adopter knows that to continue to earn this esteem of colleagues and to maintain a central position in the communication networks of the system; he or she must make judicious innovation-decisions.

Early Majority: Deliberate

The early majority adopt new ideas just before the average member of a system. The early majority interacts frequently with their peers but seldom hold positions of opinion leadership in a system.

Late Majority: Skeptical

The late majority adopt new ideas just after the average member of a system. The weight of system norms must definitely favor an innovation before the late majority is convinced to adopt.

Laggards: Traditional

Laggards are the last in a social system to adopt an innovation. Laggards tend to be suspicious of innovations and change agents.

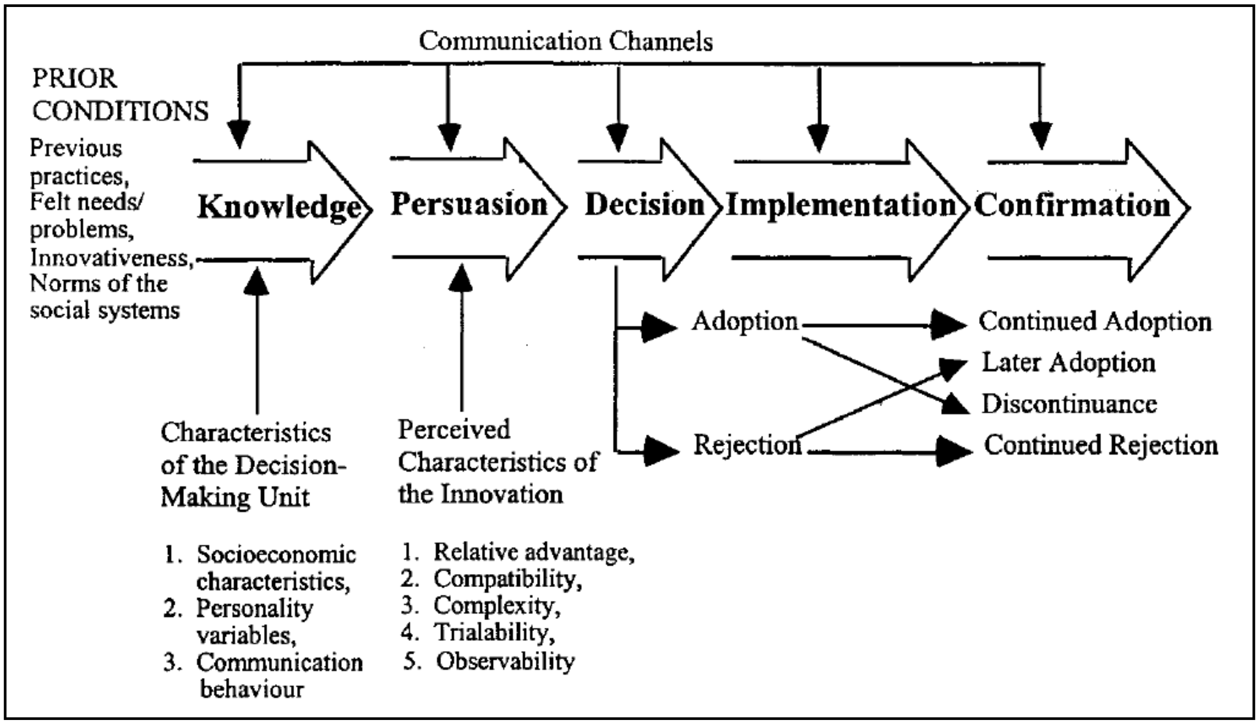

Figure 2.2 Innovation Decision Process. (Rogers, 2003, p. 170)

According to the discussion on the diffusion paradigm by Rogers (2003, p. 170), innovation diffusion among individuals is modeled by the innovation decision process. This process of communication involves the knowledge of the innovation, being persuaded to use the innovation, making the decision, implementing the innovation and finally confirming the adoption of the innovation (Figure 2.2). These findings have been found to be applicable to GIS by Onsrud and Pinto (1993).

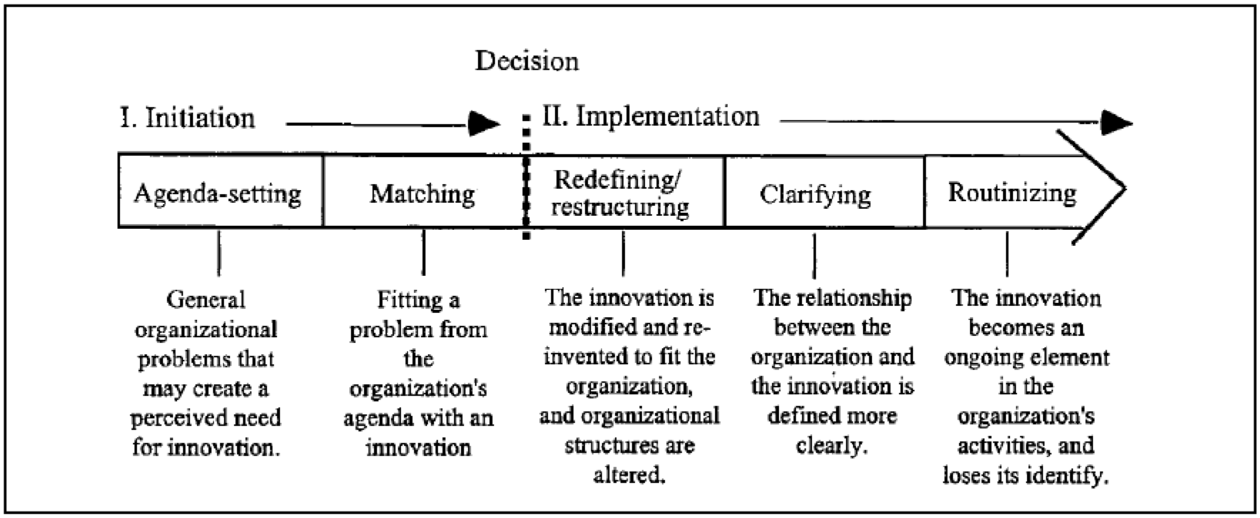

Figure 2.3 Stages in the Organizational Innovation Adoption Process. (Rogers 2003, p. 421)

Stages in the OSDS project procedure adoption process as referenced above (Figure 2.3).

I. Initiation

Agenda-setting: Geo-locating septic systems-need for better records

Matching: GIS & Environmental Health

- -

II. Implementation

Redefining/restructuring: Geo-locating procedure and database usage

Clarifying: Collaboration of both the state mandated Garrison Database and WelSTROM database for more efficiency

Routinizing: Health departments use the OSDS project procedure as a daily job function

The organizational innovation process is a Rogers' model in which there are two stages, the initiation and implementation. Initiation has two sequential sub stages called agenda-setting and matching. Implementation has three: redefining/restructuring, clarifying and routinizing. The two stages result in either a decision to adopt an innovation or not.

Managers undertake significant planning and justification of the utility factor when trying to introduce GIS into an organization (Onsrud & Pinto 1993, p. 34). MAREX began an initiation stage in 2005 with meetings among Coastal Health District managers to lay the foundation of the importance of GIS benefits to environmental health. Since most local county environmental health managers or inspectors are not experts in GIS, their perceptions of GIS can be improved if their senior management is on board with the technology. To minimize confusion, it was of utmost importance that the definition of GIS explained to the Coastal Health District was in the correct projection of the process being diffused. “A holistic understanding of GIS diffusion therefore requires understanding of how both managers and other stakeholders view GIS” (Chan & Williamson, 1999, p. 269).

Generally, when a technology is accepted, adoption takes very quickly. There are usually a small number of laggards in the end. The pattern has been observed in the adoption of computer based technologies in local government, Dutton (1982), Feller (1981) and Kraemer, King, Dunkle, & Lane (1986). There are barriers in the adoption of GIS Technology. Issues that prevent adoption are not only with system or process design but with technical capacity of the user. An organizational issue of concern is just how well the staff understands the technology.

> “Institutional issues are all the factors external to an agency that influence an organizations ability to adopt or use GIS, particularly political and economic. For example, staffing and training are described in terms of organizational commitment, but limitations may arise because external funding agencies have failed to grasp the technical difficulty of systems operation. Studies of GIS-related impediments have generally focused on adoption and implementation” (Ventura, 1995, p. 463).

Human beings vary in knowledge, attitudes, behavior as well as technical proficiency. Many organizational barriers of GIS technology can be broken down to fear of change, learning difficulties and differences of opinion between staff and management. “Unless agents of change are extremely powerful, it requires either a significant crisis or an outside intervention such as a mandate from a higher authority to change the attitudes and beliefs of individuals in entrenched bureaucracies” (Ventura, 1995, p. 464).

Theoretical Framework

Diffusion of Innovation is a major research focus today. “Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 2003, p. 11). This theory can be used as a theoretical framework to enable an organization to plan for technology. There are four elements to the framework.

Element #1: Innovation

“An innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption. A technology cluster consists of one or more distinguishable elements of technology that are perceived as being closely interrelated” (Rogers, 2003, p. 36).

The Innovation: OSDS Project Procedure

GPS unit → Computer → GIS Database

Element #2: Communication Channels

For Rogers, communication is a process in which participants create and share information with one another in order to reach a mutual understanding. Diffusion is a very social process that involves interpersonal communication relationships (Rogers, 2003, p. 36). These interpersonal channels are strong and are able to change an individual's attitude. In interpersonal channels, the communication may have a characteristic of homophily, that is, "the degree to which two or more individuals who interact are similar in certain attributes, such as beliefs, education, socioeconomic status, and the like," but the Diffusion of Innovations requires at least some degree of heterophily, which is "the degree to which two or more individuals who interact are different in certain attributes." In fact, "one of the most distinctive problems in the Diffusion of Innovations is that the participants are usually quite heterophilous" (Rogers, 2003, p. 36).

MAREX, SGRC & GA EPD (Project Management) share information in a predominately heterophilous communication channel with the Coastal Health District Environmental Health Staff (Project Implementation).

Element #3: Time

"According to Rogers, the time aspect is ignored in most behavioral research. He argues that including the time dimension in diffusion research illustrates one of its strengths. The innovation-diffusion process, adopter categorization, and rate of adoptions all include a time dimension" (Sahin, 2006, p. 15).

Phase I Project: 24 months

Phase II Project 30 months

Element #4: Social System

Rogers (2003, p. 37) defined the social system as “a set of interrelated units engaged in joint problem solving to accomplish a common goal”. The structure is “the patterned arrangements of the units in a system” Rogers (2003, p. 37).

Below are the organizations involved in the social system of the OSDS initiative as well as their role in the endeavor.

GA EPD CNPS Program: regulatory oversight of nonpoint source issues in coastal Georgia

MAREX: advisory research and management regarding water quality projects

SGRC: operates a septic and well GIS database used to analyze water quality concerns

Coastal Health District: regulatory and management agency for environmental health

Summary of Literature Review

OSDS are highly dysfunctional if not properly maintained. Faulty systems have a serious impact on coastal water quality. The leaking of highly dangerous bacteria and the overloading of nutrients can have a devastating impact on human and marine ecosystem health. Studies have been conducted to trace a link between dysfunctional OSDS and these pollutants. The use of GIS by environmental health officials is key in combating potential water quality impairment. Diffusion of Innovation theory is an appropriate research framework to study the effectiveness of a new GIS technology process on environmental health professionals. GIS technology adoption has barriers to overcome with agencies implementing the technology and Diffusion of Innovation theory may help researchers and practitioners overcome these barriers.

CHAPTER 3

METHODOLOGY

Research Design

The type of research used was relational in nature. The research for this descriptive study is classified as survey research. The information was gathered during a time frame from a group of subjects in a small social unit. The survey was of mixed method design, primarily quantitative with some demographic questions having qualitative response options. Items on the survey contained response options which were Likert in nature with most response options following an ordinal scale of measurement (see Appendix B for instrument). The instrument contained the following constructs:

Voluntariness (2 items) – the degree to which an individual's own free will factors into adoption of the innovation. (Moore & Benbasat, 1991, p. 195)

Relative Advantage (9 Items) - the degree to which an innovation is perceived as better than the idea it supersedes. (Rogers, 2003, p. 229)

Compatibility (3 items) – the degree with which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. (Rogers, 2003, p. 240)

Image (6 items) - the degree of favorabililty or perception of the innovation in the work place. (Moore & Benbasat, 1991, p. 195)

Norms (2 items) – the degree to which the theory of planned behavior is used in the adoption of an innovation. "As in the original theory of reasoned action, a central factor in the theory of planned behavior is the individual's intention to perform a given behavior. Intentions are assumed to capture the motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform a behavior" (Ajzen, 1991, p. 181).

Complexity (8 Items) – the degree to which an innovation is perceived as difficult to understand and use. (Rogers, 2003, p. 257)

Result Demonstratibilty (4 items) – the degree to which the innovation can be demonstrated to increase awareness or proof of the innovation's success. (Moore & Benbasat, 1991, p. 203)

Observability (5 items) – the degree to which the results of an innovation are visible to the user. (Rogers, 2003, p. 36)

Trialability (11 items) – the degree to which an innovation may be experimented with on a limited basis. (Rogers, 2003, p. 36)

Demographic (4 items) - age, sex, years of experience in environmental health and education level.

Sampling Population

The population for this study was Environmental Health Managers or Inspectors of the Coastal Health District of Georgia. The individuals chosen are exclusively involved in the OSDS initiative for the Coastal Health District. The Coastal Health District encompasses the counties of Bryan, Camden, Chatham, Effingham, Glynn, Liberty, Long and McIntosh. A purposive sample was acquired. These individuals were selected due to their experiences of planning and implementing the OSDS project. Fourteen questionnaires were distributed: (1 questionnaire) District Manager; (8 questionnaires) County Managers and (5 questionnaires) County Inspectors.

Development Procedures and Instrumentation Selection

Following a review of the literature, the instrument used in this study was one based on research of Moore & Benbasat (1991) by measuring the perceptions of adopting information technology innovation. Moore & Benbasat's instrument is built off of Roger's five qualities of a successful diffusion along with three new constructs, voluntariness, image and result demonstrability. The instrument was chosen because it has been successfully tested for reliability and vailidity and the survey subject could be changed to fit the study. The instrument was re-checked for reliability and validity due to the change in population used for this study and was deemed appropriate for use. Moore & Benbasat (1991, p. 204) used a three stage process to develop the instrument, item creation, scale development and instrument testing. The instrument testing stage was made up of three parts, two pilot testing Phases and a field testing Phase where 800 questionnaires were distributed. "This instrument can now be used to investigate how perceptions affect individuals' actual use of the information technology as well as other innovations" (Moore & Benbasat, 1991, p. 210).

The instrument for this study had nine constructs with fifty-four statements, plus four demographic statements. The questionnaire constructs consisted of Roger's five qualities of a successful Diffusion of Innovation as well as Moore & Benbasat's additional constructs of voluntariness, image and result demonstrability. Through discussions with an evaluation expert, an additional construct was added to the instrument regarding norms which describes planned behavior. Each participant was asked to indicate their level of agreement with each statement using a seven point Likert-type scale, except for four open ended demographic questions. The scale was coded, 1=Extremely Disagree; 2=Slightly Disagree; 3=Inclined to Disagree; 4=Neutral; 5=Inclined to Agree; 6=Slightly Agree and 7=Extremely Agree. Each survey questionnaire was mailed to each participant along with a cover letter including IRB disclaimer, as well as an addressed stamped envelope for return (Appendix A). An electronic form copy was created using Adobe Professional 9.0. This form was emailed to participants in step 5 of Dillman's protocol as the different mode of delivery (Dillman, Smyth & Christian, 2009, p. 243).

Data Collection Procedures

Data was collected from late March 2011 until early May 2011, following Dillman's protocol:

1. A brief letter was sent to respondents a few days prior to the questionnaire.
2. A questionnaire was mailed that includes a detailed cover letter explaining why a response is important, the questionnaire, and a prepaid postage envelope.
3. A thank you postcard was sent a week after the questionnaire.
4. A replacement questionnaire was sent to nonrespondents 2 weeks after the previous questionnaire mailing.
5. A final contact made by a different mode of delivery via email in .pdf form 2 weeks after the previous mailing.

Six questionnaires were returned within one week of the mailing. Four questionnaires were returned between the end of week one and the end of week three. One questionnaire was returned after final contact for a 79% response rate.

Data Analysis Procedures

Analysis was done by logging all survey questionnaire data into a Microsoft Excel 2007 spreadsheet were data was analyzed by individual item as well as construct. At this point, descriptive statistics were used to calculate the mean, mode and standard deviation. SPSS version 18.0 to was used to determine internal consistencies within construct's using Cronbach's Alpha. Item analysis was performed within each construct to determine the contribution of each item to the construct reliability.

Survey Budget

Fourteen surveys were mailed at $1.39 each with return postage of $1.39 each totaling $38.92

Thank you/reminder letters were sent to 8 participants at $.44 each totaling $3.52.

Printing, paper & envelopes totaling (estimated) $15.00

Total Budget $57.44

CHAPTER 4

RESULTS

Fourteen questionnaires were administered for this study. There were eleven responders to only three non-responders resulting in a 79% response rate. However, there was one participant who did not attempt the demographic section of the questionnaire. Therefore, the demographic information provided is for ten participants instead of eleven.

Demographics

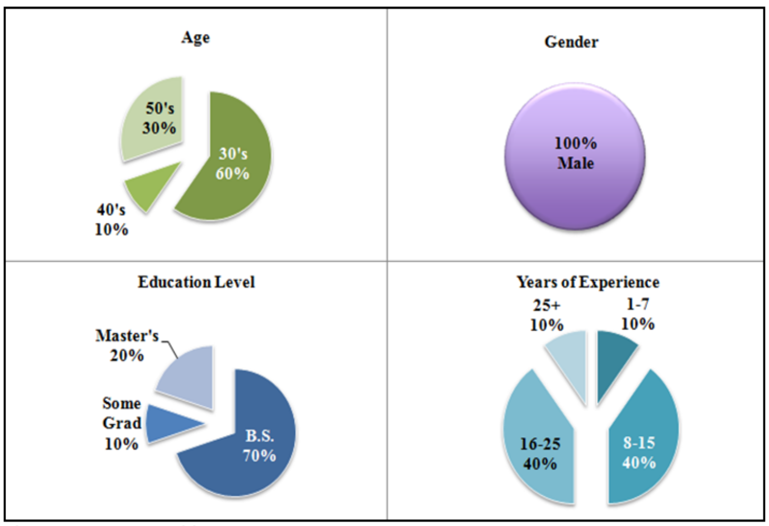

Figure 4.1 Demographics

The lowest age of participant was 30, as the oldest participant was 56. All participants were male. As required by the state as an Environmental Health Manager or Inspector, all participants had a minimum of a Bachelor's degree. Two of the participants had a Master's degree, while one participant had done some graduate work. The participants were well qualified with 90% having eight or more years of experience in environmental health.

Overall Construct Breakdown

Table 4.1

Construct Reliabilities & Summated Scale Scores

Items	Contruct Name	Cronbach's Alpha	Mean	Min/Max Score	Standard Deviation
1-3 (2*)	Voluntariness	0.73	8.1	8 / 20	3.39
4-12 (9)	Relative Advantage	0.96	42.45	23 / 56	10.2
13-15 (3)	Compatibility	0.89	13.73	4 / 19	4.43
16-21 (6)	Image	0.82	23.73	13 / 33	5.24
22-24 (2*)	Norms	0.49	6.64	8 / 14	2.29
25-33 (8*)	Complexity	0.37	35	33 / 45	3.92
34-37 (4)	Result Demonstrablity	0.69	18	13 / 26	3.41
38-43 (5*)	Observability	0.22	18.27	14 / 28	3.64
44-54 (11)	Trialability	0.88	49.45	23 / 72	11.83

The above table represents summated analysis of each individual construct. All but four constructs had Cronbach's Alpha over .70. There were consistency issues with the Voluntariness, Norms, Complexity & Observability constructs. Analysis was done for all constructs using SPSS software in order to determine the reliability. Each construct was found to have one statement that was lowering Cronbach's Alpha. The statement was omitted and analysis showed a much higher alpha for each of the four constructs, implying higher reliability.

Individual Construct Breakdown

Table 4.2 Voluntariness Construct

Voluntariness Construct
2 Statements
Average 4.05
Standard Deviation 1.7

Table 4.2 displays the overall Voluntariness construct average and standard deviation regarding the eleven participants. There were originally three statements in the Voluntariness construct. The first statement in this construct was deemed inconsistent through SPSS analysis of Cronbach's Alpha. Therefore, statement 1, "My superiors expect me to use the OSDS project procedure" was deleted from the analysis. The highest average response was statement 3, "Although it might be helpful, using the OSDS project procedure, is certainly not compulsory in my job" at 4.18 (SD=1.94). This shows that the participants held a neutral position on the whether they would use the procedure voluntarily. The lowest average score was from the statement 2 in the construct, "My use of the OSDS project procedure is voluntary (as opposed to required by my superiors or job description) at 3.90 (SD=1.87). This score was also in the neural range. The mode was 4 on all statements within the construct.

The participants did not feel that the OSDS project procedure was a top priority of their job duties. The standard deviation of the construct was very large, being 42% as large as the average. This shows signs of high variability among responses and therefore, there is much concern of the procedure being something that is viewed as voluntary. Evidence suggests that the participants were in disagreement with the Voluntariness construct.

Table 4.3 Relative Advantage Construct

Relative Advantage Construct
9 Statements
Average 4.72
Standard Deviation 1.13

Table 4.3 displays the overall Relative Advantage construct average and standard deviation regarding the eleven participants. There were nine statements in this construct. The highest averages, at 5.18, in this construct were from both statement 7, “The advantages of my using the OSDS project procedure far outweigh the disadvantages” and statement 9, “Overall, I find using the OSDS project procedure to be advantageous in my job”. This shows a very positive view regarding the advantage of using the procedure. The lowest averages, at 4, were both statement 11, “Using the OSDS project procedure gives me greater control over my work” and statement 12, “Using the OSDS project procedure increases my productivity”. This shows that the participants are neutral in using the procedure. The mode was highest at 6 on statements 5, 7, 8 and lowest at 4 on the rest of the statements. Statement 7, “The advantages of my using the OSDS project procedure far outweigh the disadvantages had the largest standard deviation at 1.47. Statement 12, “Using the OSDS project procedure increases my productivity” had the smallest standard deviation at 1.10.

The participants feel that the OSDS project procedure is advantageous. The construct average was high as well as a small spread standard deviation. This shows signs of high consistency among responses and therefore, the participants see the relative advantage of the procedure. Evidence suggests that the participants were in agreement with the Relative Advantage construct.

Table 4.4 Compatibility Construct

Compatibility Construct
3 Statements
Average 4.58
Standard Deviation 1.48

Table 4.4 displays the overall Compatibility construct average and standard deviation regarding the eleven participants. There were three statements in this construct. The highest average of this construct was statement 15, "Using the OSDS project procedure fits naturally into my work style" at 4.64. There was a tie for the lowest average from both statement 13, "Using the OSDS project procedure is completely compatible with my current operating procedure" and 14, "I think that using the OSDS project procedure fits well with the way I like to work" at 4.55. The mode was highest at 5 on statement 15. The mode was 4 on the remaining two constructs. Statement14, "I think that using the OSDS project procedure fits well with the way I like to work" had the largest standard deviation at 1.75. Statement 13, "Using the OSDS project procedure is completely compatible with my current operating procedure" had the lowest standard deviation at 1.51. This shows while the participants are still neutral, they do lean toward agreeing with compatibility of the procedure with their job duties.

The participants feel that the OSDS project procedure is compatible with their work style. The procedure is not completely compatible, but still the construct average was high as well as a small spread standard deviation. This shows signs of high consistency among responses and therefore, the participants see the compatibility of the procedure. Evidence suggests that the participants were in agreement with the Compatibility construct.

Table 4.5 Image Construct

Image Construct
6 Statements
Average 3.96
Standard Deviation .87

Table 4.5 displays the overall Image construct average and standard deviation regarding the eleven participants. There were six statements in this construct. The highest average of this construct belong to two statements, 16, “Using the OSDS project procedure improves my image within the organization” and 21, “I would be more likely to use the OSDS project procedure if others in my organization also used it” at 4.45 . The lowest average belongs to statement18, “People in my organization who use the OSDS project procedure have more prestige than those who do not” at 3.63. The mode was 3 on statement 18 and 4 on the remaining statements within the construct. Statement 17, “Because of my use of the OSDS project procedure others in my organization see me as a more valuable employee” had the largest standard deviation at 1.54. Statement 19, “People in my organization who use the OSDS project procedure have a high profile” had the smallest standard deviation at 0.65.

The participants feel that the OSDS project procedure did improve image and would use the procedure more if others did. However, the participants did not believe that using the procedure made them prestigious. The average scores were low as well as a small spread standard deviation on the procedure making the participants seem more valuable to the health department. Evidence suggests that the participants were in disagreement with the Image construct.

Table 4.6 Norms Construct

Norms Construct
2 Statements
Average 3.32
Standard Deviation 1.15

Table 4.6 displays the overall Norms construct average and standard deviation regarding the eleven participants. There were originally three statements in this construct. Statement 22, “I feel pressure to perform the OSDS project procedure” was deemed inconsistent through SPSS analysis of Cronbach’s Alpha. Statement 22 was deleted from the study. The highest average of this construct was statement 23, “In my office, one sees the OSDS project procedure equipment on many desks” at 3.73. The lowest average was statement 24, “ I feel as I am in competition with other health departments in better performing the OSDS project procedure” at 3.09. The mode was 4 for all three statements in the construct. Statement 23, “In my office, one sees the OSDS project procedure equipment on many desks” had the largest standard deviation at 1.51. Statement 24 had the lowest standard deviation at 1.30.

The procedure was found not to be competitive among other health departments. The construct average was low as well as a small spread standard deviation. Evidence suggests that the participants were in disagreement with the Norms construct implying that the health departments are more inclined to use the OSDS project procedure if others are using it.

Table 4.7 Complexity Construct

Complexity Construct
8 Statements
Average 4.38
Standard Deviation .50

Table 4.7 displays the overall Complexity construct average and standard deviation regarding the eleven participants. There were originally nine statements in this construct. Statement 29, "Using the OSDS project procedure is often frustrating" was deemed inconsistent through SPSS analysis of Cronbach's Alpha. Statement 29 was deleted from the study. The highest average response for this construct was statement 30, "My interaction with the OSDS project procedure is clear and understandable" at 5.09. Statement 27, "My use of the OSDS project procedure required a lot of mental effort" had the lowest response average at 3.36. The mode was the lowest at 3 on statements 25 and 27. The highest standard deviation was statement 32, "The difference between the WelSTROM and Garrison database and why each is used in the OSDS project is easily understood" at 1.34. The smallest standard deviation was statement 25, "I believe that the OSDS project procedure is cumbersome to use" at 0.82.

The participants feel that the OSDS project procedure is clear and understandable. The procedure was found to not require a lot of mental effort. The construct average was high as well as a small spread standard deviation. This shows signs of consistency among responses and therefore, the participants view the procedure as easy to use. Evidence suggests that the participants were in agreement with the Complexity construct.

Table 4.8 Result Demonstrability Construct

Result Demonstrability Construct
4 Statements
Average 4.5
Standard Deviation .85

Table 4.8 displays the overall Result Demonstrability construct average and standard deviation regarding the eleven participants. There were four statements in this construct. The highest average of response in this construct was statement 34, “I would have no difficulty telling others about the results of using the OSDS project procedure” at 5.27. The lowest average of response was statement 37, “I would have difficulty explaining to others the rationale behind using the OSDS project procedure” at 3.36. The mode was lowest at 4 on statement 37, but 5 on the remaining statements. The largest standard deviation was statement 35, “I believe I could communicate to others the consequences of not using the OSDS geo-location procedure” at 1.35. The smallest deviation was statement 37, “I would have difficulty explaining to others the rationale behind using the OSDS project procedure” at 0.92.

The participants feel that they have no problem telling others about the results of the OSDS project procedure. The participants believe that they could communicate to others the consequences of not using the procedure. The construct average was high as well as a small spread standard deviation. This shows signs of high consistency among responses and therefore, the participants feel that they can demonstrate the procedure with no issues. Evidence suggests that the participants were in agreement with the Result Demonstrability construct.

Table 4.9 Observability Construct

Observability Construct
5 Statements
Average 3.65
Standard Deviation .73

Table 4.9 displays the overall Observability construct average and standard deviation regarding the eleven participants. There were originally six statements in this construct. Statement 40, "The OSDS project procedure is not very visible in my organization" was deemed inconsistent through SPSS analysis of Cronbach's Alpha. Statement 40 was deleted from the study. The highest average response was statement 41, "It is easy for me to observe others using the OSDS project procedure in my health district" at 4.27. The lowest average response was 39, "I have seen the OSDS project procedure in use outside of my county" at 3.09. The mode was evenly distrusted throughout the construct at 4 & 3. The largest standard deviation was 39, "I have seen the OSDS project procedure in use outside of my county" at 1.76. The smallest standard deviation was statement 43, "I have not seen many others using the OSDS project procedure in my health district" at 1.22.

The participants feel it is easy to observe other health departments in the district using the OSDS project procedure. Although, the average scoring was lower on the statement regarding the participant seeing the procedure in use outside of the county. The construct average was not very high; however the construct had a small spread standard deviation on observing the procedure elsewhere. The participants do observe the procedure within the district. Evidence suggests that the participants were in agreement with the Observability construct.

Table 4.10 Trialability Construct

Trialability Construct
11 Statements
Average 4.50
Standard Deviation 1.08

Table 4.10 displays the overall Trialability construct average and standard deviation regarding the eleven participants. There were eleven statements in this construct. The highest average response was statement 53, “A proper on-the-job test-run of the various uses of the OSDS project procedure is needed” at 5.18. The lowest average was statement 44, “ I've had multiple opportunities to try various OSDS project procedure applications” at 3.27. The mode was lowest at 1 on statement 44, “I've had multiple opportunities to try various OSDS project procedure applications” and noted at 2 on statement 54, “There are enough people in my organization to help me try the various uses of the OSDS project procedure”. The largest standard deviation was statement, 44 “I've had multiple opportunities to try various OSDS project procedure applications” at 2.00. The smallest standard deviation was statement 53, “A proper on-the-job test-run of the various uses of the OSDS project procedure is needed” at 0.60.

The participants feel that a proper on-the-job test run of various uses of the OSDS project procedure is needed. The participants disagreed on having multiple opportunities to try various OSDS project procedure applications as well as there being not enough people in my organization to help me try the various uses of the procedure. This construct had the lowest scores of all. Evidence suggests that the participants were in disagreement with the Trialability construct.

Comparing Phase I & Phase II Constructs

Table 4.11

Construct Summated Scale Score Comparison Among Phase I & II

Construct	Phase I Average	Phase II Average	Phase I STDEV	Phase II STDEV
Voluntariness	13.2	13.5	4.56	2.88
Relative Adv	48	37.83	6.96	10.63
Compatibility	15.6	12.16	3.05	5.04
Image	26	21.83	1.58	6.59
Norms	10.8	10	2.17	2.53
Complexity	38.8	37.16	4.15	3.54
Result Demo	18	18	4.95	1.9
Observability	22.4	22	5.59	1.55
Trialabilty	53.8	45.83	11.84	11.53

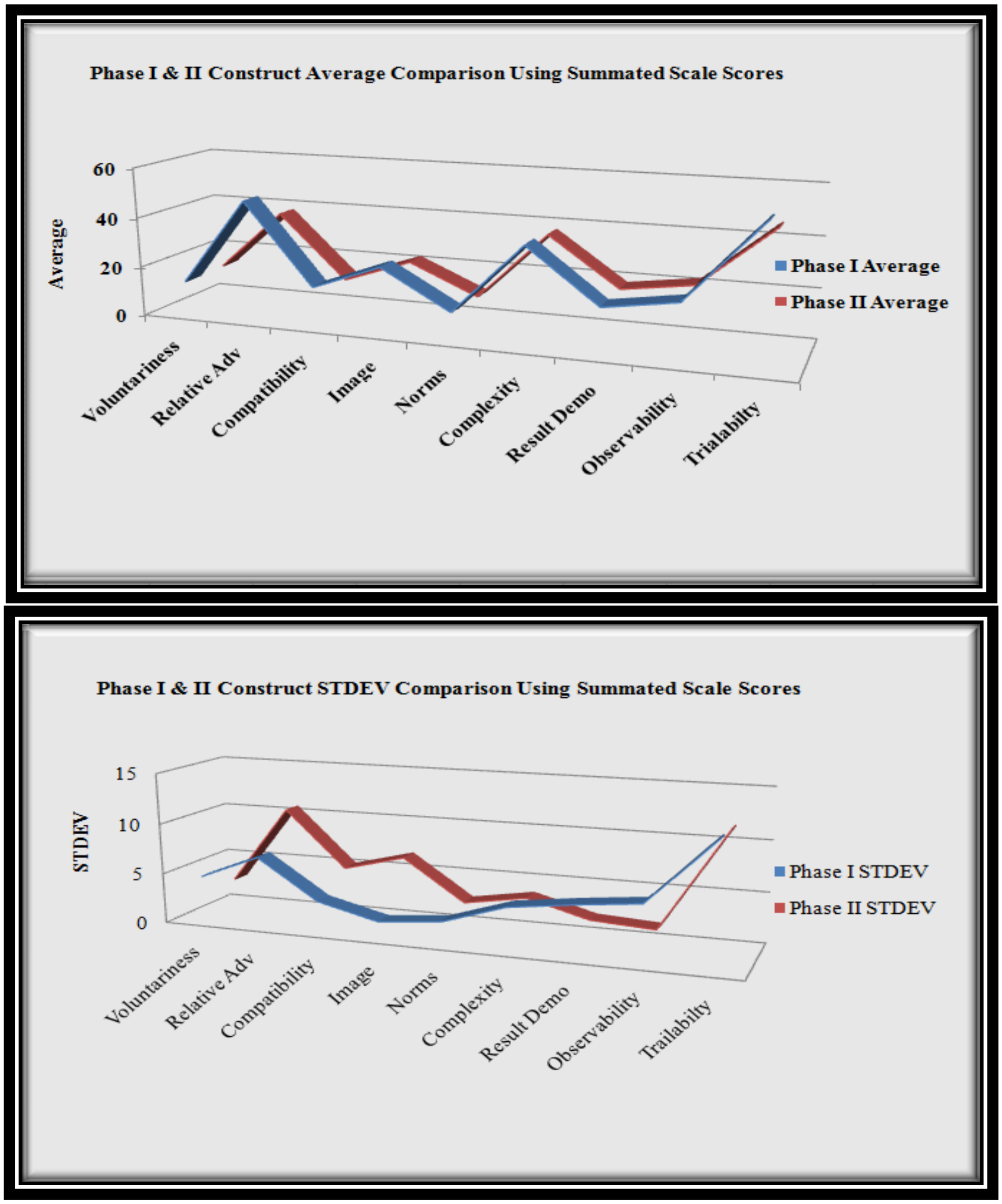

Figure 4.2 Phase I & II Average & Standard Deviation Comparisons Using Summated Scale Scores

The average score comparison between Phase I and Phase II participants are very similar (Table 4.1). The largest average discrepancy between the two groups were between the Compatibility construct with the Phase II participants having a 22% lower average; the Complexity and Relative Advantage construct with Phase II participants having a 21% lower average; the Trialability construct having a 16% lower Phase II average and a 15% lower Phase

II average with the Image construct. The constructs of Relative Advantage, Compatibility and Image show a large spread of standard deviation, whereas the constructs of Voluntariness, Norms, Complexity, Observability and Trialability had a small spread of standard deviation (Figure 4.2).

CHAPTER 5

DISCUSSION

Even though this initiative did not kick off until 2008, there has been an ongoing conversation with MAREX, GA EPD, SGRC and the Coastal Health District since 2005. There have been numerous meetings between project partners from brainstorming the initial grant application to project planning and implementation. This project has been a successful endeavor, in that data was collected using the OSDS project procedure over the period of the grant. The big question is will the Coastal Health District continue using the process once grant funding expires.

Lessons Learned

Unforeseen issues did surface during the implementation of the procedure in Phase I, as would be expected in a pilot study and therefore potentially hindering adoption of technology to a degree. Through lessons learned, these issues were combated, in hopes of a smoother adoption process for Phase II. Due to economic constraints, the Coastal Health District along with the local county health departments of Phase I were forced to reduce their workforce and operating budgets during the project period. Unfortunately, the additional project responsibilities produced a work overload for the cooperating inspectors when combined with day-to-day health department duties. The scheduling of times and days for field data collection became less structured, by picking up GPS coordinates when possible and not necessarily adhering to a set schedule. MAREX developed a field collection schedule that corresponds with an invoice period for each of the Phase II counties. This will keep Phase II counties on track and prevent a last minute push to gather any remaining data.

Data transfer from the local county office to the administrator of the WelSTROM database was a convoluted process in Phase I. Environmental Health Inspectors periodically emailed captured GPS coordinates to the MAREX GIS Coordinator for quality control. Data sets were then loaded into an OSDS Google Earth project tracking website. Once quality control was ascertained, the MAREX GIS Coordinator would then send the file of OSDS coordinates to the SGRC to be loaded into the WelSTROM database.

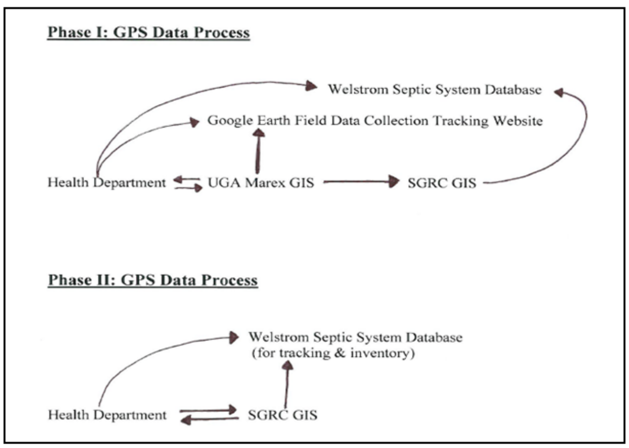

Figure 5.1 GPS Data Process

Phase II of this initiative involved only one GIS expert, as shown in the diagram (Figure 5.1). The SGRC will cover all GIS tasks in this project and will monitor quality control and tracking with only one website, the WelSTROM database. This streamlined process will be more efficient than before. There was also some early resistance in using the WelSTROM database among the individual county health departments. The counties are already using the state mandated, Garrison Enterprises, Inc. database for OSDS permits, as well as, for restaurants, individual hospital records, etc. However, the Garrison database is neither designed with a GIS mapping tool, nor provides the means to analyze important water quality layers such as, flood zones, pollution susceptibility, groundwater recharge zones, etc. The early confusion among counties was that in each county employee's believed they would be required to enter data into two separate computer databases, producing twice the workload. However, this is not true. The

State of Georgia and the Southern Georgia Regional Commission are working in together, so that all Garrison OSDS information is compatible with the WelSTROM database. At this time a periodic data transfer between the two databases is made to keep project data updated. In the future, the WelSTROM GIS mapping component will be a fixture inside of the Garrison database. As of now, any data that is entered into the Garrison database will be available in WelSTROM and vice versa. The goal of the database system will be to have Garrison seamlessly linked to WelSTROM as the GIS mapping portal.

Project Observations

Phase I counties were very proactive in the beginning. Environmental Health Managers and Inspectors saw the value in the process immediately. However, when some learned that each county would be given the same amount of funding to do the fieldwork, there was an issue. Some Phase I counties are populated tenfold of others. Just before beginning the project, some counties went through budget cuts, which resulted in the elimination of some staff positions. Some counties also had logistical issues having two offices, with only one Trimble Juno SB GPS unit. Being each county in this project was only given one of these units for historical data, this kept the OSDS project procedure speed at a slow pace at some points during the process. This made the adoption of technology much harder to diffuse if the process in question is not used consistently. One county had technical computer proficiency issues and had a very hard time grasping the concept of the process. Three of the four Phase II counties have quickly begun the project and have continued to meet every data transfer deadline. One county in Phase II has not begun fieldwork due to budget reduction.

Conclusion

Table 5.1 Phase I & II Construct Analysis

Disagree	Agree
Voluntariness	Relative Advantage
Image	Compatibility
Norms	Complexity
Trialability	Result Demonstratibility
	Observability

Moore & Benbasat evaluated adopters and non-adopters by analyzing the construct data and asking the participants one question, are you still using the technology after the technology has been put in place. This way of analyzing the data would be impossible with this study, due to the different stages in which the participants have arrived. Therefore, the evaluation took into consideration the survey results and qualitative data from project management observation. The scoring of the instrument shows four constructs where participant are in disagreement and five constructs with the participant's agree (Table 5.1). Evidence presented here suggests that the Coastal Health District Environmental Health Managers and Inspectors are late majority adopters of the OSDS project procedure. The organization is very conservative and they seem to be a little uncomfortable with the innovation. The initiative has fallen short under the process of installing and testing the OSDS project procedure. As the evidence suggests, the Coastal Health District will continue to use the non-GIS database to inventory permit data until more training of the OSDS project procedure has taken place.

Recommendations for Practice

According to the survey results, more training of the OSDS project procedure is needed as well as instilling in the Mangers and Inspectors that this will improve image of their departments. The "Big Bang" or instant change over strategy was high risk as well as the micro level diffusion focus that can be often a prolonged process. A long term training strategy is needed to ensure adoption. Rogers defines Diffusion of Innovation as the decision to continue full use of an innovation. Therefore, project funding for more training is much needed.

Geographic information systems have had a continuous increase in use among local government agencies. These systems are now being found in almost any work environment, even public health. Even with popularity of such an innovative tool, GIS is not immune to issues regarding the diffusion of technology. The main underlying reason found for difficulties in diffusion, especially on a local government level is the lack of understanding of the appropriate steps in which in introduce the technology at rate where adoption is successful. As the findings of this study show, education, training and planning of a GIS process does not guarantee a successful adoption. “Getting a new idea adopted, even when it has obvious advantages, is difficult” (Rogers, 2003, p. 1).

The benefit of this study sheds light on constructs that are essential for adoption of GIS technology. While the some of the results reported in this study were designed under previous tested constructs, this study took additional steps in expanding and exploring the view of GIS technology adoption through developing new construct on norms. It is my hope that this study will help the Diffusion of Innovation research as well as increase the understanding of the important steps in GIS technology adoption.

Recommendations for Further Research

Future studies could be explored between the differences in both Phase I & II. This could include both a further defined survey questionnaire as well as using qualitative data by holding interviews with participants. A larger sample size may help refining the study. The South Health District has used a very similar GIS technology procedure, albeit this health district is not under the GA EPD’s CNPS program area. There are ten counties in the South Health District: Ben Hill, Berrien, Brooks, Cook, Echols, Irwin, Lanier, Lowndes, Tift & Turner. This could drastically help in gathering thirty plus participants. An instrument could be designed for district management personnel, to determine their knowledge, attitude and behavior towards the OSDS project procedure. Some future construct statements could answer the following questions:

How long will it take for adoption?

Is there an economic benefit?

Will there be regulatory change?

Will this change the way the health district does business?

Does the process take too long in the field?

Are you eager to be the first to try new innovations?

Do you adopt innovations easily and influence others to do so?

Are you willing to follow the lead of others in adopting innovations?

Are you suspicious of innovations?

Are you always looking for innovations?

Are your opinions about innovations respected by your supervisors?

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APPENDIX A

personal access code: (000-000)

Date

Environmental Health Manager or Inspector
County Environmental Health Department
Street or P.O. Box
City, Georgia Zip

Dear Madam or Sir:

I am a graduate student under the direction of Professor Diana King in the Department of Agricultural Leadership, College of Agriculture and Environmental Science at The University of Georgia. I invite you to participate in a research study entitled, "Diffusion of Innovation: The Adoption of GIS Technology by Coastal Georgia Environmental Health Departments". The purpose of this study is to gather information in understanding the quality of the coastal septic and well system location, inspection & maintenance initiative (OSDS), to be more specific, the GPS equipment and process of entering data, visual inspection method and the transfer of coordinates and other information into either the WelSTROM or state mandated Garrison database. The survey will gather important information as to how the procedures have affected your day to day operation. The best way we have of learning the quality of the project is by asking the environmental health authority in each of the counties to share their thoughts and opinions.

Your participation will involve taking a survey questionnaire and should only take about 20 minutes. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. Your responses are voluntary and will be kept confidential. No personally identifiable information will be associated with your responses in any reports of this data. The results of the research study may be published, but your name will not be used. In fact, the published results will be presented in summary form only. Your identity will not be associated with your responses in any published format. The findings from this project may provide information on technology adoption regarding the coastal septic and well system location, inspection & maintenance initiative (OSDS). There are no known risks or discomforts associated with this research.

If you have any questions about this research project, please feel free to call me, Ray Bodrey at (912) 264-7341 or send an e-mail to rbodrey@uga.edu. Questions or concerns about your rights as a research participant should be directed to The

Chairperson, University of Georgia Institutional Review Board, 612 Boyd GSRC, Athens, Georgia 30602-7411; telephone (706) 542-3199; email address irb@uga.edu.

By completing and returning this questionnaire in the envelope provided, you are agreeing to participate in the above described research project.

Thank you for your consideration! Please keep this letter for your records.

Sincerely,

Ray Bodrey
Project Coordinator
University of Georgia Marine Extension Service
Water Quality Program
715 Bay Street
Brunswick, Georgia 31520
(912) 264-7341 office
(912) 531-2549 cell
rbodrey@uga.edu

APPENDIX B

Coastal Septic & Well System: Location, Inspection & Maintenance Initiative

Project Questionnaire

Please use the following response options in the table provided:

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

1. My superiors expect me to use the OSDS project procedure.

7 6 5 4 3 2 1

2. My use of the OSDS project procedure is voluntary (as opposed to required by my superiors or job description).

7 6 5 4 3 2 1

3. Although it might be helpful, using the OSDS project procedure, is certainly not compulsory in my job.

7 6 5 4 3 2 1

Instrument Number 001

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

4. Using the OSDS project procedure enables me to accomplish tasks more quickly.

7 6 5 4 3 2 1

5. Using the OSDS project procedure improves the quality of work I do.

7 6 5 4 3 2 1

6. Using the OSDS project procedure makes it easier to do my job.

7 6 5 4 3 2 1

7. The advantages of my using the OSDS project procedure far outweigh the disadvantages.

7 6 5 4 3 2 1

8. Using the OSDS project procedure improves my job performance.

7 6 5 4 3 2 1

9. Overall, I find using the OSDS project procedure to be advantageous in my job.

7 6 5 4 3 2 1

10. Using the OSDS project procedure enhances my effectiveness in issuing permits and keeping clear records.

7 6 5 4 3 2 1

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

11. Using the OSDS project procedure gives me greater control over my work.

7 6 5 4 3 2 1

12. Using the OSDS project procedure increases my productivity.

7 6 5 4 3 2 1

13. Using the OSDS project procedure is completely compatible with my current operating procedure.

7 6 5 4 3 2 1

14. I think that using the OSDS project procedure fits well with the way I like to work.

7 6 5 4 3 2 1

15. Using the OSDS project procedure fits naturally into my work style.

7 6 5 4 3 2 1

16. Using the OSDS project procedure improves my image within the organization.

7 6 5 4 3 2 1

17. Because of my use of the OSDS project procedure others in my organization see me as a more valuable employee.

7 6 5 4 3 2 1

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

18. People in my organization who use the OSDS project procedure have more prestige than those who do not.

7 6 5 4 3 2 1

19. People in my organization who use the OSDS project procedure have a high profile.

7 6 5 4 3 2 1

20. Having the OSDS project procedure is a status symbol in my organization.

7 6 5 4 3 2 1

21. I would be more likely to use the OSDS project procedure if others in my organization also used it.

7 6 5 4 3 2 1

22. I feel pressure to perform the OSDS project procedure.

7 6 5 4 3 2 1

23. In my office, one sees the OSDS project procedure equipment on many desks.

7 6 5 4 3 2 1

24. I feel as I am in competition with other health departments in better performing the OSDS project procedure.

7 6 5 4 3 2 1

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

25. I believe that the OSDS project procedure is cumbersome to use.

7 6 5 4 3 2 1

26. It is easy for me to remember how to perform tasks using the OSDS project procedure.

7 6 5 4 3 2 1

27. My use of the OSDS project procedure required a lot of mental effort.

7 6 5 4 3 2 1

28. Learning to operate the OSDS project procedure was easy for me.

7 6 5 4 3 2 1

29. Using the OSDS project procedure is often frustrating.

7 6 5 4 3 2 1

30. My interaction with the OSDS project procedure is clear and understandable.

7 6 5 4 3 2 1

31. I believe that it is easy to get the GPS device and GIS database to do what I want it to do.

7 6 5 4 3 2 1

32. The difference between the WelSTROM and Garrison database and why each is used in the OSDS project is easily understood.

7 6 5 4 3 2 1

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

33. Overall, I believe that the OSDS project procedure is easy to use.

7 6 5 4 3 2 1

34.I would have no difficulty telling others about the results of using the OSDS project procedure.

7 6 5 4 3 2 1

35. I believe I could communicate to others the consequences of not using the OSDS geo-location procedure.

7 6 5 4 3 2 1

36. The results of using the OSDS project procedure are apparent to me.

7 6 5 4 3 2 1

37. I would have difficulty explaining to others the rationale behind using the OSDS project procedure.

7 6 5 4 3 2 1

38. I have seen what others do using their OSDS project procedure.

7 6 5 4 3 2 1

39. I have seen the OSDS project procedure in use outside of my county.

7 6 5 4 3 2 1

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

40. The OSDS project procedure is not very visible in my organization.

7 6 5 4 3 2 1

41. It is easy for me to observe others using the OSDS project procedure in my health district.

7 6 5 4 3 2 1

42. I have had plenty of opportunity to see the OSDS project procedure being used.

7 6 5 4 3 2 1

43. I have not seen many others using the OSDS project procedure in my health district.

7 6 5 4 3 2 1

44. I've had multiple opportunities to try various OSDS project procedure applications.

7 6 5 4 3 2 1

45. I know where I can go to satisfactorily try out various uses of the OSDS project procedure.

7 6 5 4 3 2 1

46. The OSDS project procedure was available to me to adequately test run various applications.

7 6 5 4 3 2 1

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

47. Before deciding whether to use any OSDS project procedure applications, I was able to properly try them out.

7 6 5 4 3 2 1

48. I was permitted to use the OSDS project procedure on a trial basis long enough to see what it could do.

7 6 5 4 3 2 1

49. I am able to experiment with the OSDS project procedure as necessary.

7 6 5 4 3 2 1

50. I can have OSDS project procedure applications for long enough periods to try them out.

7 6 5 4 3 2 1

51. I did not have to expend very much effort to try out the OSDS project procedure.

7 6 5 4 3 2 1

52. I don't really have adequate opportunities to try out different things with the OSDS project procedure.

7 6 5 4 3 2 1

53. A proper on-the-job test-run of the various uses of the OSDS project procedure is needed.

7 6 5 4 3 2 1

extremely disagree	1
slightly disagree	2
inclined to disagree	3
neutral	4
inclined to agree	5
slightly agree	6
extremely agree	7

54. There are enough people in my organization to help me try the various uses of the OSDS project procedure.

7 6 5 4 3 2 1

55. I was born in 19

56. Male Female

57. Years of experience in environmental health

58. The highest level of education I have completed is

H.S. Diploma	
Some College	
Bachelor's Degree	
Some Graduate School	
Masters	
Doctorate	

Thank you for your responses!