Understanding of data quality in human sensor web

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by

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Abstract

As Volunteered Geographic Information (VGI) evokes many researches about geoinformation collecting, it also causes some problems about its data quality. Because of those VGI contributors without academic or technique background, sometimes those VGI becomes unreliable. Hence, the factors to impede individuals to contribute correct information are needed to be understood.

Human sensor web is one typical example of VGI in Zanzibar. Citizens can send SMS to complain about their water problems to human sensor web system. However, because of their culture or their personal judgement about reporting water problem, there are different complaining types. This research used test-retest method, history of water complaining events, water meter data, and the outcome of human sensor web to explore the reason to hinder citizens from contributing correct messages to human sensor web system.

One reason to impede citizens send correct message is the information gap between man and woman in one household. Most of mobile phone users in Zanzibar are men, but the one dealing with water collecting job is woman. Even 40% to 50% of women with mobile phones, women still share the ownership of mobile phones with their husbands or relatives. In the process of informing their husbands to send SMS to human sensor web system, it causes the water complaining messages not be sent immediately, information delayed, or wrong messages because of the wrong memory.

Mistrust of water provider also causes citizens not willing to use human sensor web system. Because of the water payment issue, unbalanced development between urban and rural area, and no feedback about their complaints, citizens do not trust ZAWA can improve their lives. In this cases, citizens consider human sensor web represents the complaining system of ZAWA. Hence, citizens will not willing to use this system.

Local leader (Sheha) plays a crucial role of changing citizens' willingness to use human sensor web in one community. If sheha support human sensor web system, most of the citizens from that community will be encouraged to use this system. In other case, if sheha rejects to use human sensor web, there will be no one from that community sending complaining messages.

Finally, by evaluating the messages from human sensor web system, there are there types of wrong messages be sent by citizens. Wrong typing style, long sentence of SMS, and the SPAM cause those SMS can not be identified and recognizes automatically by system.

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List of Abbreviations

CER	Civil Event Reports
GSM	Global System for Mobile Communications
HSW	Human Sensor Web
ICT	Information and Communications Technology
SMS	Short Message Service
VGI	Volunteered Geographic Information
ZAWA	Zanzibar Water Authority
ZMCP	Zanzibar Malaria Control Program

1. Introduction

Over the past decades, collecting the information of the water supply in Africa has been heavily relying on traditional labour work, without the aid of geo-informatic technology. In addition, the data of water access points have been available merely for the governmental officers. A recently developed method using mobile communication is investigated in Zanzibar, an island in the United Republic of Tanzania (Fig. 1.1). The employed method is based on human sensor web, which monitors a service by public activity as observers(Jürrens, Bröring et al. 2009).An evolution of data quality is studied as a fieldwork in Zanzibar. Currently cell phones are widely used in Tanzania; people deliver messages by voice and texts (Molony 2008). As cell phones being a popular communication tool, the proposed human sensor web is applicable for monitoring water service and supply in Zanzibar. This research investigates the reliability of a system that human can be considered as sensors to provider volunteered geographic information.

Figure 1.1 Zanzibar map

1.1. Background

1.1.1. Study area - Zanzibar

The principal source of water on Zanzibar is ground water, which is found in various places under differing aquifer condition, including natural springs and caves, and exploitation has been through drill boreholes and hand dug shallow wells. Currently about 65% of total population has access to clean and safe water supply comprising about 51% in rural and 75% in the urban areas. The

challenges in the rural area are irregular supply caused by aged pumps, few water sources, and insufficient availability of water (Millennium Challenge Account-Tanzania 2008).
Most people in Zanzibar subsist on incomes of less than US $0.50 per day, with tourism being the major resource of the employment. Tourism and commerce are basic source of revenue for Zanzibar government. With the growth of tourism business, the total water abstracted from the ground of three urban areas by 2020 will be 12,000 cubic meters, daily giving annual 4.4 million cubic meters(Halcrow 1994). As a result, adequate and reliable water resources are crucial for the economic development of Zanzibar. Moreover, monitoring the water supply system is an essential method to provide information of availability and proximity water sources for the citizens.

1.1.2. Volunteered geographic information

In the past few years, as the people can contribute their own local knowledge to the Web, the way people interact with information has been changed. The ability to connect with others and share the information creates the new way to communicate to the world quickly and easily. Goodchild (2009) considers this contributed information as Volunteered Geographic Information (VGI). As the proliferation of VGI, it also evokes the problem of data quality. Because most VGI are contributed by individuals without academic or technical background, it is difficult to connect and authenticate those VGI. Hence, this problem produces another cost for gatekeepers and quality controller.

Source information is crucial to credibility because it is the primary basis to VGI. The way people contribute VGI and the motivation of contributing VGI are the essential to evaluate data quality. In some cases, these VGI are unavailable, masked, or missing from a web site. More specific cases are in chapter 2.

1.1.2.1. Human sensor web

Since VGI is used widely, one case of VGI is human sensor web system in Zanzibar. Sensor Webs are deployed to collect and disseminate real or near time data enable and hoc monitoring of environmental phenomena(Joshi and Wytzisk 2005). As defined in the NASA New Technology Report on Sensor Web, the Sensor Web consists of a system of wireless, intra-communicating, spatially distributed sensor pods that can be easily deployed to monitor and explore new environments (Delin, Jackson et al. 1999). The goal of Sensor Web is to extract knowledge from the data collected and adapt and react accordingly. The information gathered by one pod is shared and used by the other pods. Data from various pods are shared as well as communicated throughout the entire web (Delin and Jackson 2003).

The human observation integrates with the Sensor Web technology and present as Human Sensor Web system. As cell phone is rapidly growth as the main communication techniques, every human with cell phones is able to act as an intelligent sensor to report his or her own observation with geographic knowledge of the area where he or she lives(Goodchild 2007).Those human sensors/pods distribute around the communities where they live and with the sensitivity to every environmental event in their daily lives. All coming observations are processed by Sensor Event Service (SES) using a trust model based on reputation of each user who submitted an observation to system via mobile phones (Jürrens, Bröring et al. 2009). Based on the VGI of each human sensor, human sensor web can improve and empower the service quality.

The function of reporting environmental event s to human sensor web system is as figure 1.2 below. At the initial stage of human sensor web, this system uses for water availability monitoring in Zanzibar. First, the reporters submit observations about the water supply and quality. Second, subscribers receive alerts regarding the local water availability information. The submission of data as well as the alert notification relies on the Short Message Service technology. The users of the system are untrained citizens who report if a water point is out of order. This system covers those regions where water points are located, such as public pipeline water points or local well. Those water points with the billboards to necessary information for submitting observations, such as the ID of the water points, a phone number where to send the observations and the allowed vocabulary to encode the observation (Jürrens, Bröring et al. 2009).

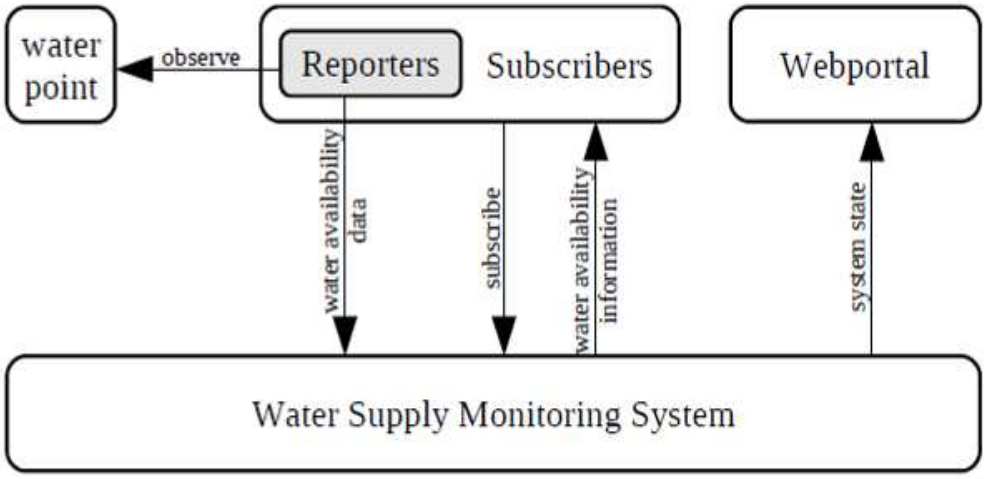

Figure 1.2 : water supply monitoring system (Jürrens, Bröring et al. 2009)

1.1.2.2. Citizens are the key VGI source

All the VGI information is based on citizens' contribution. Without citizens' messages, decision makers or system manger cannot understand what citizens' need immediately and react to these urgent problems quickly. Those people who participant in human sensor web system can be classified as three different characters. Figure 1.3 illustrates the operation and three participants' relationships in the system, including 1) citizens, 2) system managers, and 3) decision makers. Citizens observe water availability problem and then report to system by SMS (short message service). Based on citizens' messages, a system manager can allocate engineers to repair the water availability problem and provide feedback to those citizens who are subscribed to the system. In the initial stage of operation, system managers are also the tester of this system. Finally, based on the reliability of water availability report in system, decision makers can assign water equipments on the areas where lack of water availability.

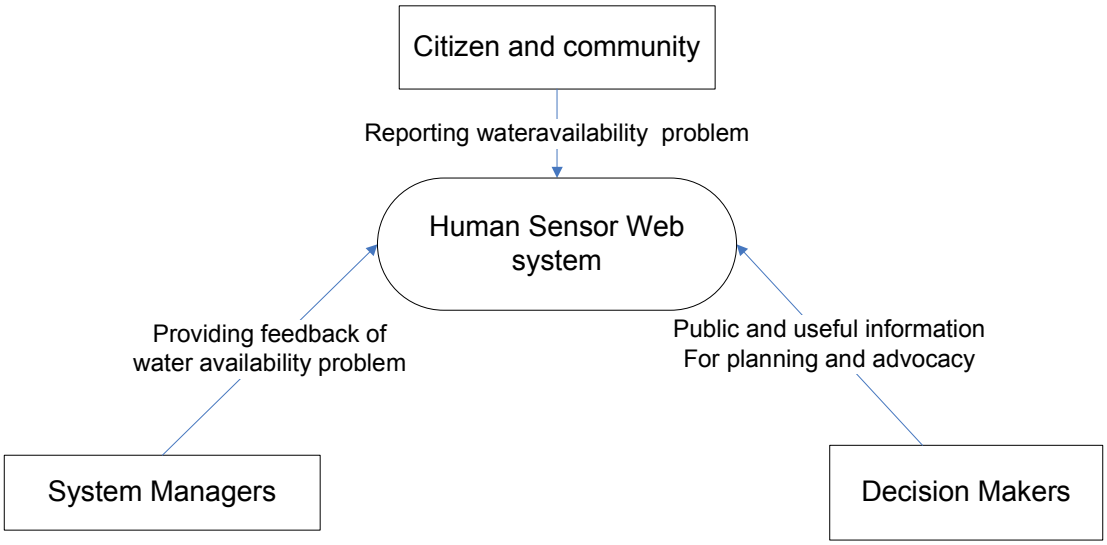

Figure 1.3: Operation of human sensor web system

1.1.3. Definition of data quality

The VGI of each human sensor (citizen) produces concerns with its quality, reliability, and value as an information resource. Many of the information contributors are developed by those individuals with no background of interests in the technological training. Because VGI is unlike the traditional mapping agency data which always has been collected with the minimum of quality measure or standards, VGI is without appropriate mechanism to standardise and validate data. Sometime, VGI may become a liability rather than an asset. If appropriate data validation and checking has been undertaken, the liability can be reduced dramatically.

Data are considered as high quality if they correctly represent the real-world construct to which they refer. Quality can simply be defined as the fitness for use for a specific data set (British Columbia Government). In the information system literature, data quality is a multi-dimensional concept.(Wang and Strong 1996; Ballou, Wang et al. 1998; Pipino, Lee et al. 2002) Data quality is the state of accuracy, completeness, currency, volatility, and timeliness that makes data appropriate for a specific use.

Accuracy is defined as the closeness between a value v and a value v', considered as the correct representation of the real-life phenomenon that v aims to represent. Completeness can be generically defined as "the extent to which data are of sufficient breadth, depth, and scope for the task at hand." Currency concerns how promptly data are updated. Volatility is defined as the length of time data remains valid. Timeliness implies that data not only are current, but are also in time for events that correspond to their usage. Therefore, a possible measurement consists of (i) a currency measurement and (ii) a check that data are available before the planned usage time (Batin and Scannapieca 2006).

Table 1.1 Dimensions of data quality (Batin and Scannapieca 2006)

Dimension of data quality	Definition
Accuracy	the closeness between a value v and a value v'
Completeness	the extent to which data are of sufficient breadth, depth, and scope for the task at hand
Currency	how promptly data are updated
Volatility	the length of time data remains valid
Timeliness	Not only are current, but are also in time for events that correspond to their usage

In this research, data quality is considered as the reliability of citizen's reporting message via SMS. High reliability of citizens' message represents the water availability problems. If data quality is poor, the water availability problem can not be verified. To simplify the data quality problem, this research has two different definitions of reliability, including 1) data quality and 2) uncertainty. Figure 1.4 illustrates the relative characters involved in different classes.

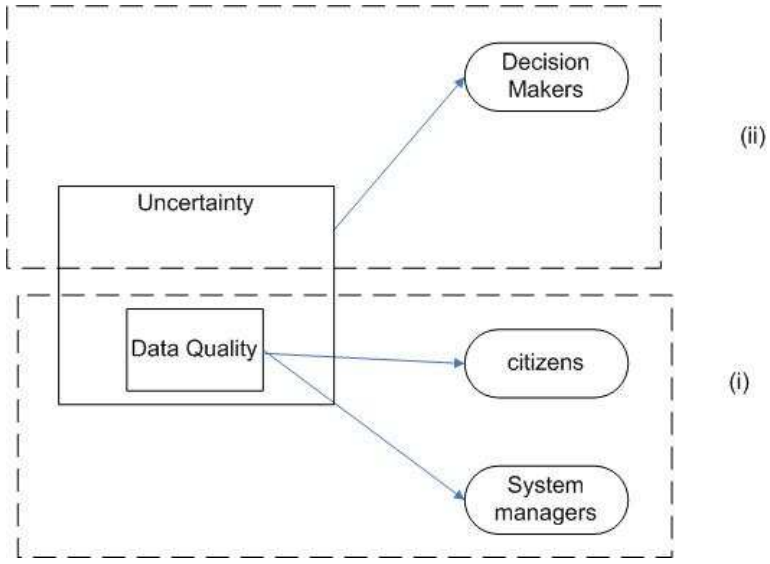

Figure 1.4: Data quality and uncertainty

1.1.3.1. Data quality

In this research, data quality considers as the reliability of citizens' messages in human sensor web system. In figure 1.4, box (i) illustrates that data quality contains citizens' reporting messages and system managers' providing feedback to citizens. The main source of dubious data quality may come from the differences of personal reactions to report water availability. Hence, the key driving factos of citizens' various messages are needed to be understood.

1.1.3.2. Uncertainty

The uncertainty contains reliability of data quality and how decision makers handle and react to perceived data quality. In order to improve water supply system, decision makers understand water availability problems based on citizens' reporting to human sensor web system. According to the output data from human sensor web system, decision makers deal with the uncertainty to give the reaction to allocate future availability of water supply. Citizens' messages and decision makers'

reaction have same influence to uncertainty. Because the time limited in fieldwork, this research did not collect the opinions from decision makers, and only focused on the basic class of data quality.

1.2. Justification of this study

The data quality of the system is important for water provider to improve the water availability. Decision of consequence depends on thousands of pieces of data. Lack of complete, accurate, and timely data about water availability problems may hinder water provider from developing sound strategy. Poor data impacts decision making that makes implementation of data warehouses, whose purpose is to help an organization make better decisions, more difficult(Celko 1995). The current state is preliminary test for human sensor web system to understand data quality. Poor data quality could make misunderstanding about water availability condition. Therefore, water provider could make incorrect decision and put water resource on inappropriate place. The inappropriate relocation of water resource may lead directly to users' dissatisfaction, mistrust of water providers, and increased cost in the operating process(Redman 1998). When trust breaks down, the users' initial low trust level can encourage negative judgement. Even though the offender may be unintentional and previously benevolent, the user is more likely to perceive the offender's actions as being intentional (Vasalou and Riegelsberger 2008).

The system would be promoted to report more significant events in future, for instance, damaged bridges, a fire, pollution, pipeline leakage, violence in East Africa. The system manages water availability problem in the initial state. In this case, this research focuses on specific part of water availability problem. The impact of verified human sensor web system in water availability of Zanzibar should be considered.

1.3. Research Design

1.3.1. Objective

This research is to understand the factors influencing the data quality of human sensor web system. To evaluate the data quality, this research used test-retest method, the history of water complaining in Zanzibar, water meter data, and the current complaining water SMS from human sensor web system as the data sources. And based on data, find out the factors cause citizens to send wrong or false messages.

1.3.2. Problem

Because of the real/ near real time observation data, human sensor web is not only to monitor community events, but also monitor what people need about their environment. Table 1.2 illustrates the difference between human active or inactive behaviour on report and their result on active or inactive water usages. If there is no human active behaviour on report and water usages, the outcome is like technically system of water availability; hence, there are no reporter's opinions involved. If human is with inactive behaviour on active water usage report, the technique system only can collect water consumption data on each water point; hence, the system would be like water meter, only record

the time and amount of water usages. If there is human with active behaviour on report but without active on water usages, the outcome is like flood disaster control. People's responses are passive about water happened around them. So the active reporter cannot express their opinions of flood. If human is with active behaviour on reporting active water usages, the technique system is not only record water consumption but only what people need about water. And this active manner and behaviour of contributing information is typically local VGI.

Table 1.2 Human behaviour on report and water usages

	Humans inactive on report	Humans actives on report (human sensors)
Humans inactive on water usages	Water availability	Disaster control (flood)
Humans active on water usages	Water consumption (water meter)	Water needs (human sensor web)

.

However, since human sensor web is typical VGI, it also has the same problems as other VGI cases. Human sensor web has to be validated and checked its data quality. Because of different motivation and situation of individuals, everyone has different water need. Hence, this will cause citizens to send VGI messages about water need by his/her own judgement of water condition to human sensor web system.

To understand the reasons to make VGI unreliable, this research is basically empirical. As the SMS received in human sensor web system, the reliability and credibility of citizens' message would influence the output of data quality. To monitor what people need and their manners about water complaint, this research used test-retest method to evaluate if citizens' answers about water complaint are consistent or not in the two tests. This research also compared the result of history of water complaining, water consumption from water meter, and the initial result from human sensor web system, hence, this research points out the reasons and factors influencing citizens sending messages.

1.4. Research Questions

1 How does the level of data quality affect the human sensor web?
2 What are the key drivers to cause reliability of citizens' message?
3 What are the suggestions to provide useful information to support and empower the user?

Research Matrix

Research Objectives		Research Questions	Data Sources	Data Acquisition	Method of Analysis
To understand the factors influencing the data quality of human sensor web system	a) Understand the data quality of human sensor web system	What are the key drivers to cause reliability of citizens' message?	Secondary / primary	Literature Review/ Questionnaires/ Interviews	Statistical analysis/ Qualitative analysis
	b) To provide recommendations to increase accessibility and usages of human sensor web	What are the suggestions to provide useful information to support and empower the user?	Secondary / primary	Literature Review/ Questionnaires/ Interviews	Statistical analysis/ Qualitative analysis

2. Literature Review

2.1. Mobile phone usages

Information and Communications Technology (ICT) has transformed the world. By connecting people and place, mobile phone compensates for the insufficient infrastructures, such as bad roads, and slow postal services, not only allowing people to move more frequently and freely, but also making market more efficient.

There is a clear shift from fixed telephone line to cell phone use in the world. Figure 2.1 shows the report of International Telecommunication Union about the globe ICT development. At the end of 2008, the world has 1.3 billion fixed telephone lines, which refers to 19 per 100 inhabitants, but the global presentation of fixed telephone line has already been stagnant under 20% since 1998. In the contrast, there are around 61 per 100 inhabitants in the world with mobile cellular telephone subscriptions. There is an increase of mobile phones between 2002 and 2007.Especially in Africa countries (see figure 2.2), the mobile cellular telephone subscription is already raised 7 times (28/4), which is the most rapidly increasing region in the world.

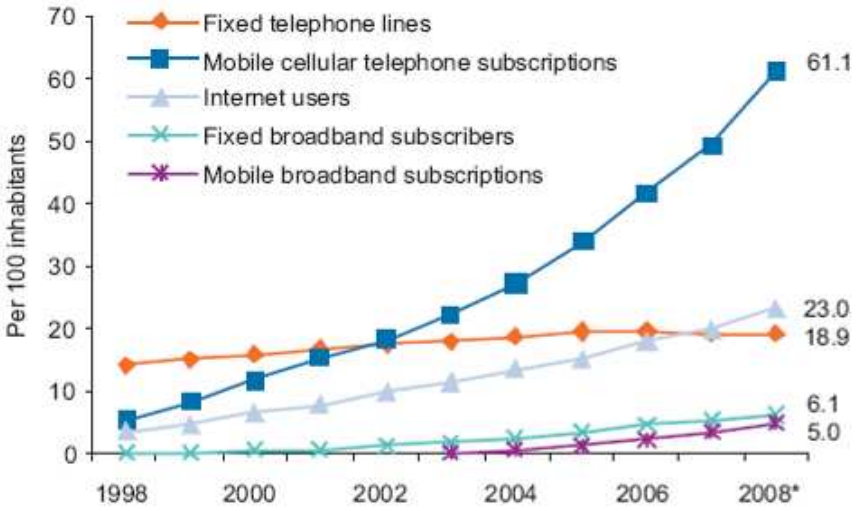

Figure 2.1: Globe ICT development (International Telecommunication Union 2009)

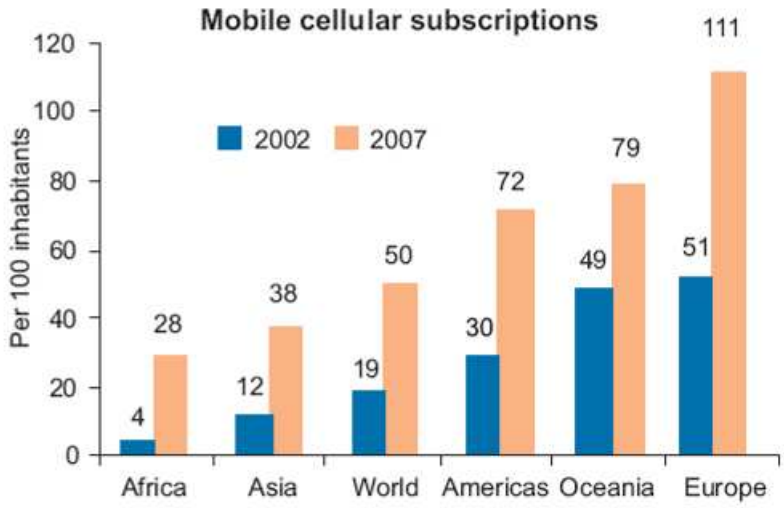

Figure 2.2 Mobile cellular subscriptions (International Telecommunication Union 2009)

2.1.1. Mobile phone in Africa

Because of insufficient coverage of the traditional and fixed telephone line, there are now more and more people in Africa using mobile phones with Global System for Mobile Communications (GSM) coverage across the continent. In 1995, there are only 2 fixed phone lines per 100 inhabitants in Africa. This limited accessibility of fixed telephone line had done only little effect to people in Africa (ITU Telecom Africa 2004). And the slowly upgrading of the availability of fixed line made insufficient state worst. For example, a wait of four to five years to have a line installed was apparently common in Zanzibar(Hancock 2005). The slowly upgrading of fixed line aggravates the digital divide in Africa (Dickinson 2003).

The mobile phone diminishes the digital divide of traditional fixed telephone lines to improve poor people's lives. Being able to make and receive a call means people are not isolated, even they are in poor area without sufficient infrastructure. In the place with bad roads, unreliable postal service, few trains and rare landlines, it is difficult for poor people to access the latest information. But now, it is a big advantage for people to use mobile phone .Mobile phones can substitute for travel; allow quicker and easier access to information on prices enable traders to reach wider market boost personal entrepreneurship. For instance, fish is one of income source in Zanzibar. Fishman in Zanzibar now carry mobile phone while they are at sea, and they use mobile phones to check the market price. At that time, if there are too many fish in Zanzibar, they will sail to Dar es Salaam to get better price to make more money (Hancock 2005).

As mobile phone become commonplace, service providers use mobile phone to offer multiple services to facilitate people's lives. M-PESA is the product of a money transfer service via mobile phone in Kenya. People can complete basic transactions by their mobile phones without the need to visit a bank branch. M-PESA customer can use e-money to deposit and withdraw money, transfer money to other users and non-users, pay bills, and purchase airtime. M-PESA first becomes popular as a way for young, male urban migrants to send money back to their families in the rural area. Those migrants are the money-senders, and then they influence recipients, who are usually female, less educated, and poorer in the rural area, to use M-PESA. The recipients are usually considered as "technology

laggards", who are always less access and adapt to an innovation (Rosenberg 2008). Because of the non-direct relationship with a bank, M-PESA has lead to m-banking, which benefit people that there is no need to queue up at the bank every month to hand over a wad of bills, and carry lots of money. It is a fast, cheap, and safe way to transfer money than the traditional alternative, which is slow and costly to carry money through public transport to arrive the bank. Because of the convenience of using M-PESA, people use to pay for everything from school fees to tax, and the recipients in rural area can spend their time on more productive issues(The Economist 2009).

2.2. Citizen as a sensor

As ICT rapidly increased, more and more ICT users start to involve and report what happened in the world through ICT technology. There are largely untrained users and their action are always voluntary. Their action changes the relationship between media and users usually done before. Users are not only just the receiver of information, but they can be the information provider now. At the initial stage of Web technology, users only can surf the wed and download from Web page. This interaction is only one way. But now, users can extend what they can do on Web page. One can surf the web and create his/her personal account to access the information and refresh the databases on server. This interaction between users and media represents a dramatic innovation of what users can influence and react to the world. Goodchild (2007) called this special case of more general Web phenomenon of user generated information as Volunteered Geographic Information (VGI). Goodchild (2007) gave some VGI expamples , such as Wikimapia, Flickr, MissPronouncer, OpenstreetMap, and Google Earth. They are all geoinformation cases influenced by storming and using through users. These VGI cases refine the traditional way of collecting and mapping geoinformation.

One key role of this VGI is the users, or human. As there are 6 billion components in the world now, each human with the accessibility of Web page can change the VGI (Goodchild 2007). By motivating individual's willingness as a volunteer, Goodchild (2007) suggested that it is far cheaper than any other alternatives to collect geoinformation. VGI can tell us about what is happening in the world, especially somewhere with limited resource or nation security. VGI put focus on these regions where are ignored by the world, and empower the VGI contributors the right to speak out to the world (Goodchild 2007). We can consider VGI as an effective way to collect local information, but the reasons of volunteer contributing information are virtual to concern about data quality.

Depending on users' contribution, Coleman et al.(2009) classify VGI contributors as different category, such as neophyte, interested amateur, expert amateur, expert professional, and expert authority. Normally, the trust inclination will be focus on those individuals with high level knowledge of mapping profession. However, Coleman et al. (2009) also give the examples that either an "expert amateur " or " interested amateur" may understand an organization's mapping specifications but without the local knowledge of history or attributes. A "neophyte" knows little or nothing about the position technology, but familiar with features and detail in the location being mapped. Then those individuals with the label of "professional" or "amateur" are not sufficient for classifying the VGI contributors (Coleman, Georgiadou et al. 2009). Even different characters of each VGI contributors can have their values, non-expert amateur and the expert professional is quickly blurring (Goodchild 2009).

As VGI is reported by volunteer citizens, how to find out the trustworthy information is essential of VGI data quality. Contributors may post VGI in constructive way. Goodchild (2009) and Kramer (2009) category the motivation of users contributing VGI as their personal reputations/rewards, self-promotion, personal satisfactions, and reduce community crime. However, because we cannot assume that one VGI item is based on well-being or report is trustful, we still cannot make sure the data collected is still trustworthy. Especially with anonymous reporting, a decision maker cannot discriminate true and false report on the basis of reporter ID. In analyzing the civil event reports (CER) in Iraq and Afghanistan conflicts, Kramer (2009) found out discouragement through social pressure, threat and intimidation may be the challenges. Hence, the better way to find out the trustworthy information is to understand the motivation of individuals to impede VGI information. Coleman et al. (2009) classify several factors to impede VGI information and decrease the data quality, such as mischief, agenda, and malice and/or criminal intent.

2.2.1. Mischief

Coleman et al. (2009) define mischievous person or vandals as " *hoping to generate scepticism or confusion by replacing legitimate entries with nonsensical or overtly offensive content* " Viégas et al. (2004) give five common types of vandalism in Wikipedia, such as mass deletion, offensive copy, phony copy, phony redirection, and idiosyncratic copy. Mass deletions are the actions to remove most of the contents of a page. Offensive copy is insertion of vulgarities or slurs. Phony copy is the insertion of unrelated text to the page topic. Phony redirection often occurs in pages which contain a redirect link. Those links should redirect to a more precise term, but those redirects linking to an unrelated or offensive term. Idiosyncratic copy is the action of adding text that is related to the topic of the page, but with one-side, not of general interests, or inflammatory (Viégas, Wattenberg et al. 2004).

2.2.2. Agenda

Someone may report false events or delete information to make it overly biased in order to achieve their personal or institutions' purposes. Coleman et al. (2009) define agenda as "*independent individuals or representatives motivated by beliefs in a given community, organization or cause*". In Wikipedia, those specific contributors are always be indentified and characterized as government institutions with special interest groups to make overtly biased, misleading modifications. One example is the Diebold voting machine in Wikipedia. Someone at the company's IP deleted 15 paragraphs about the detail of the security industry's concerns over the integrity of the voting machines, and the information about the company's CEO's fund which is raising for President Bush in November 2005(Borland 2007).Another example is the civil event reports (CER) in Iraq and Afghanistan conflicts. Kramer (2009) found out one main reason causes people report false events is to harm a third party. Clans in Iraq and Afghanistan have attempted to exploit US troops by falsely reporting that another clan was an insurgent group, provoking a military reaction against the rival clan(Kramer, Costello et al. 2009). Those two cases are not the isolated ones. The biased information will cause totally different result as with full scale aspects.

2.2.3. Malice and/or Criminal Intent

When a false report is created to draw attention and resource away from an area where a hostile act is planned, a decoy occurs. Coleman et al. (2009) give the definition as “individuals possessing malicious (and possibly criminal) intent in hopes of personal gain”. One example is the false news in ireport.com that the Apple chief executive had been rushed to the emergency room. The result made a short-term fluctuation in Apple share. Apple stock fell as much as 5 percent after ireport.com published false news(Cohen 2008). The poster is from an unknown perpetrator, who did not make any earlier stories. The first poster is the Apple chief’s health issue.

After several false VGI cases, relying on the community and transparency might be one method. Google News and newstrust.net try to create some methods like rating or vetting system to ensure the reliability of news. Some reviewers can evaluate news article on a range of criteria, if these reviewers are trustworthy. Kramer (2009) proved reputation system can still give positive force multipliers reuslt even with the majority of foe elements in the population (see figure 2.3). Even there are several tool can help to identify the location of the computer from which contributors, the long-term solution will be vigilance and the literacy training for the public. Every VGI contributor is not only an information provider but also an evaluator and reviewer about what others done in the community. Everyone will be able to aware of digital vandalism and avoid the spread of rumours.

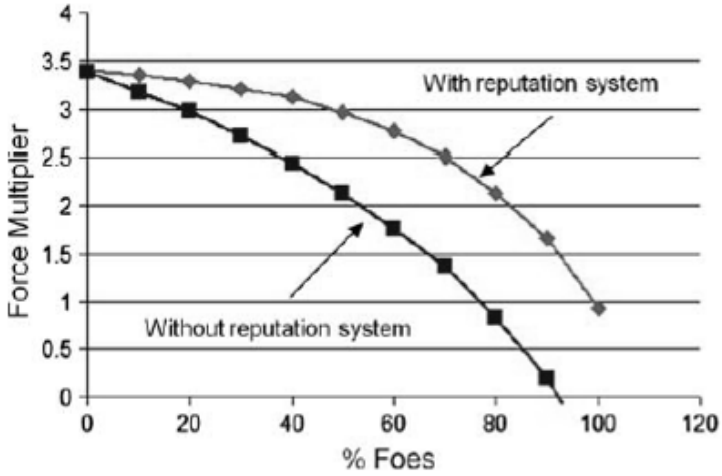

Figure 2.3 With and without a reputation system (Kramer, Costello et al. 2009)

3. Methodology

In Zanzibar, human sensor web was not widely employed in the period of fieldwork. There were not many human sensor web users and SMS reporting data. In this case, this research focuses on evaluate if citizens with consistent manner of what they send and what they said through test-retest method, not through human sensor web yet. Hence, the fieldwork consists of two parts: 1) to distribute a paper questionnaire regarding to the regional water supply, 2) to establish the human sensor web system by repeating the same questionnaire with SMS using a cell phone. There were also two additional dataset of water meter data and complaining events to ZAWA to crosscheck if citizens' SMS are consistent with reality.

3.1. Methods

There are three methods to distinguish if the information from citizens is reliable or not. Figure 3.1 shows the methodology in this research. One is test-retest reliability method, the other one is compared with water meter data, and another is water complaining events from ZAWA. The test-retest procedure is the most widely used paradigm to assess reliability, especially in neuropsychology which is the specific psychological processes and overt behaviours (Heaton, Temkin et al. 2001; Farahat, Rohlman et al. 2003). Since human sensor web is operated based on the media of SMS, the test-retest method focuses on if Zanzibarians could have consistent manner of water problems via SMS. To test the consistent manner, in the retest process, I used SMS as the media (the same as human sensor web system) to send 3 questions to interview people. And the water meter data can be additional resource to test people answer about water consumption. History of water complaining events can help to understand the characteristics of water problems in each area

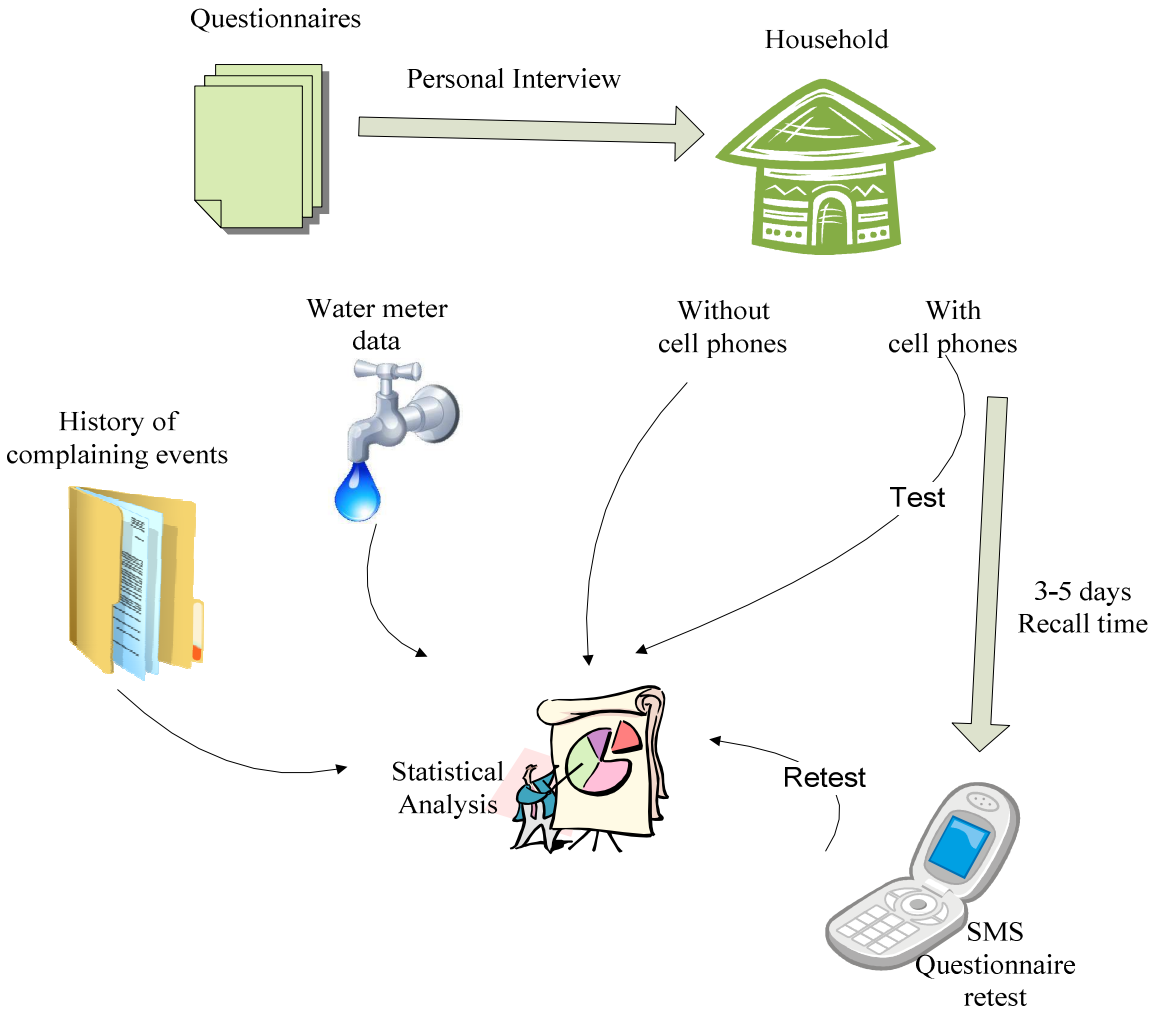

Figure 3.1 methodology in this research

3.1.1. Test-retest

According to the literature review in chapter 2, there are several factors to impede citizens to contribute VGI information. These factors will change citizens' answers and attitude via SMS, therefore, the reliability of SMS will change. It will be needed to evaluate if citizen with the consistent manner of what they send and what they say. Therefore, this reliability is considered as the ability of a measuring instrument to measure the concept in a consistent manner. In practice, the possible procedures for evaluating the reliability are test-retest, alternate form, and split-half reliability assessments (Field 2005). The "split-half" separates the questionnaire into two parts of answers. The answers on the first half of the questionnaire compared to the answers on the second half of the questionnaire. But if there is a high correlation between these two halves of the questionnaire, it can be considered as internal consistency in the questionnaire. The problem of "split-half" is how to separate the questionnaire into two parts. Different methods to separate will cause the different consistency result (Farahat, Rohlman et al. 2003; Hinton 2004; Field 2005).

Alternate form is not always available. The idea of alternate form is to change the wording of the survey question in a functionally equivalent form, or simply to change the order of the questions in the first and the second survey of the same respondents. But the problem is how to make sure the second questionnaire of alternate form is equivalent to the first test.

To test the reliability, test-retest method is the most widely used paradigm to assess reliability(Farahat, Rohlman et al. 2003). The test-retest reliability involves administering the same test to a group of participants on two different occasions. Because of the time limitation of fieldwork, this research sent retest questionnaire via SMS in 3-5 days. It measures if the two tests give the same result, and correlate the findings. A high correlation means a high level of reliability (Hinton 2004).

Test-retest reliability involves the same test to a group of participants on two different times. The interval of time between two questionnaires may be as short as with the same day or it can be as long as several years(Farahat, Rohlman et al. 2003). If the interval time is too short, respondents may remember the answers.
There are several literature researches about how the interval time between the two surveys. Farahat et al. (2003) used test-retest reliability of neurobehavioral test to evaluate changes over time. They compared two groups with 6 hours (same day) and 1 week. Therefore, they found out that the result had no difference between the group with 6 hours interviewing interval and another group with 1 week interviewing interval. Marx et al. (2003) studied the test-retest reliability for health-related quality of life instrument. They concluded that there was no significant difference by comparing the reliability at 2 days and 2 weeks.

Some literatures claim that they have used correlation as the sole indicator of reliability(Shrout and Fleiss 1979; Marx, Menezes et al. 2003), concerns have been raised about the use of Pearson product-moment coefficient (correlation coefficient) as a measure of reliability. However, according to Farahat et al (2003), this research didn't use correlation coefficient as the measure of reliability because of the following reasons. First, reliability is considered as the degree of similarity between test and retest, but correlation is often used of a predictive relationship instead of agreement. Second, the correlation coefficient cannot differentiate the error or true difference among variance components in the data set. Hence, this research consider correlation coefficient as not a true reliability coefficient (Farahat, Rohlman et al. 2003)

3.1.1.1. Participants

Households are the units of using water resource. To explicitly identify problem of water availably, this research proposed to investigate households with questionnaires and SMS. The participants of this research were the one collecting water from specific water points. Those water points were involved in the primary human sensor web system locations (see chap 4). The main method to collect data from household was personal interview in water points of urban and rural area.

3.1.1.2. Procedure

Before final form of questionnaire, this research will prepare a pilot work for questionnaire. Good pilot work is essential for successful use of questionnaires. Pilot work is likely to be exploratory, consisting of unstructured interviews and talks(Burton and Cherry 1970). This pilot work will

help to develop “free answer” to “multi-choice”. Pilot samples use respondents as similar as possible to those who will be approached in the main inquiry.

According to the result of pilot survey, fix the ambiguous and unsuitable question items to get the final questionnaire version. Before start to interview citizen, I connected to the leader of local community and showed the official introduction document of this survey from ZAWA. Therefore, I delivered questionnaires to citizens by personal interviewing in rural and urban area. Therefore, according to the returning paper questionnaires, I sent the SMS to those respondents of the paper questionnaire via mobile phone. The questions of SMS were the same as those in paper questionnaire. This research compared the answers from questionnaire and from SMS to check if those two answers are coincided or not. Because the limited time of fieldwork in Zanzibar, I chose 3-5 days recall time for retesting the questionnaire for those people who filling the questionnaires.

3.1.2. Water meter

The other method to distinguish reliability of citizens’ message is using another data source of water meter reader. Water meter records the time whenever every 10 litres be supplied in water point. In Zanzibar, there are two public water supply points with water meters, Mwembe Shauri and Nyarugusu. This research compares the water meter data with citizens’ complaining about no water. Because water meter data can assist to monitor the exact time when each water point supplies water, it can help to understand if citizens’ complaining about no water is reliable or not.

3.1.3. History of water complaining events

The other method to assist to understand the reliability of citizens’ messages is the history of complaining events to ZAWA. ZAWA organizes the customer department as the window to handle all complaining events. These complaining events are from ZAWA customer department’s database. The coverage of complaining events is almost all Zanzibar, also contains those area with human sensor web system and Mwembe Shauri and Nyarugusu where have water meter. The history events of water complaining may not give directly support to test the reliability of citizens’ message or answers about water complaining. But, the complaining event database can help to understand the history and characteristics of water problems in each area.

3.2. Questionnaire Design

Since human sensor web with an objective of empowering users and monitoring what people need, the practical challenges of data quality face a goal of creating useful, usable, and delightful HCI (human computer interaction) (Nakhimovsky, Eckles et al. 2009). To make the process of using the human sensor web effective, efficient and satisfying, the design of a user interface takes in account the reporting process of users. Hence, qualitative method can get in-depth understanding of human behaviour and the reason that govern such behaviours. Besides understanding people and what they say and do, it also important to know why someone did something or why something happened (Myers 2009).

To understand the factors that facilitate and impede information in citizens’ messages about water availability, interviewing citizens about their use of system should be considered. Because this system was not yet operated in the period of fieldwork, this research created a pretended system to help citizens experience human sensor web system and the factors of influencing data quality. Ndokosho (2007) has done the questionnaire survey about public water utilities in Namibia. He suggested a

standard questionnaire should be administered to various water customers about awareness of water service provider, quality of service, affordability of water, water quality perceptions and complaints resolutions(Ndokosho, Hoko et al. 2007).

There are three types of questions in the questionnaire general information, closed ended questions, and open ended questions part. Closed-ended question can be answered using a simple “Yes” or “No”, a specific piece of information, or a selection from multiple choices. Closed-ended question can be used for clarifying facts, verifying information already given or controlling a communication. Second kind of question is open-end question which designed to encourage a full, meaning full answer using the subject’s own knowledge and feelings. Open-ended questions also tend to be more objective and less leading than closed-ended question. The questionnaire in this research was in English and Swahili (questionnaire is translated to Swahili by James Gachanja).

3.3. Topics of the survey questions

User’s interaction with a technological production is the result of the interplay among the user’s cognition, the possibilities and constraints afforded by the production and the nature of the task (Benbunan-Fich and Benbunan 2007). As users carry out their tasks with a technological artefact, the interaction includes physical activities as well as mental activities (or cognitive process). Accordingly, the steps necessary to complete the task can be separated into physical and cognitive components. Hence, this research defines topics of survey questions as four sections as the following sections. Based on different objectives of questions, this research used relative types of questionnaires (see table 3.1).

1. SMS usage

Mobile phone is considered as a new hope to upgrade communication ability in developing countries, as discussed by many researchers(Buys, Dasgupta et al. 2009). However, the impact of SMS on people in Zanzibar has not been substantiated empirically.

User’s familiarity with the technology environment is the key factor in achieving automaticity. Automaticity relies on the retrieval of stored information accumulated after practice in a consistent environment (Benbunan-Fich and Benbunan 2007). Novice users of a technological production may take more time to carefully think about how to perform the steps to carry out the tasks. In contrast, the experienced users can draw from their familiarity with the domain and perform the automaticity. It is desirable to know how people in Zanzibar are familiar with using SMS to report water availability. There is a gap in between use of mobile phone and reporting water availability. Therefore, this research attempt to fill this gap via questionnaire survey to figure out the ability and behaviour pattern of using mobile phone to report water availability by people in Tanzania.

In SMS usages part, the objective is to find out the relationship between cell phone usage and the consistent message. This section focuses on the individual’s technique skill of SMS usages. Normally, if people expose themselves to cell phone more often, they will be more familiar with this communication technology and make fewer mistakes in sending SMS. That means people would have no difficulty to send SMS while they using cell phones. In SMS usage section, the questionnaire design focus on closed- end with multiple choices of quantitative answers.

2. Water usage

In urban and rural areas, there are various sources of water, including pipeline, local well, vendor, and natural spring. Different water sources result in different behaviours in collecting water. Even urban and rural area, they have different methods to collect water. Most households in urban area have water accessibility by connecting to the public water pipeline or by buying water from vendor. Because

there is poor accessibility to the public pipeline in rural area, households collect water from local well and natural spring.

Generally, housewife and children are responsible for collecting water, but most of cell phone users are men in Africa culture. Thus, there is a gap in the information transfer due to different tasks by the household members. The husband may spend money on his own cell phone even when there are other urgent household needs (Comfort and Dada 2009).This variability of women's ability to negotiate highlights the need to understand more about how decisions are made in water collecting, and how women and men take part in decision making and influence the process and outcomes of data quality. To increase reliability of the returned surveys, I used household survey to understand the impacts of different water sources and water collecting behaviour on the reports of the water problem.

In water usage section, the objective is to determine the water source, use and means of collection in each household. This section also focuses on closed-end with multiple choices with the fittest household description.

3. Reaction to water availability problems

It is abstractive that individuals think about specific activities, especially personal definition of water problems. People usually try to solve or report the water problem when facing serious problems about collecting water. Whether or not the problems are reported to some extend depends on the seriousness of the problems and the level of willingness to report problem. Normally, because of the poor accessibility to customer services office or even the poor water availability, people who live in rural area have different complaining behaviour and habits from people in urban area. In response, this research used questionnaire to understand how often, the way, and under what condition people report the problems.

In the reaction to water availability problems part, the objective is to determine people's reaction of facing water availability problems to understand the way people choose to complain about water. The questions of reactions of facing problems are complex and case by case. In this part, the question designed with closed-open with multiple choices and open end question to understand the reason people do not complain or what service people expect to have from human sensor web system

4. Willingness to pay water information

In the future, people can receive water information by SMS. Currently, it is in testing progress that is free of charge. However, later this information may cost money to supply more and better services in operating process. It is important to understand the users' willingness of payment.
This part focuses on if people are willing to pay for water availability information. This section of questions have closed-ended questions about the usage of system, and the willingness of information payment, and open-ended questions about the reason why respondent is not willing to pay for water information if human sensor web system operators

General information part contains age, gender, marriage status, household numbers, occupation, residential area, and cell phone numbers. The following table contains four categories of questions and their relative specific objectives.

Table 3.1 Categories of questions and questions designed

Categories of Questions	Objectives	Type of questionnaire
SMS usage	To determine the relationship between familiarity of cell phone usage and the willingness of SMS report	Closed-opened questions with multiple choices
Water usage	To determine the water source, use and means of collection in each household	Closed-opened questions with multiple choices
Reaction to water availability problems	To determine people's reaction of facing water availability problems	Closed-opened questions with multiple choices / open- ended question
Information affordability	To determine if people are willing to pay for water availability information	Closed-opened questions with multiple choices / open- ended question

4. Data

4.1. Interviewing area

The study area contains 4 shehias in rural area and 8 shehias in urban area as interviewing area (figure 4.1, table 4.1). Shehia is the administrative primary unit in Zanzibar. There are 236 shehias and 3 administrative regions in Zanzibar, involving North region, South/Central region, and Urban/ West region. Among theses three region, North and South/Central are rural area. This research chooses two shehias from North and South/Central regions. Nungwl and DongeVijibweni are located in North regions. Tunguu and Kati Bungi are located in South/Central region. In Urban/West region, there are 8 shehias where the human sensor web billboards already established (figure 4.2), including Malindi, Kilimani, Kisimama Jongoo, Magomeni, Mwembeladu, Mwembe Tanga, Mwembe Shauri, and Nyarugusu.(figure 3.3). The billboard contains the information about how to report water problems via SMS. Each water problem of water supplying location has its unique code. For instance, in figure 4.2, the billboard is located in Mwembe shauli. If there is no water from public water supplying point, citizens can send “A” and “location code” by short message service via cell phone to 0778700700. For instance, in Nyarugusu, if there is no water, people have to send “A 427” to human sensor web system. This research interviews people who are going to public water supply points to collect water or live around water points in urban area. Those people are interviewed in daytime as they were collecting water. This research also interviews 15 customers of Zanzibar Water Authority (ZAWA). Finally, there are totally 102 respondents of the first test process.

In the retest process, send three questions via SMS to all respondents of test process in 3-5 days. These three SMS questions are “How many days do you collect water from your water source in one week?”, “How do you compliant?”, and “How many SMS do you send or receive per month?” Totally receiving 26 SMS replies, but because of 3 protest responses, 1 reply from unknown number, and 1 reply without any answer, finally 21 SMS replies are representative.

Table 4.1 Interviewing area

Urban/rural	Region	Shehia	Test process	Retest process
Rural	North	DongeVijibweni	9	2
	North	Nungwl	16	
	South/Central	Kati Bungi	11	2
	South/Central	Tunguu	6	5
Urban	Urban/West	Malindi	6	
		Kilimani	13	2
		Kisimama Jongoo	5	
		Magomeni	5	1
		Mwembeladu	2	
		Mwembe Tanga	7	1
		Mwembe shauli	3	1
		Nyarugusu	4	1
		ZAWA	15	6
Total			102	21

This research also collects the secondary dataset of citizens' complaining events from ZAWA customer department. This period of dataset is from 2008/07 to 2009/09, which contains 916 water complaining events and 62 shehias (figure 4.4). But only the data with the location names after 2009/07, others are with unknown location name. Most complaining events come from urban area. MIEMBENI shehia with 21 complaining events in this period, where is the most complaining events in data set. In this research, 8 water points of human sensor web also have ZAWA complaining events. This research uses ZAWA complaining data set as a reference to check the data quality of human sensor web. We can expect there will be water problems in these 8 water points.

There are also water meters data from field. There are two water points of human sensor web with water meters, Nyarugusu and Mwembe Shauri (see figure 4.3). Period of water meter readers is from 2009/03 to 2009/09. This research also uses water meter data as a reference to check the data quality of human sensor web.

4.2. Result of test-retest

The characteristics of test and retest respondents are shown in table 4.2. In the table4.2, those respondents of the retest process (34.43) are younger than test process (37.52). Considering the rate of replying SMS, women (8/25) are more willing to answer and reply SMS questionnaires than men (13/77), and rural area (8/25) is replying more than urban area (13/77).

Table 4.2 Respondents characteristics

	Test process	Retest process
Age in years (mean ± S.D.)	37.52 (±14.56)	34.43 (±12)
Area		
Urban	60 (59%)	9 (43%)
Rural	42 (41%)	12 (57%)
Gender		
Male (n%)	77 (76%)	13 (62%)
Female (n%)	25 (24%)	8 (38%)

In table4.3, the total consistent rate is 56%, almost half answers are inconsistency. As the items of questionnaires, respondents have high consistency (80%) in answering the question of how to complain water.

Table 4.3 Consistent rate of test-retest

	Consistency between test and retest	Received Answers	Consistent rate
Water in One week	8	20	40%
How to complain water	8	10	80%
Frequency of using SMS	7	11	63%
Total	23	41	56%

4.3. Result of questionnaire analysis

4.3.1. SMS usages

A key factor in achieving automaticity is the user's familiarity with the technological environment. This familiarity refers to the repeated exposures to a consistent technological environment will facilitate the consistency. When someone uses new technological productions, individual with the prior experience will dominate to achieve tasks(Benbunan-Fich and Benbunan 2007).Novice users of a technological production have to carefully think how to achieve the task. In contrast, experienced users with higher familiarity will be dominant to perform automatically. Since human sensor web system collect citizens' water need via SMS, the familiarity of using SMS technology is considered. Table 4.4 illustrates the SMS usages in Zanzibar. There is only 1 respondent never using SMS before. Most respondents have experience of using SMS service via mobile phone. In this case, the users of 0-10 SMS per month are considered as novice users, and users with more than 11 SMS usages per month are considered as experienced users. There are 50 (54%) respondents claim that they send or receive SMS 0-10 times (novice users) per month. It illustrates that more than half respondents have basic usages of SMS per month. Table 4.5 shows the result of test-retest about the SMS using frequency. There are 7 out of 11 consistent with their answers between test and retest, and those answers all locate in 0-10 times SMS usages per month. Because of sending or receiving 0-10 SMS per month is the basic using frequency of SMS, the consistent result of 7/11 respondents with 0-10

SMS per month refers to that majority mobile phone users with basic skill of SMS still can send reliable message.

Table 4.4 SMS usages

SMS frequency in one month	
Never	1 (1%)
0-10	50 (54%)
11-20	6 (6%)
>21	36 (39%)
Total	93

Table 4.5 Frequency of SMS usages per month

	Test process					Total
		Never	0-10	11-20	>21	
Retest process	Never	0	0	0	0	0
	0-10	0	7	1	0	8
	11-20	0	3	0	0	3
	>21	0	0	0	0	0
Total		0	10	1	0	11

4.3.2. Water usages

More than 90% of urban water supply in developing countries is provided by public water provider (United Nations Development Programme 2003). Table 4.6 illustrates the water source of each household in urban and rural area. In rural area, majority claim that public tap (62%) or tube well (72%) is one of their water source. Comparing to rural area, city water supply is the main water source (63%) of each household in urban area. It figures out that urban area has better water service from public water provider, but rural area does not have water accessibility to public water provider This unbalanced water supply causes the high time consumption of water collecting (table 4.7). In rural area, 31% of respondents claim that they spend more than one hour to collect sufficient water per day, however, 79% of respondents from urban area spend less than 30 minutes to have sufficient water per day. People from rural area hope ZAWA can take care of their region, and have 24 hours water supply. This unbalance water supply situation between rural and urban area causes the problem of mistrust of government in rural area.

Table 4.6 Water source of each household

	City water supply (ZAWA)	Public tap	Tube well	Total respondents
Rural	0	26 (62%)	31 (72%)	42
Urban	38(63%)	24(40%)	3(5%)	60

Table 4.7 time consumption of water collecting in each household

	less than 30 minutes	31-60 minutes	more than one hour	Total respondents
rural	20 (48%)	9 (21%)	13(31%)	42
urban	42 (79%)	7 (13%)	4 (8%)	53

4.3.3. Reaction to water availability problem

The water problem in the rural area comes from aged pumps, few water sources, and insufficient availability of water (Millennium Challenge Account-Tanzania 2008). The insufficient water availability cause people complain a lot. Generally, in Zanzibar, people have 3 ways to complain about water, including write to ZAWA, go to ZAWA directly, or complain to Sheha. Sheha is the local leader of each region. In urban area, 50% of respondents claim that they ever wrote to ZAWA or complained to Sheha about water problems, and only 19% of respondents claim that they went to ZAWA directly to complain water. In contrast, people from rural area preferred to go to ZAWA (87%) to show their water problems (see figure 4.5). This situation shows that people from rural area think they have to show their anger and problems directly to water provider, or water provider will ignore the opinions from rural people.

From 2008/07 to 2009/09, there are 916 water complaining reports. Table 4.8 illustrates the amount of complaining events are taken over by which department. The commercial department of ZAWA takes over majority complaining events (65%), such as no water in household. Technical department takes the case of leakages or pipeline broken issue. Financial department handles the event of no ability to pay water fee. Legal officer takes over the illegal link to public pipeline events.

Table 4.8 History of complaining events (from ZAWA)

Category	Commercial	Financial	Legal Officer	Technical	Total
Complaining events	593 (65%)	40(4%)	20 (2%)	260 (28%)	916

Table 4.9 Complaining Method

		write to ZAWA	go to ZAWA directly	compliant to Sheha	Total respondents
urban	rural	7	33	15	38
	urban	13	5	13	26
Total		20	38	28	64

4.3.4. Willingness to pay water information

Because of the insufficient water supply, people have to spend time on checking if water is avaliable in water supply points. For instance, one lady live in Mwembe Shauri, and her house just 6 houses far from public water supply point. Without the connected to city supply system in her household, she has to try and error several times per day to to make sure if water is avaliabile or not. If she can know

exactly public water supply point is avaliable or not, it will help her save a lot of time. However, if people have to pay for the information of water avaliability, the willingness of payment would be one quesiton.
The survey of water information affordability is shown in table 4.10. 100% of people in rural area are willing to pay the water avaliability information, and almost the same in urban area. A few urban people (3 repsondents) agree with the water avaliability information via SMS can improve their lives a lot, howeve, they think this information via SMS should be free to the public. Majority people claim that they do not care about the payment of water information, but they want to have the water immediately if they use the service to know water avaliability information.

Table 4.10 Willingness to pay water information

		Willingness to pay water information		
		yes	no	Total
urban	rural	40	0	40
	urban	50	3	53
Total		90	3	93

4.4. Water meter data

Figure 4.6 and 4.7 illustrate the water consumption in both Nyarugusu and Mwembe Shauli. In the water consumption record, everyday in both water points have water supply. But going into more detail about daily supply in both areas, there is no 24 hours water supply because there are some gaps in water consumption record. I take water consumption in Nyarugusu on 2009/4/11 and 2009/5/14 in Mwembe Shauli as examples. In Mwemembe Shauli, on 2009/5/14, the total water consumption is 4010 litres. People always collect water until it stops supplying. There is no water consumption during 12:00 AM to 6:00 PM everyday, because people are sleeping at midnight. It is normal that people do not collect water in the sleeping time. But in the daytime, there are still some gaps. In figure 4.8 and 4.9, there are several gaps around 1:00 AM and 6:00 AM in 20009/4/12 in Nyarugusu, and a huge gap from 10:00 AM to 12:00 PM in Mwembe Shauli. It shows that even in the time people are awaking and looking at the water supply system, water supply is still not continuous and breaking water supply several times per day.

In the survey of days in one week with water supply, people in Mwemembe Shauli and Nyarugusu have 100% consistence with the water meter data. This consistence between people's answer in water supply and water consumption data from water meter record shows that residents were always keeping an eye on water supply period. Because of the irregular supply of water, residents always test and try several times per day to see if there is any water supply in public water points. One lady who lived in Mwemembe Shauli said that she had to try around 5 -6 times everyday to know if this only one public water supply point in Mwemembe Shauli is available or not. This try and error method causes residents have to pay attention to when and where water is supplied.

Table 4.11 consistent rate between water meter data and the water collecting from questionnaire

Area	Days with water supply (from water meter)	Respondents	Consistent rate
Nyarugusu	7	4	100%
Mwemembe Shauli	7	3	100%

However, as the consistent rate between water meter data and retest data, the consistent rate decreases to 0. I received 1 SMS response from each Nyarugusu and Mwemembe Shauli. The reason why the consistent rate decreases a lot is the respondents complain about the different area. Both of SMS respondents claim that they didn't have any water in their household instead of answering if water is available in water points. The respondent of Nyarugusu said that he lived in Mwkwerekwe, where is around 1 km far from Nyarugusu. Because the water shortage of his region, he has to go to Nyarugusu to collect sufficient water. The respondent of Mwemembe Shauli claims that her house does not link to public pipe line, so that's the reason she thinks she never has water in her household.

Table 4.12: consistent rate between water meter data and the water collecting from questionnaire

Area	Days with water supply (from water meter)	Respondents	Consistent rate
Nyarugusu	7	1	0
Mwemembe Shauli	7	1	0

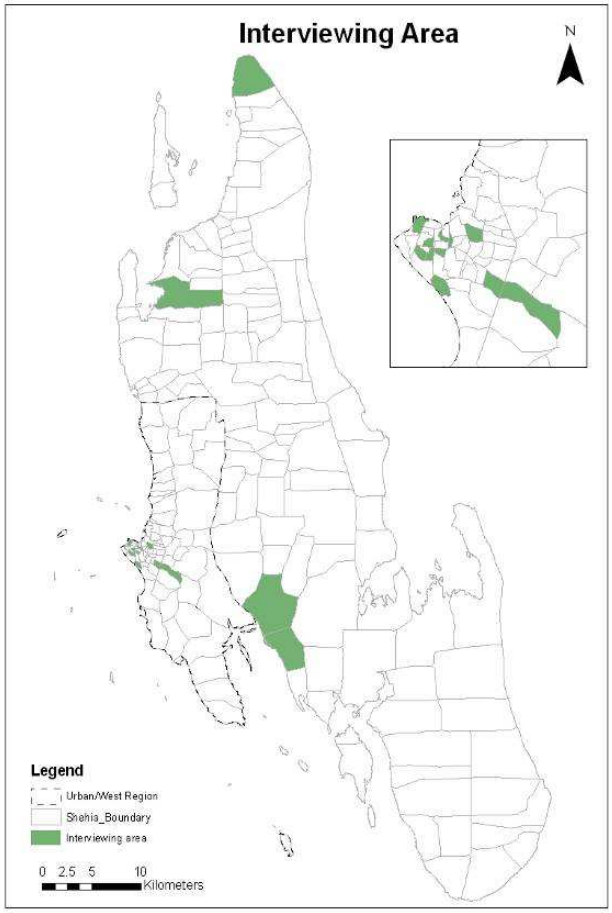

Figure 4.1: Interviewing shehias in Zanzibar

Figure 4.2: Billboard of Human Sensor Web in field

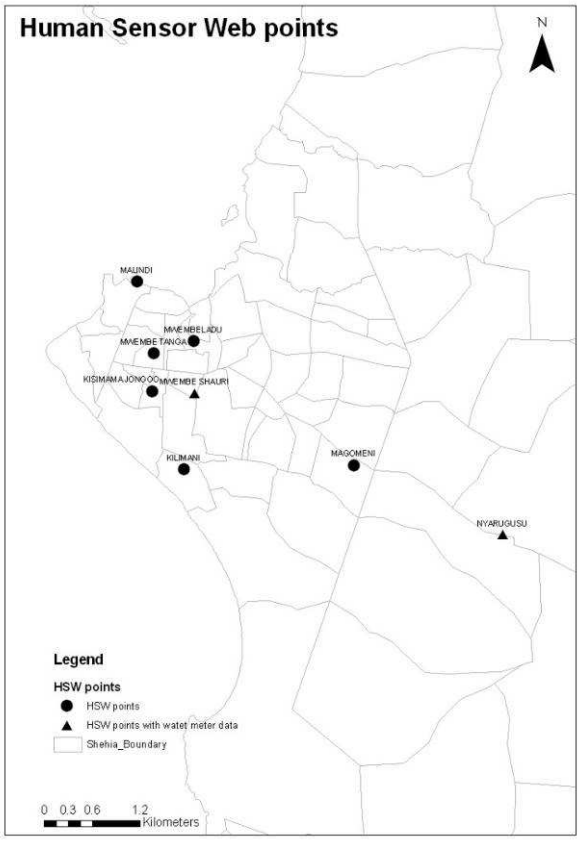

Figure 4.3: Human Sensor Web points

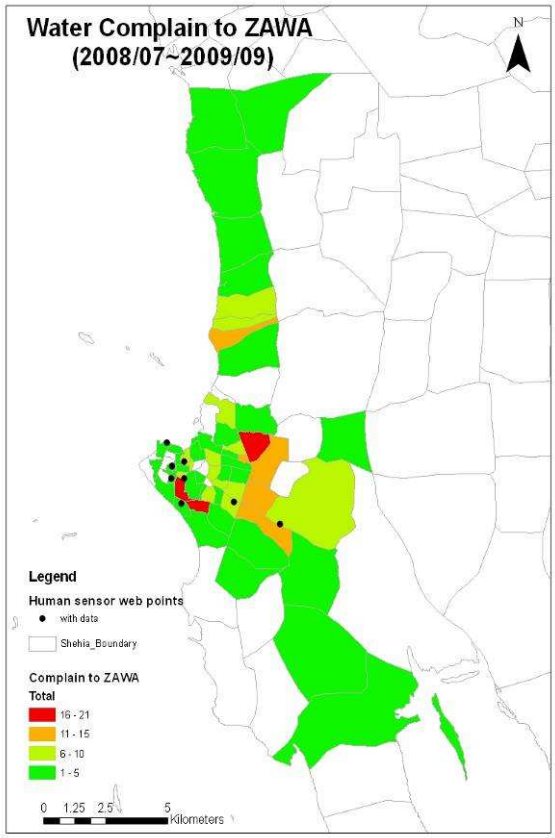

Figure 4.4 Water complaining events to ZAWA

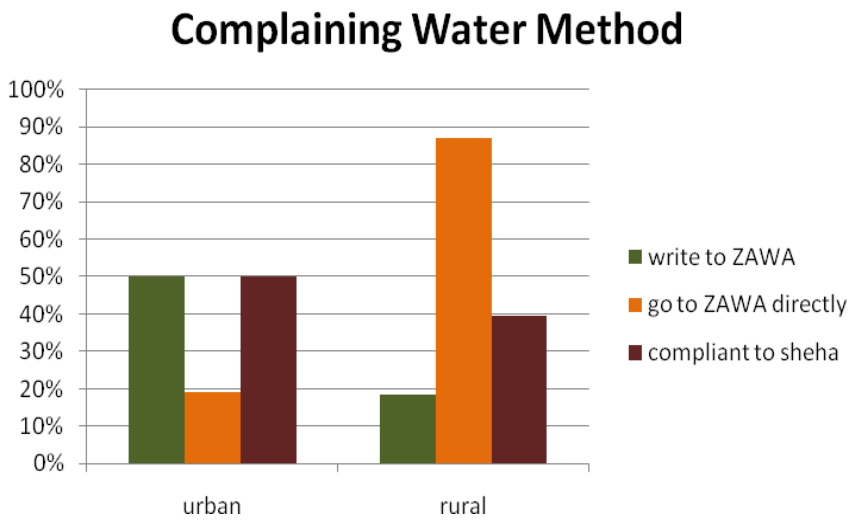

Figure 4.5 Complaining water method

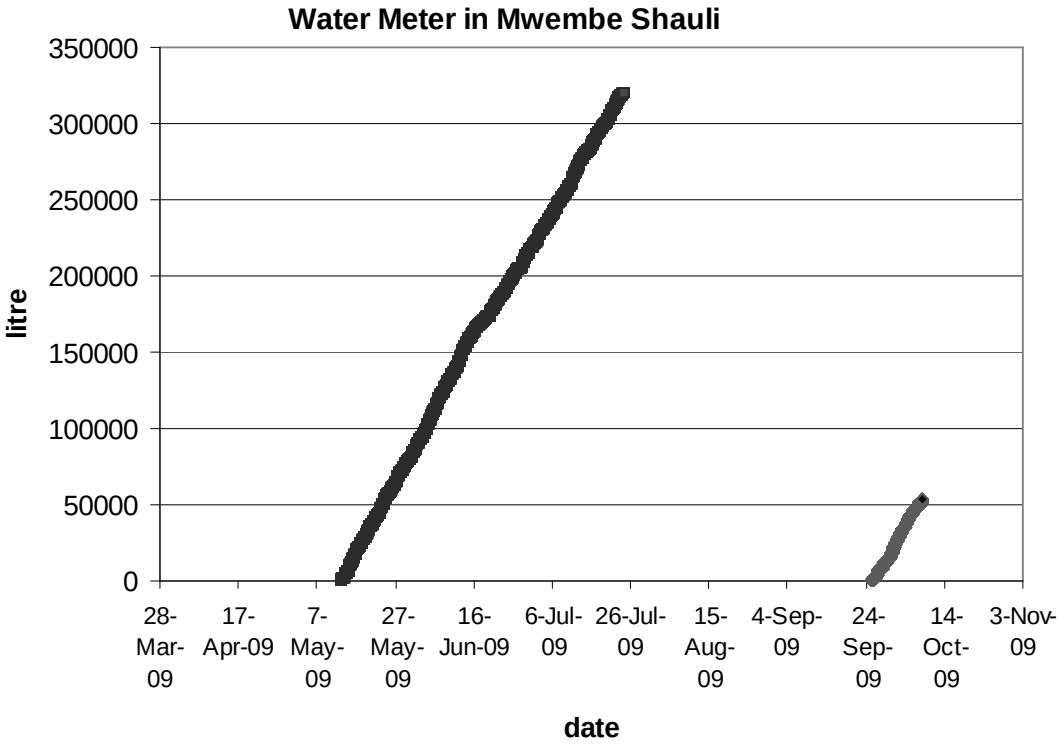

Figure 4.6: Water meter in Mwembe Shauli

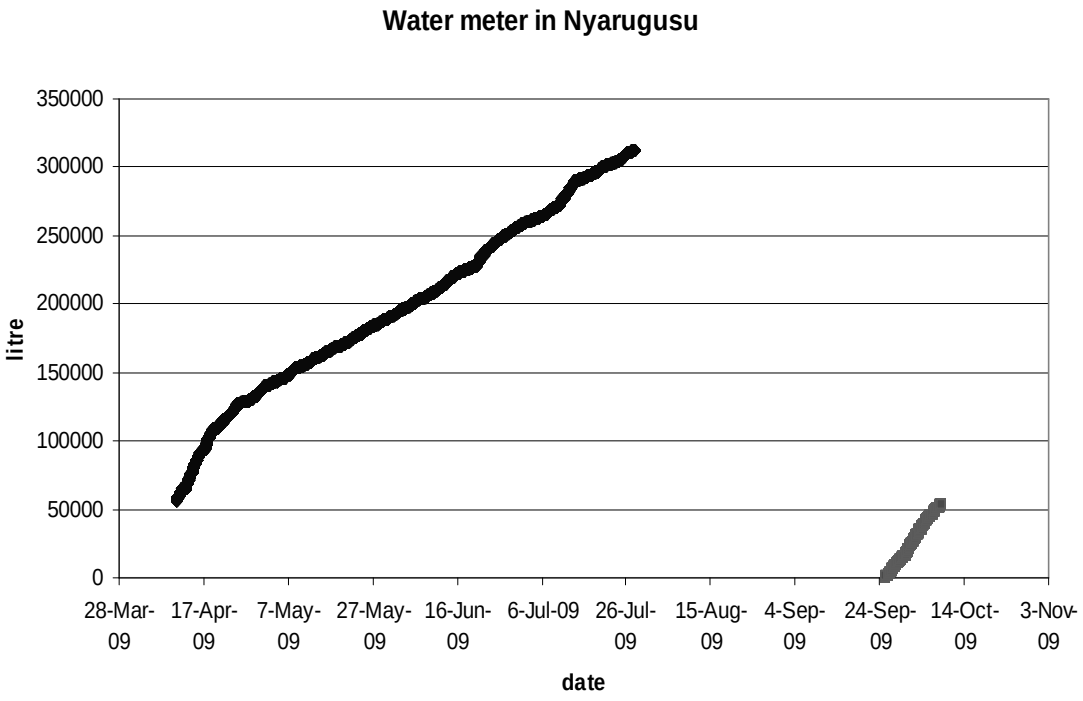

Figure 4.7 Water meter in Nyarugusu

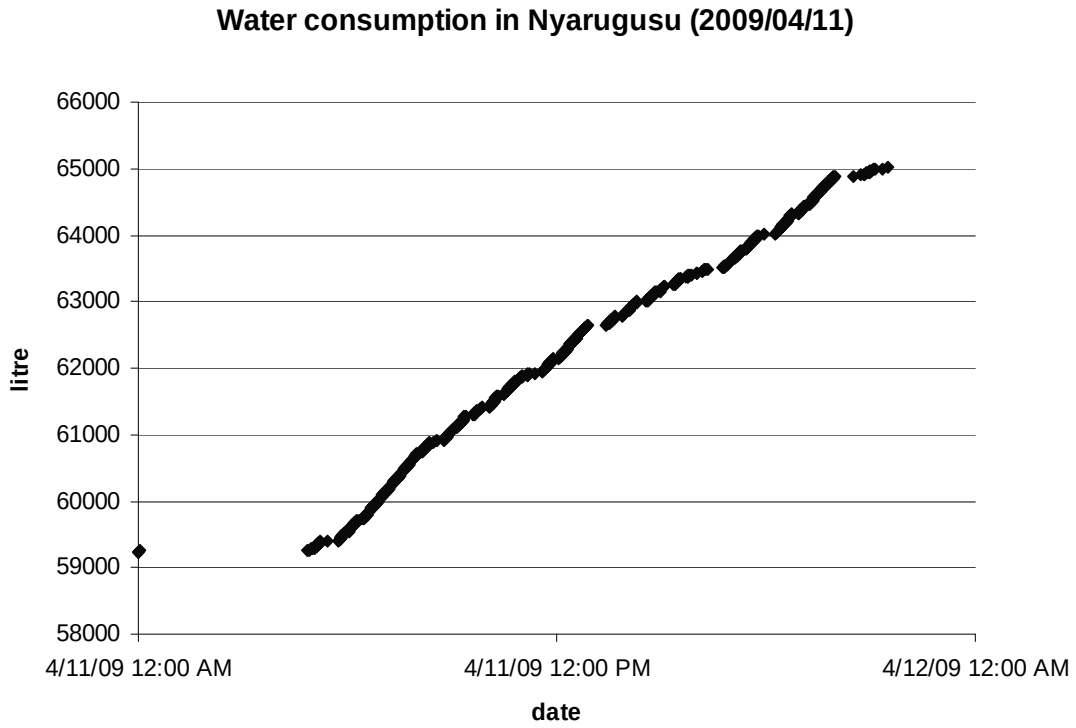

Figure 4.8 Water meter in Nyarugusu (2009/4/11)

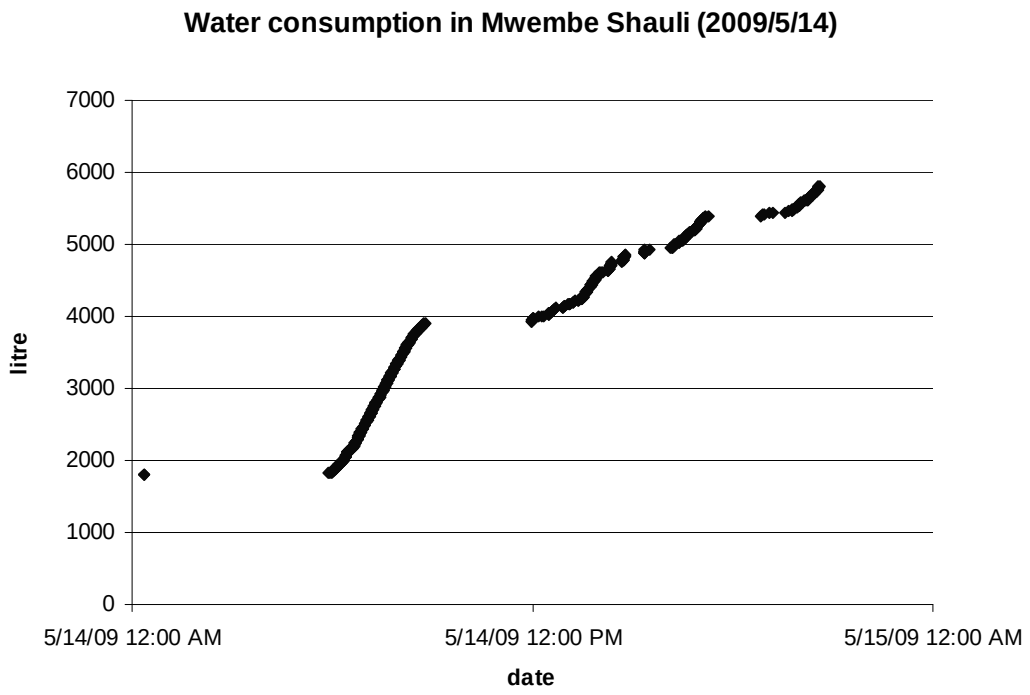

Figure 4.9 Water meter in Mwembe Shauli (2009/5/14)

4.5. Data from human sensor web system

The human sensor web system starts to operate in October 2009. Until now, this system has received some water complaining SMS messages (see table 4.13). From 2009-10-16 to 2010-1-17, there are 61 correct SMS sent to human sensor web system and 202 SMS error. However, there are 48% (29/61) of correct SMS are sent by the system testers. The rate of citizens to send correct SMS messages is still very a few. Those correct SMS sent from citizens are only 8 % (22/263).Among those 22 correct SMS complaints from citizens, the spatial distribution is as the figure 4.10. The most complaints are from Gulioni, where has 9 complaints in this period (see table 4.14). Among those 202 SMS error, there are 136 text messages from citizens, others are from tester. Among those 136 messages sent by citizens, there are 34 SPAM messages (25%).

As for the citizens' time of sending SMS in one day, those SMS messages were sent during 2:00 AM to 11:00 PM (see figure 4.11). By analyzing those 158 SMS messages from citizens and classifying the time they sending messages to human sensor web system, most citizens sent SMS during 10:00 AM to 7:00 PM. There are 79% (124/158) of messages sent at this period. In the daytime, the time citizens start to send SMS is 7: 00 AM. And the peak hour for sending message in one day in from 10:00 AM to 11:00 AM (32 SMS messages).

Table 4.13 SMS from human sensor web system

Categories	Correct SMS	SMS error	Total
Tester	29 (11%)	66 (25%)	95 (36%)
Unknown name	10 (4%)	--	10 (4%)
Citizen	22 (8%)	136 (52%)	158 (60%)
Total	61 (23%)	202 (77%)	263

Table 4.14: Correct SMS complaints

Location	Number of correct SMS complaint
AMANI	8
CHUKWANI	1
FUONI KIBONDENI	1
GULIONI	9
KILIMAHEWA JUU	3
KILIMANI	1
MELINNE	1
MWANAKWEREKWE	2
MWEMBELADU	2
NYERERE	1
TOMONDO	1
Total	22

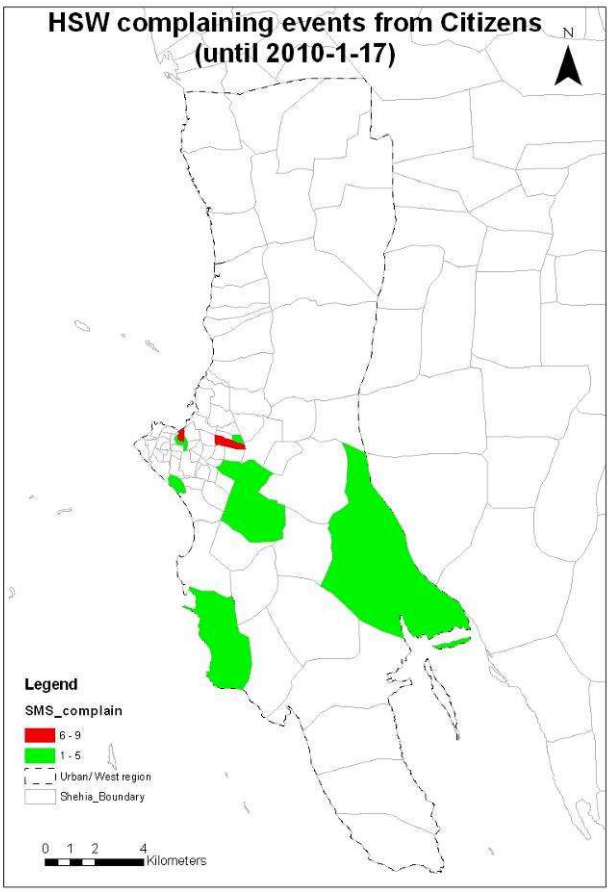

Figure 4.10: HSW correct SMS complaints from citizens

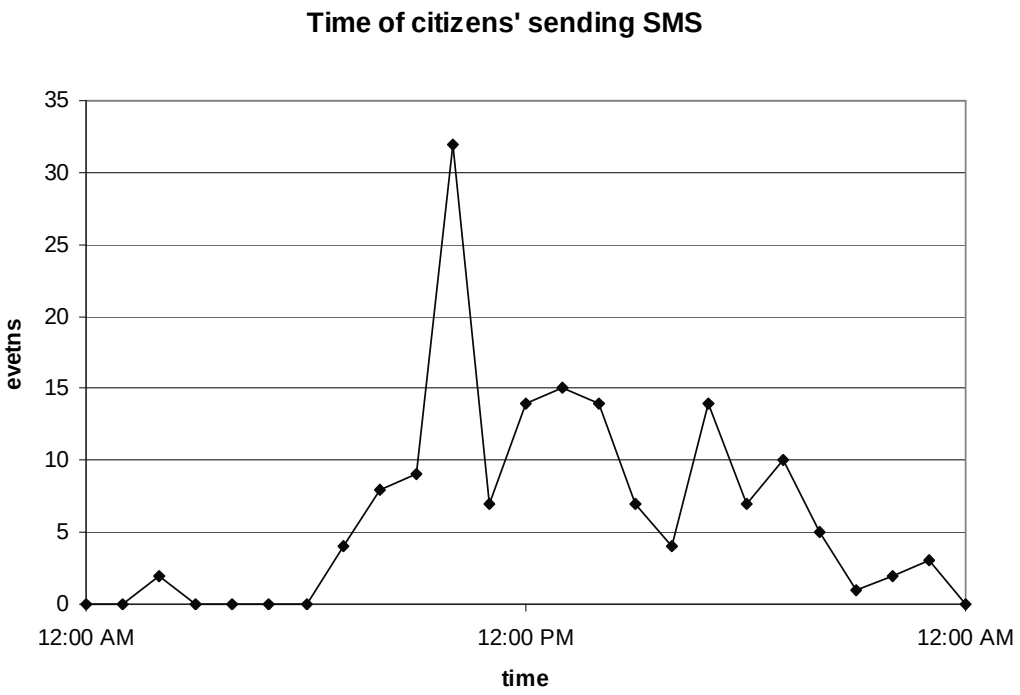

Figure 4.11: The time of sending SMS to HSW from citizens

5. Data Analysis and Discussion

5.1. Key drivers to cause unreliability of citizens' message

The result of test-retest is only 56% consistency. Because citizens' message will influence the data quality in human sensor web, the high rate of inconsistency and unreliable information will cause data poor data quality. There are several factors to impede the sharing and sending reliable data between citizens and human sensor web system. Based on interviews, questionnaires, and history of water complaint, this research classifies the following key reasons.

5.1.1. Information gap between man and woman in one household

Information gap will cause the information delay, inaccuracy of water complaining report via SMS, and even wrong messages. Information gap comes from the different role between male and female in the same household. According to fieldwork, women usually do not have their personal mobile phones. Women have to depend on their relatives or husband to use the mobile phone technology. Women have to share the ownership of mobile phones with their relatives or husbands. The ownership of mobile phone is not always belonging to one user, especially not for women. There are different roles in each household to deal with water collecting (women) and cell phone use (men). For those people who have cell phone to send SMS and complain about water are different with the one has the responsibility to deal with water issue in each household. Most male in each household deals with money issue, uses cell phones, and reports the water problems to ZAWA. However, Female in each household is the main role to deal with water issue and care every detail of daily lives.

In rural and urban area, compared to female cell phone users, man is still the main cell phone users in each household. In this research, 71 respondents claim that there is at least one man with cell phones in their household (see table 5.1). Compared to 36 respondents claim that there is at least one woman with cell phones in their household, cell phone users in each household are man. In figure 5.1, the percentage of male cell phone users in rural area (71%) is more than urban area (68%). Among 42 respondents from rural area, and 30 respondents (71%) claim that there is at least one man with cell phone in their household, 11 respondents (26%) claim that there is at least one woman with cell phone in their household. Among 61 respondents from urban area, 41 respondents (67%) claim that there is at least one man with cell phone use, and 25 respondents (41%) claim that there is at least one woman with cell phone in their household. There are much more women with cell phones in urban area than in rural area.

Table 5.1: cell phone users in each household

	Man	Woman	Total
Urban Area	41	25	66
Rural Area	30	11	41
Total	71	36	107

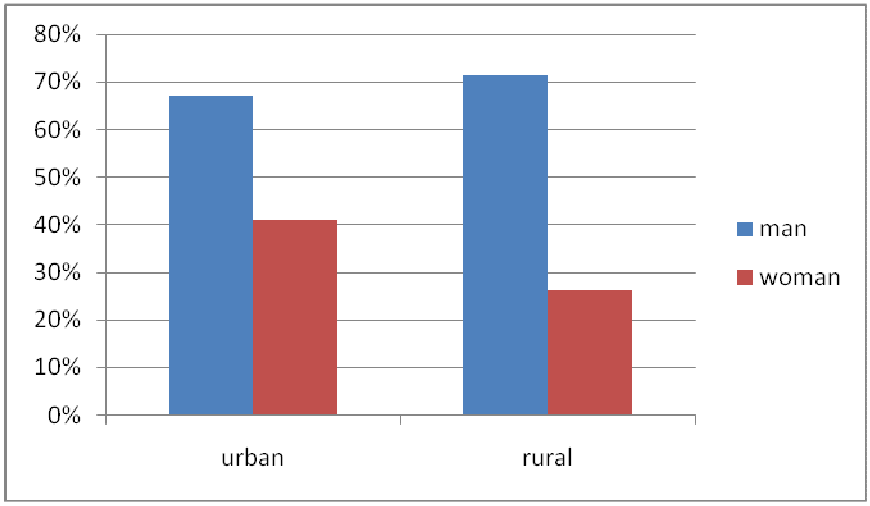

Figure 5.1:Male and female cell phone users in urban and rural area

In the dataset of ZAWA customer complaining events, majority who go to ZAWA directly to complain about water issue are male. From 2008/07 to 2009/09, among 916 water complaining reports, there are 359 complaining events with shehia name. In table 5.2, the category of those complaining events is based on which department of ZAWA should take over this complaining event. Commercial department charges most case about the events of no water in household. Technical department takes the case of leakages or pipeline broken issue. Financial department handles the event of no ability to pay water fee. There are 359 data with name of respondents. Based on names of residents, this research classifies the gender of reporter of water problem to ZAWA. Among 359 reporting events, only 90 events are reported by female, and 259 events are reported by male.

Table 5.2: ZAWA Complaining Events

Complain Events		Female	Male	Total
Category	Commercial	67	200	267
	Financial	9	27	36
	Technical	14	42	56
Total		90	269	359

Majority of respondents claim that all household members are responsible for water collection in their household. In table 5.3, there are 95 respondents answered the question of responsibility of water collection in their household. In rural and urban area, more than 70% of respondents claim that every household member is responsible for water collection (see figure 5.2). In rural area, 24% of respondents put the duty of water collection on female and children. Compared to urban area, 19% of respondents put the duty of water collection on female and children.

Table5.3: Responsibility of water collecting in household

	Responsibility of water collecting				
	all household members	housewife/ female in household	children in household	others	Total
rural	32	4	6	0	42
urban	42	6	4	1	53
Total	74	10	10	1	95

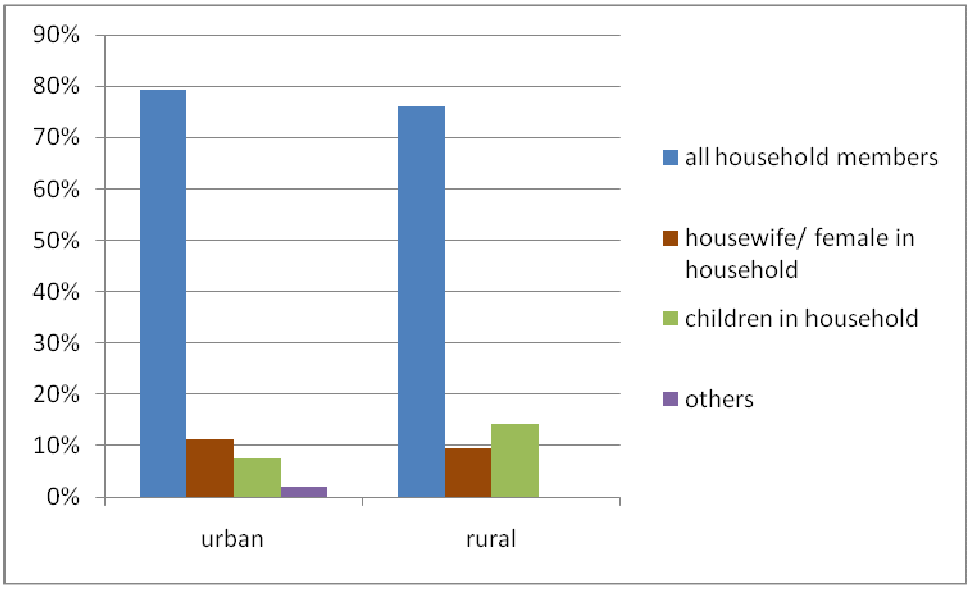

Figure 5.2 : Responsibility of water collection in each household

Information delay happens between husband and housewife in the same household. Even all household members are responsible for water collecting, majority men go out for working. If there is water problem happened, women meet with their husbands at evening to ask for sending SMS. In Zanzibar culture, man has the duty to go out for work and earn money. In most case, man is the only income source and controls all money issues in each household. Women collect money everyday from their husband or sons to pay for their daily lives in each household. For example, Mr. Juma lives in urban area with his wife and two daughters. He goes out for working in education department of Zanzibar everyday in 7 am. Around 15:30, he goes home to have lunch, and then he goes out again to meet relatives and friends. Next time he meets his wife will be around 21:00. The time he meets with his wife everyday to understand what happened in his household are morning before he goes out for working, lunch time and, evening. The family of Mr. Juma is the normal case in Zanzibar. Most men go out in daytime, only women stay at home and do the housework. That may be one reason causes the amount of SMS from human sensor web to increase again around 17:00 and 21:00 daily (figure 4.11).

Generally, in rural area, woman takes the responsibility to housekeeping job, including water collection. Even more than 70% of respondents claim that every house member has the duty to collect water. In rural area, water supply structures are hand dug wells with rope and bucket as water lifting

devices, powered mostly by women and children(Millennium Challenge Account-Tanzania 2008). In water supplying points of rural area, woman and children are always the water collectors (see fig 5.3).

Figure 5.3 children are collecting water in hand drag well in rural area

This information gap and different role in one household will cause the mismatch in the process of passing information, and therefore sending wrong or unreliable message to human sensor web system.

If citizens send wrong codes of location, this message will refer to different location with insufficient water supply in human sensor web system. Therefore, because this message mismatches with the reality condition, it will be considered as wrong messages which refer to poor data quality in human sensor web system. This likelihood error will exacerbate because it's difficult for women to remember the codes of no water or dirty water all day. In Zanzibar, citizens find out some specific water points without water, citizens can use SMS to send no water code to human sensor web system. For example, in Nyarugusu where there is a billboard to teach people how to report water problems, if there is no water, people can use SMS to send the code "A 427" to "0778700700". But it is difficult for women to remember those long special codes and numbers all day. It would easily have the wrong memory of the codes and numbers. Therefore, because of the wrong memory, women would inform their husbands the wrong codes or have to spend another day to find out the correct codes. This wrong memory would not only cause delay of citizens' observations, but also the inaccuracy reporting messages.

Information delay and gap happen more seriously in rural area. In rural area, husband is the decision maker in household. Women do not have the rights to control money, so women have to follow their husbands' willingness. Men sell the products from farm and collect money from market, and even can control what their housewives to do everyday. If husband disagrees to send SMS to report water problem or any other methods to solve water problems, housewives have to follow. In Zanzibar, they call this behavior " Mfumo Dume", which means man power. This gender issue happens more

seriously in rural area than urban area. This gender issue causes the information gap and delay about water problems.

5.1.2. Mistrust of water provider

Data quality bases on amount of data from citizens' SMS report. Doubt or trust the institution behind the system will cause people willing or not willing to send SMS to report events.People do not trust ZAWA can improve water availability if the problem is still not yet solved. Since they complained, they still do not get any response or information, and the problem still not be solved. As time goes by, ZAWA lost the trust from people. Most of respondents have the experience of complaining about the water problem to Sheha or ZAWA, however, they did not get any response or information about when or how the water problem can be solved. People from urban area where with better water availability service complain less than rural area. In this research, 64 respondents claim that they ever reported or complained about the water problem to ZAWA or shehia (see table 5.4). In figure5.4, 38 respondents (90%) from rural area and 26 respondents (43%) from urban area claim that they have ever complained about water problems. People in rural area complain more than urban area.

Table 5.4 : Ever complain about water problem

	Ever compliant water		
	yes	no	Total
Rural	38	4	42
Urban	26	34	60
Total	64	38	102

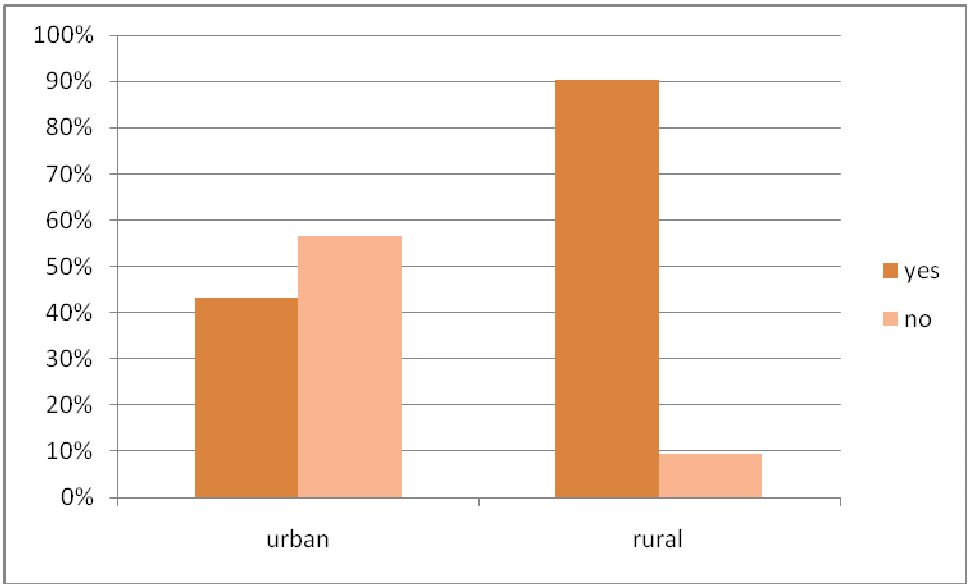

Figure:5.4 Experience of complaining water problems

People in rural area already lost the faith of government in water availability issue. Mr. Haji , who lives in Nungwi, has his own business of selling fruit. He claims that he never got any water from ZAWA. He ever complaint to Sheha, and hope the local community leader can improve their water availability, and until now, he didn't get any response from Sheha or ZAWA. He thinks that those

urban people already forgot rural area. Even rural people can send SMS to complain about water, ZAWA still will not do anything to improve water availability in Nungwi.

The priority of water supply causes residents distrust ZAWA. In Nungwi, the famous location with beach and 5 star hotels, residents still suffer for lack of water availability. But those 5 star hotels always have water immediately if hotel complaint to ZAWA. Since tourism is the main source of income in Zanzibar, ZAWA has the priority to supply water to hotels. In the tourist area, such as stone town or Nungwi, sometimes residents have to collect water from hotel.

The other reason causes people do not trust ZAWA is the policy of water payment. ZAWA charges residents water fee at first, instead of improving water availability. The new water payment policy is made since September 2008. Each household had to pay water fee to ZAWA in 4000 Tsh each month, no matter how much water each household used. Because the argument of water fee, majority people complained water fee was to high for them. ZAWA decreased the water fee from 4000 Tsh to 2000 Tsh in July 2009. However, people still complain about the payment because the insufficient water supply. In most places, there is no 24 hrs water supply and even water supply by rations. In urban area, people have to find out the other water source or pay to water vendor to collect enough water. Mrs. Othman lives in Mwembe shehia, where has a public water tap. Her family uses 301-400 litres water per day, but there is no pipeline connection in her household. As a housewife, she has the duty to collect enough water for her family everyday. She complains that even this public tap almost with water everyday, water is only available between 6 AM to 7AM, and then the supply is closed. It would be lucky to get water during the daytime and around 8 PM to 9 PM in some days. If there is no water in public tap, she has to go to other place or pay 300 to 500 Tsh per bucket (around 20 litres per bucket) to water vendor.

Those people with insufficient water supply still have to pay the same water fee as those people have 5 or 7 days water supply. This unfair policy for water fee causes people anger to ZAWA. And the complaining system makes people lost more faith for ZAWA. Especially people in rural area, they think ZAWA already ignored rural area's opinion and right. Their image about ZAWA is a government department with greedy mind.

5.1.3. Local leader

As people complain water problems to Sheha, the decision of Sheha is the key reason to improve data quality. In local community, Sheha is the powerful leader of one shehia. In Zanzibar culture, no one will obey Sheha's decision. This powerful leader with high position has the right to decide and handle everything in the community. Hence, if water problem occurs, there are still 50% of respondents in urban area and 40% of respondents in rural area choosing to complain to Sheha (see figure 4.5).This powerful leader has stand on the key point to represent or even control most residents' opinions.

If Sheha rejects to cooperate, then no one will cooperate in that shehia. In Nungwi, the north part of Zanzibar, the Sheha rejects to pay the water fee to ZAWA, so he keeps whole water bills of Nungwi and refuses to hand over to those bills to every resident. The reason Sheha rejects to pay is that they don't have the water from ZAWA. Residents in Nungwi use tube well as their water source. They

already complaint to ZAWA about no water, but they still didn't receive any response. Finally, they consider ZAWA as a cheat government department.

Sheha is not always as a negative driver, but sometimes he is also a positive driving force to encourage citizens to use human sensor web system. In the process of interviewing people, one Sheha in urban area had already organized one meeting to announce and educate all people in that shehia about how to send water problem via SMS to human sensor web system. In this shehia, people were more willing to cooperate and understand the detail to send water problem via SMS.

Sheha is the key person to improve and encourage residents' usages of human sensor web system in one shehia. As his powerful position in community, winning the trust and communicating to every Sheha would make human sensor web system collect more data and operate smoothly.

5.1.4. Other factor

There is still several potential factor cause unreliable SMS. This factor might be puny, but it is the living condition of Zanzibar. This factor might indirectly or directly influence the data quality.

5.1.4.1. Dry seasons

The climate of Zanzibar is characterised by wet and dry seasons. The rainy season is from the middle of March to the end of May, and there is also a short rainy season in November. The dry seasons are from December to February and June to October. In dry season, because of the low rainfall, the groundwater level is decreasing. In this case, it causes water collection more difficult.
By classifying the data from ZAWA complaining events monthly, we can see the frequency of complaining events has the clear difference between dry season and rainy season. Figure 5.5 shows the complaining events to ZAWA from July 2008 to Sep 2009. It figures out that in the dry season from December to February and June to October, the complaining events are relatively higher than rainy season. Hence, we can expect that human sensor web will have more complaining events during dry season in Zanzibar.

As for the spatial distribution of water complaining events, most complaining events come from urban area. Because the data limitation of ZAWA complaining events, only 360 complaining events have location names after 2009 July. I take August 2009 as example for spatial analysis (see figure 5.6). In August 2009 (in dry season period), majority ZAWA complaining events come from urban area. Especially Miembeni has 11 complaining events, where is the area with most complaining water problem in August. Hence, we can expect that in dry season, human sensor web system will receive more complaining events, especially from urban area.

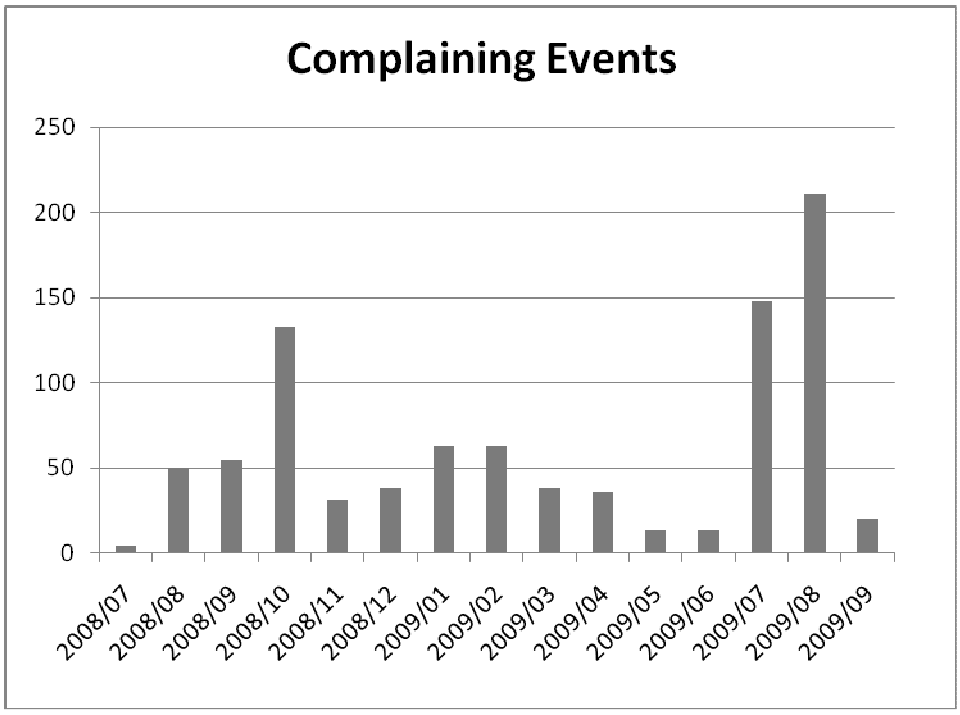

Figure 5.5: Complaining events to ZAWA monthly

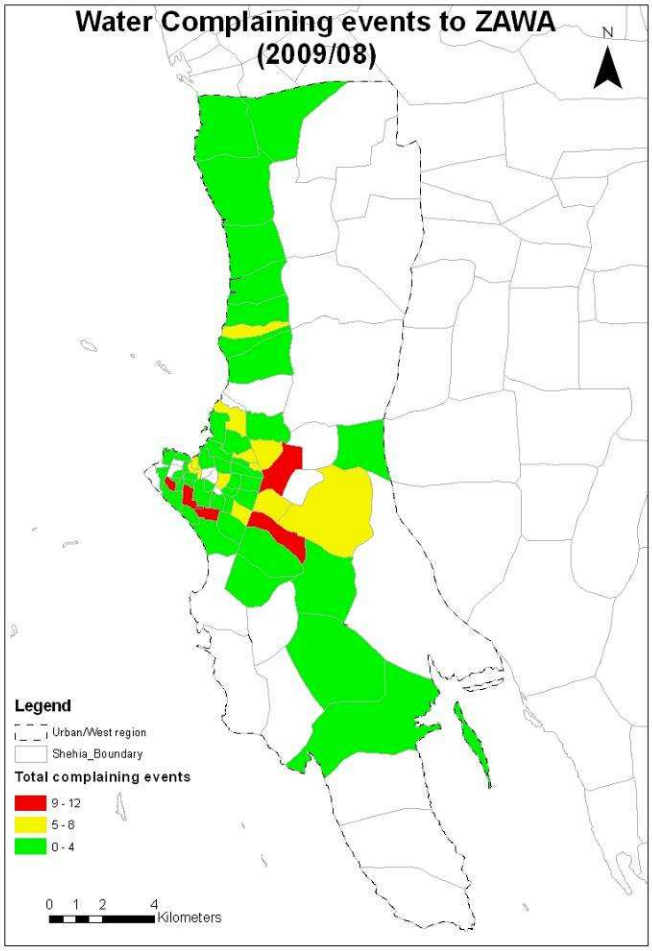

Figure 5.6: water complaining events in August 2009

5.2. Other similar VGI cases in Zanzibar

For government or organization participants may interest in the VGI from citizens might provide early warning of disease outbreak or constant streams of data about the local environmental impacts (Elwood 2008).Since mobile phone becoming popular, there are some more l VGI usages to improve people's living quality in Zanzibar via mobile phones. In Zanzibar, there are already several similar VGI cases using mobile phones to regularly report healthy condition in one community. In fieldwork period, I attended those health facility and agent to understand how those programs work and change people's lives. Those programs may give human sensor web several predictive difficult it may face somehow in future.

"Wired mothers" is the use of mobile phones to improve maternal and neonatal health in Zanzibar. Use mobile phone to link pregnant women and their newborns to the health system. Midwife will remind those pregnant women back to a primary health care centre for free health care through Short message service regularly. Even most Zanzibar women delivery babies in health facility, they stay there less than one day. More than 50% of Zanzibar women do not receive postnatal care (Lund 2009). Those pregnant women will still receive SMS remind for free health care until 45 days after they delivering, so women and their infant babies also receive health care. In this period, through person-to-person intervention, midwife can send SMS to pregnant women not only remind them for free health care, but also provide medical information. However, women in rural area rarely have their own cell phones. Midwife has to contact with their relatives or husband who own one cell phone to pass the healthy care information. This indirectly information transferring will cause pregnant women may not back to health facility on time or even not receiving any information. Especially in rural area, women are more used to delivery at home. In Matemwe where is rural area, the midwife claims that as those pregnant women receive the reminding information that it is almost the time they delivery, midwife always gets the feedback that those pregnant women already delivered.

Zanzibar Malaria Control Program (ZMCP) is developed to quickly response to the unusual occurrence of Malaria cases in Zanzibar through the weekly report from health facilities via mobile phones. Malaria is the leading cause of morbidity and mortality in all health facility in Zanzibar. 50% of all outpatient attendance is due to malaria (Ali 2004). Malaria is characterized by perennial stable transmission. In this case, one early detection system will help to prevent and control malaria transmission. First, health facility records in paper of the amount of daily test if malaria test is positive or negative. Secondly, report the amounts of patients, positive and negative malaria test case via SMS to system serve weekly. The server will automatically generate graphical images viewable on a secure web site. An engineer will visit these health facilities routinely to check the accuracy of SMS report. If increased numbers of malaria cases are reported, representatives from the district health management team and ZMCP will visit the health facility within 24 hours after notification to rule out false alarms (President's Malaria Initiative 2009). Once confirmed the malaria case, a key step is to rapidly make the community and health case system aware of the confirmed increases in malarial transmission. This step aims to treat to probable malaria cases as quickly as possible to alleviate illness and control the transmission of malaria.

An increase of malaria positive test could have many factors, including human error and the timely control of outbreak of malaria. To facilitate reporting of consistent, accurate, and timely data, the

sentinel health facilities are reporting only three indicators: total number of outpatient visits, number of laboratory-confirmed malaria cases, and number of persons tested for malaria that week. In Matemwe, compared the data received from system serve with data of paper recorded from health facility in 2008, there is 7% of error, and majority is typing error. This phenomenon points out that human typing error is the key driving factors as reporting via SMS through small keypad in mobile phone. Even an engineer visits each health facility routinely to check the operation of reporting malaria indicators via SMS, the inaccuracy of data still exist. Another issue of influencing malaria case control is the routine SMS report to system serve weekly. Even outpatients spend only 15 minutes in health facility to know the result of malaria test is positive or negative, staffs of health facility still report total amount of positive cases weekly. In that case, that means there will be one week information delay to delivery malaria cases to the final system serve. If there were outbreaks of Malaria, the programme management of ZMCP could response timely or not will be one questionable point.

5.3. Typing error

In those SMS from human sensor web system, there are still large part of SMS (52%) considered as wrong SMS. Those SMS cannot be identified and recognized by system automatically, because of typing error or SPAM messages. There are three kinds of typing error in this case, such as wrong typing, long sentence, and SPAM messages.

1. The example of wrong typing, such as the No.046 SMS reporter

- `Reporter 046   | 2009-11-29 08:11:09+03 | Maji ( A   046  ).`
- `Reporter 046   | 2009-11-29 08:19:50+03 | Maji D  046.`

In the first SMS, this reporter also used brackets () in his/her text sentence. In the second SMS above, he/she finished the report as ".". Another example is the No 427 SMS reporter. This reporter also used ".", but not " " (space) in the text sentence.

2. Long sentence. Another example for No. 427 reporter. He/she typed some words to explain the time and the location of water problems in the first SMS. Those typing problems cannot be recognized by system automatically.

- `Reporter 427 | 2009-11-16 23:20:12+03 |`
  `MAJI...A....427.LEO.JIONI.HAYAKUTOKA.TUKESHO.ASUBUHI`
  (Water…a….427. Today evening there is no water, only tomorrow morning)
- `Reporter 427 | 2009-11-17 07:24:22+03 |HAKUNA.MAJI..MAJI.A.427`
  (No. mater, water. A. 427)
- `Reporter 427 | 2009-11-17 10:21:52+03 |HAKUNA.MAJI..MAJI.A.427`
  (No. mater. Water. A. 427)
- `Reporter 427 | 2009-11-27 20:16:08+03 |MAJI.A.427`
  (Water. A. 427)

Some people prefer to use long sentence to explain what water problem they faced instead of typing the specific codes. It is becoming more frequency that people send long sentence via SMS report to

explain their water problems, such as the following SMS. It explained the location where has water problem, but this location did not belong to the public water points.

- 2010-01-17 17:47:21+03,A michenzani jumba namba 5 tobo la tatu

(Michenzani house number 5)

- 2009-11-28 13:15:28+03 | ASALAM ALAYKUM HABARI YA SKUKUU KUBWA HUKU ERIA YA MWEMBE SHAURI MAJI HATUPATI TANGU SAA 1 ASUBUHI PROBLEM HATUIJUI TUNAOMBA MUJE MTUSAIDIE

(Greeting, how are you this holiday? In the area, Mwembe Shauri, there is no water since 7:00 in the morning, we do not know what the problem is. We request you to come and help us.)

3. SPAM messages

Since human sensor web is open to public, it cannot be avoided to receiving several spam SMS.

- Tafadhali Nipigie!Please Call Me!From/Kutoka: +25575XXXX319

(Please call me)

Those SMS cannot be recognized or identified by human sensor web system automatically because of typing error or someone sent spam SMS. The way to handle those errors is to find someone as human agent to read those SMS and decide how to react. Because the additional time of the human agent to react and deal with those SMS error, it not only increases the cost of system but also makes HSW relatively low efficient compared to the case if citizens send correct messages.

5.4. Discussion

5.4.1. Agenda and Malice intent

Coleman et al. (2009) classified the native motivation to impede VGI sharing are mischief, agenda, and malice and crime intent (see chapter 2). In this case, citizens only have the rights to complain and contribute water problems. They do not have the accessibility to change or erase any data in dataset. The mischief of erasing or replacing others' contribution will not be the problem. However, the agenda and malice intent might happen in future.

As mentioned in chapter 5.1.2, people do not trust water provider can improve their lives. Urban people they want water supply for 24 hours because they already paid for the water fee. But in fact, there is no 24 hours water supply in Zanzibar. That's the reason urban people are angry to ZAWA. Those people from rural area, they think those people in urban area already forget rural area. Especially, citizens have faced a specific problem of no electric power from December 2009 in Zanzibar. And this situation of lack of power will be continuous until March 2010.Even for those people who have electric generator, they cannot afford it because of oil is becoming scary at this moment. People have no power for water pump now, and they have to pay for water vendor to buy water in 20 litres, but they have no idea where this water comes from.

This conflict and barrier between citizens and government will be more serious in 2010, because there is an election in October. Past election in Zanzibar has featured violence during the campaign season (Reuters Africa 2009). People from the two opposite politician parties will cause lots of conflicts,

especially at the mistrust issue. This election will also face the water shortage problem in dry season (around June to October) and the water payment issue; even people do not have to pay for water fee in this period of power shortage. The unrest for violence conflict may exacerbate people's dissatisfaction about water problem in dry season. People would make decision and complain a lot based on political and social statement. Hence, unreasonable water complaining events based on personal and political states may happen and increase in this period.

5.4.2. Information bias

Elwood (2008) examines VGI may have the questions about the participatory and feminist, such as the target users of VGI, participation in VGI, and the method to empower users, and through what means to alter societal role and local knowledge. In this case, VGI is based on the mean of usages and popularity of ICT in Zanzibar. If the ICT usage has bias, the contribution of VGI may have the prejudice against the meaning of empowerment. Hence, although ICT in Zanzibar can provide new opportunities to empower every human sensor, ICT can also further disenfranchise already marginalized regions and deep people's gap between poor information and rich information. Especially the gap between those people without and with accessibility to ICT, the marginalized group will be ignored in the ICT world, such as women in Africa.

Women are restricted access to ICT resources and opportunities (Wakunuma 2006). As Rathgeber (1989) mentioned "for most women in the developing world, technology has failed." This points out the fact that ICT are not gender neutral. Women's limited accessibility to ICT causes that women lost the opportunity to become information provider. Hence, the world lost their women's voice. African woman in particular in danger of being further disenfranchised in this process.

In Zanzibar, women are the one dealing with water problem in every household. But men are the one with mobile phones. Even women with their cell phones, they still share the ownership with their relatives, such as the problem mentioned in Wired Mothers programs (see chapter 5.2). Women share the ownership and the usages of mobile phones with their relatives so that information is transformed indirectly. Women have to depend on their husbands' mobile phones to send SMS. As the example of men's daily lives explained in chapter 5.1, men go home around 15:30 and 21:00. That may be one reason why SMS from human sensor web system (figure 4.11) increase again around 17:00 and 21:00.This information gap between men and women in one household may cause the information delay and incorrect information report. So that citizens might send wrong or delayed messages to human sensor web system because of the indirectly information transforming.

5.4.3. The role of culture

Culture may be one reason to adopt or resist the information exchange. Hofstede (1997) mentioned five culture factors that affect how people interact. One of these five factors is the power distance. Power distance is a measure of how much people at the lower castes of society differ from those at top. Hofstede gave two examples of power distances societies, Africa and United States.In Africa, a high power distance societies," whoever holds the power is right and good." It causes majority member of non-ruling and no power class follow those with high power position. Hence, majority people from high power distance society are more likely to obey the e-service. In contrast, lower power distance

culture like the US government as a serving system to people. Because of the equality of everyone, citizens in societies with great power are more likely to adopt available e-government services (Hofstede 1997).

In Zanzibar case, people do not obey sheha's willingness. This powerful local leader can not only collect and accept citizens' complaining and opinions, but also be the representative of one community to complain about any issue to government. In Nungwi case (see chapter 5.1.3), we can see that sheha's willingness to pay for water fee would influence the result of citizens' payment of water bill. And there are around 40% to 50% of respondents ever expressed their complaint to sheha. People may not trust government, but they are more willing to talk and express their opinions to sheha, especially in rural area. The local leader may play an important role to influence people's willingness to use human sensor web system in future. Hence, get the support and understanding from each sheha may help human sensor web operate more smoothly and receive more data from citizens to achieve the purpose of empowering every citizen.

5.4.4. Typing error or human error

Typing error is a mistake made in originally. An error while inputting text via keyboard, made despite the fact that the user knows exactly what to type in, this usually results from the operator's inexperience at keyboarding, rushing, not paying attention, or carelessness. Especially in mobile phones, the small screen and numeric keypad layout of the mobile phone may present physical constrains such as difficulties in reading and comprehension due to small screen displays, as well as interactivity restriction related to the use of fine motor skills when operating the keypad (Buchanan, Farrant et al. 2001; Palen and Salzman 2002; Benbunan-Fich and Benbunan 2007).In another similar VGI cases in Zanzibar, there is 7 % error in ZMCP database (see chapter 5.2), and most of them are human error and typing error. Human typing error is the key driving factors as reporting via SMS through small keypad in mobile phone.

This reporter may understand human sensor web can be used to complain and explain their water problems, but the typing error or human error may reduce data quality and increase the cost of operating the system. Until now, the method to deal with those typing and human error is find one human agent to read and react to every SMS error. As the system received one SMS error report, this human agent would call them back to understand reporters' complaint and water problems. This human agent might be the solution to solve the error problem in the initial stage. After human sensor web system operating for one period, there will be more complaints and it may be not efficient to call back to every reporter. To educate and give every reporter the correct complaining type to human sensor web system might be the long term solution.

5.4.5. Time for contributing VGI

From those SMS of human sensor web, we can see that the period of citizens sending a message is from 2:00 AM to 11:00 PM, and the daytime citizens start to send is from 7:00 AM (figure 4.9). That means as citizens wake up and begin their daily lives, they need water at the same time. Hence, citizens have the water need for 16 hours (from 7:00 AM to 11:00 PM).

But the time public water points supply water is normally 9:00 AM to 8:00 PM at Mwembe Shauli and 6:00 AM to 8:00 PM at Nyarugusu (see chapter 4.3). There are around 11 to 14 hours per day with water supply. Even the water supply starts earlier, it does not mean this area has more water in one day. No matter in which area, there are always some blank gaps in water meter records. That means sometimes the water point stops to supply water. Compared the time of water supply (11 to 14 hours) with the time citizens' water need (16 hours), it is obvious that the time for citizens' water need is longer than water supply. Hence, at the time citizens have water need but without water supply, that will be the time citizens complain and start to send SMS messages to human sensor web system. Compared the figures of water supply in one day and the figures with water complaining from citizens, as there are always several gaps around 12:00 PM without water supply, citizens' complaining events focus on the10:00 AM to 7:00 PM.

As there is gender bias for ICT usages in Zanzibar, the time for sending SMS is typically based on men's time schedule. As mentioned in chapter 5.1.1 about men's daily lives, men start their daily lives and go to office around 7:30 AM. That is the time people start to send SMS to human sensor web system at 7:00 AM. Men start to send SMS to human sensor web system and the amount of SMS increases until 10:00 AM to have the maxmum value of complaining SMS. Men finish their work and go home at 3:30 PM. That is the reason why around 5:00 PM the amount of SMS increases again. And usually men go outside for visiting friends and relatives at evening, and arrive home around 9:00 PM. That is the reason why around 10:00 PM the amount of SMS increases again.

5.4.6. Recommendations to improve data quality

According to the factors mentioned above, there might be several ways to improve data quality and empower the users of human sensor web:

1. According to the gender bias of ICT usages and typing error , the way to educate citizens to send correct complaining codes to human sensor web can not just billboards located near public water points. The information of typing codes can be delivered and reached to each household. This method may not only reduce the wrong memory problems caused by gender bias of ICT usages in each household, but also reduce the typing error from citizens.
2. Get the support and understanding of each local leader. This might be the efficient way to educate and encourage citizens to use human sensor web system.
3. Mistrust of government department is a serious problem and difficult to solved. Since citizens have low trust level of the water provider, erasing the symbol or logo in billboard which mentioned this system is supported by ZAWA might improve the willingness of citizens to use human sensor web.

5.4.7. Answers for research questions

1 How does the level of data quality affect the human sensor web?

Since human sensor web is based on citizens' VGI, the reliability of VGI will influence the output and efficient and effectiveness of problem solving. In this case, there are 77% of SMS considered as errors in human sensor system (see table 4.13). Those SMS cannot be recognized and identified automatically. The method to solve these SMS error is use the human agent or gatekeeper to read every SMS. The human agent has to call back to reporter

to check what those citizens would like to convey via their SMS. It not only cost additional time to operate and find out the exact location of problems, but also reduces the efficiency and effectiveness of the original purpose of human sensor web system as an immediate monitoring system.

2 What are the key drivers to cause reliability of citizens' message?

Gender bias of ICT usage influences the data quality of human sensor web in Zanzibar. Only 40 % to 50% women have mobile phones, but they still share the ownership with others. Therefore, not only the ownership of VGI has gender bias, but also the time citizen contributing VGI has typically based on men's daily schedule. The bias ICT accessibility between men and women causes unreliability and information delay of VGI.

Local community leader plays a crucial role to change citizens' willingness to cooperate or impede the usages of human sensor web. This powerful local leader can not only collect and accept citizens' complaining and opinions, but also be the representative of one community to complain about any issue to government. People may not trust government, but they are more willing to talk to and express their opinions to sheha, especially in rural area. The local leader may play an important role to influence people's willingness to use human sensor web system in future.

Mistrust of government impedes citizens to send SMS about specific complaint to human sensor web. Because of the water payment and the priority of water supply, citizens lost the trust of water provider. Especially people from rural area, they have poor accessibility of urban water supply and have to spend more time to collect water. Those unbalance development between urban and rural area exacerbates rural people's anger and mistrust.

Typing error of SMS causes the system manager has to recheck the SMS sent from citizens, and this typing error also reduces the data quality of human sensor web system. The wrong typing, long sentence to explain the location and time without water, and SPAM messages produce SMS error which can not be identified automatically by system.

3 What are the suggestions to provide useful information to support and empower the user?

See chapter 5.4.6.

6. Conclusion and recommendation

6.1. Conclusion

According to the above discussion, this research has the following conclusions:

1. Gender bias of ICT usage influences the data quality of human sensor web in Zanzibar.
2. Local community leader plays a crucial role to change citizens' willingness to cooperate or impede the usages of human sensor web.
3. Mistrust of government impedes citizens to send SMS about specific complaint to human sensor web.
4. Typing error of SMS causes the system manager has to recheck the SMS sent from citizens, and this typing error also reduces the data quality of human sensor web system.

6.2. Rcommendation for future studies

1. Since the purpose of VGI is to empower citizens, how the decision makers react to VGI will need to be understood. Based on the output of VGI from citizens, decision makers can improve the local service. The understanding of the criteria of how decision makers decide the locations and specific issues to be improved will directly change people's lives. The further research could try to understand not only the output of VGI from citizens, but also decision makers' opinions about the requirement and criteria of VGI to help them improve citizens' lives.

2. In future, citizens will not only send water complaining events, but also send more events, such as healthy issue or fire issue. Based on this research, citizens have low trust level to specific government departments. The understanding of each VGI issue which citizens would like to contribute and the trust level of the relative government departments would help to improve the usages of human sensor web in future.

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Appendix- Questionnaire (English)

Dear Sir or Madam:
This questionnaire is about the water consumption and availability problems in Zanzibar. Your kindly response will help us understand those problems. Most part of question is about the water consumption and availability in each household. The other part is about the willingness of people to report problems by SMS. This question will help us build a monitoring system of water availability in Zanzibar. This final result will help ZAWA monitor water problems and supply a better water service in future.

After 3-5 days, you will receive one SMS about the water availability question in you cell phone. Please reply by SMS. Your reply will be considered as the pre-test database about how people willing to report the water availability problem through SMS. This research will help us understand the relationship between serious level about water availability and the reporting problems by SMS. Thank you very much for your time for filling the questionnaire and SMS in advance.

For those who reply all SMS questionnaires (around 5 questions) will participate the lottery to win 3000 TSH free recharging budget. If you win the price, we will send you a SMS with recharging code on Oct 10 2009.

Regards,
Chou Yen Sung
Macleod Mwale

International institution for Geo-information Science and Earth Observation (ITC),
Netherlands
Cell phone numbers: 0776539253 (Chou)
Cell phone numbers: 0776599200 (Macleod)

WATER CONSUMPTION AND AVAILABILITY SERVEY IN ZANZIBAR

0. IDENTIIFICATION PANEL

QUESTIONNAIRE NUMBER	
NAME OF DISTRICT……..	
NAME OF PLACE_____	
DATE OF INTERVIEW……	
INTERVIEW STATUS……	**2009**
* **RESULT CODES** 1. COMPLETED 2. NOT AT HOME 3. PARTLY COMPLETED 4. REFUSED 5.INCAPACITATED 6. OTHER…….	
Urban=1 Rural 2	
FOR DATA PROCESSING **DATE EDITED……. /____/____/2009** **DATE ENTERED……. /____/____/2009**	

A. WATER CONSUMPTION AND SERVICES

#	Questions	Options					
Q 1		**Usage**					
	Source of water	Drinking	Washing	Bathing	Business/ washing vehicles/ selling	Livestock drinking	Gardening/ irrigation
	City / town water-supply system						
	Rural (local) water-supply system						
	Public tap						
	Tube well						
	River or stream						
Q 2	What is the role of your household?	All household members……..1 Household leader ……..……..……2 Female / housewife in household…….….3 Children in household……....4 Others_____.....5					
Q 4	How much liters do your household use per day?	0-100 litres……..1 101-200 litres …….... 2 201-300 litres ……..…...3 301-400 litres…… 4 401-500 litres ……5 > 501 litres ……..……....6					
Q 5	How many minutes does it take from home to get water and back (including travel time)?	**Minutes**					

Reaction to water availability problems		
#	**Questions**	**Options**
Q7	How many days do you collect water from your water source in one week?	**Days** ☐
Q9	How many times do you ever report or compliant that for the past year?	Times ☐☐
Q10	How do you compliant?	Writing to ZAWA……1 Go to ZAWA directly……..2 Compliant to sheha……..3 Others_____.....4
Q10a	What is the complaint about?	There is no water……1 The water tasty is not good…….2 Others_____.....3
Q10b	How long do you find out the problem solved?	Never……1 1 week…….2 2 weeks ……3 3 weeks……4 1 month……5 More than 1 month……6
Q11	Which response do you get from reporting?	ZAWA……1 Sheha…….2 Others…….3

C. Short Message Service				
#	**Questions**	**Options**		
Q13	Do you have a cell phone?	Yes……1 No……..2		
Q15	What is the main purpose for you to use cell phone?	Business		Very Important …..4 Important ……..3 Normal ……...2 Less important ……1
		Family		
		Friends		
		Others_____		
Q17	How many SMS do you send or receive per month?	Never…….…. 1 0-10 times…..……..…2 11-20 times …….. 3 Above 21 times……4		
Q18	What is the main purpose for you to use SMS?	Business		Very Important……..4 Important……3 Normal……...2 Less important……1
		Family		
		Friends		
		Others_____		

Information Affordability		
#	**Questions**	**Options**
Q22	Do you think reporting water availability problems using SMS can improve water service?	Yes…….……. 1 Never…….…. . 2
Q22a	What is the response you expect?	_____ _____ _____
Q23	If there is no water available at your regular source, would you be willing to pay for SMS information of where water is available?	Yes……1 No……2

General Information for cell phone users in each household

The household members:_____

No	Name	Gender (Female& Male)	Age	Marital Status (Single, Married, Separated, Divorced, and Widowed)	Education Level (Never, Primary, Secondary, Higher)	Occupation (employed, owning a business, no employed)	Income per month (0-500000Tsh 500000-1000000 Tsh, Above 1000000 Tsh)	Cell phone numbers

The convenient time to call: _____

Appendix- Questionnaire (Swahili)

Hujambo:
Hi ni fomu ya maswali inayohusu shida za utumiaji na upatikanaji wa maji Zanzibar. Majibu yako yatatusaidia kujuwa ni matatizo yanayowafika. Maswali mengi yanahusu utumiaji na upatikanaji wa maji katika nyumba. Sehemu ya pili inahusu ushiriki wenu katika kuripoti shida za maji kwa kutumia SMS. Haya maswali yatatumika kutengeneza mfumo wa kusimamia uasilishaji wa maji Zanzibar. Matokeo ya mwisho yatasaidia ZAWA katika kusimamia shida za maji na kuboresha uasilishaji wa maji.
Baada ya siku 3-5 utapokea ujumbe mfupi katika simu yako wenye suali kuhusu kupatikana kwa maji.Tafadhali jibu ujumbe huo. Majibu yako yatachukuliwa kama ni kianzio cha kujuwa jinsi gani watu wataripoti matatizo ya upatikanaji wa maji kupitia njia ya ujumbe mfupi. Utafiti huu utatusaidia kuelewa uhusiano kati ya matatizo ya maji na utumaji wa meseji kuhusu matatizo hayo. Nakushuru sana kwa muda wako ulioutumia kujibu maswali yangu.

Kwa wale waliojibu ujumbe wa masuali katika simu wataorodheshwa katika bahati nasibu itakayowawezesha kujipatia shilingi 3000 za kitanzania zitakazoingizwa katika simu yako(vocha) tarehe 10 Oktoba 2009

Asante ,

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Macleod Mwale

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Cell phone numbers: 0776599200 (Macleod)

UKAGUZI WA MATUMIZI NA UPATIKANAJI WA MAJI ZANZIBAR	
A. UTAMBULISHO	
NAMBA YA FOMU	
WILAYA……..	
JINA LA MAHALI_____	
NAMBARI YA KAYA……...	**2009**
TAREHE YA MAHOJIANO……	
KIWANGO CHA MAHOJIANO……	
* **Kodi za Matokeo** 1. KAMILI 2. ASIPO NYUMBANI 3. NUSU KAMILI 4. WALIKATAA 5. HAJIWEZI 6. INGINE……. Mjini=1 Kijijini=2	
KWA NYENDO ZA DATA **TAREHE YA KUREKEBISHA…..…….** **/____/____/2009** **TAREHE YA KUINGIZWA …...…….** **/____/____/2009**	

A. UTUMIZI NA HUDUMA YA MAJI							
#	**Maswali**	**CHAGUO**					
Q1	**Vyanzo vya maji**	**Matumizi**					
		Kunywa	Kufulia	Kuogea	Biashara/kuoshea magari/	Kulishia Mifugo	Kumwagilia Bustani
	Mfumo wa Maji Mjini						
	Mfumo vijijini						
	Mifereji ya umma						
	Kisima						
	Mito						
Q2	Ni jukumu la nani kuchota maji?	Wote ……1 Mkubwa wa nyumba ……..…..……2 M'Ke / Mke…..…….3 Watoto……4 Ingine_____.....5					
Q4	Unatumia lita ngapi kwa siku?	0-100 lita……1 101-200 lita ……2 201-300 lita ……..3 301-400 lita…… 4 401-500 lita ……5 > 501 lita ……..……...6					
Q5	Unatumia muda gani kupata maji?pamoja na muda wa usafiri	**Dakika**					

B.Majibu kuhusu matatizo ya upatikanaji wa maji?		
#	**Maswali**	**CHAGUO**
Q7	Kwa wiki unapata maji kwa siku ngapi ?	**Siku** ☐
Q9	Kwa mwaka uliopita , umeriporti au kulalamika mara ngapi?	**Mara** ☐☐
Q10	Ulitoa malalamiko yako vipi?	Unaandikiwa ZAWA……1 Mnaenda ZAWA……2 Unalalamika kwa sheha……..……..3 Nyenginezo_____.....4
Q10a	Malalamiko yalikuwa yanahusu nini?	Hakuna maji……1 Yana ladha mbaya……2 Bei ya maji……3 Nyenginezo_____.....4
Q10b	Inachukuwa muda gani kutatuliwa tatizo lakoHow long do you find out the problem solved?	Haijawahi kutatuliwa……1 Wiki 1……..2 Wiki 2 ……3 Wiki 3……4 Wiki 4……5 Zaidi ya mwezi mmoja……6
Q11	Ni majibu gani unayapata baada kuripoti?	ZAWA……1 Sheha……2 Nyenginezo_____……3

C.Matumizi ya Huduma za SMS				
#	**Maswali**	**CHAGUO**		
Q13	Una simu ya mkononi?	Ndio……1 Hapana…….2		
Q15	Simu yako unaitumia kwa matumizi gani ya msingi?	kibiashara		Muhimu zaidi…..4 Muhimu……3 kawaida……...2 Haina umuhimu…1
		Kifamilia		
		kirafiki		
		Nyenginezo_____		
Q17	Unatuma na kupokea meseji ngapi kwa siku?	Hakuna ……1 Mara 0-10 ……2 Mara 11-20 …… 3 Zaidi ya mara 21 ……4		
Q18	Unatumia meseji kwa ajili gani?	Marafiki		Muhimu zaidi…..4 Muhimu……3 kawaida……...2 Haina umuhimu.1
		Biashara		
		Kifamilia		
		Nyenginezo_____		

D. Habari kuhusu Uwezo wa Kulipa		
#	**Maswali**	**CHAGUO**
Q22	Kama ndi yo unadhani mfumo huo utasaidia?	Ndio……1 Hapana……..2
Q22a	What is the response you expect?	_____ _____ _____
Q23	Kama hupati maji ungekuwa tayari kulipia ujumbe mfupi kuwajulisha wanaohusika kuhusu kukosekana kwa maji?	Ndio……...…….1 Hapana……..2

Habari za Jumla

Idadi ya wanaoishi nyumbani kwako:_____

No	Jina	Aina	Umri	Hadhi ya Unyumba (pekee, Ameowa/ ameolewa ametaliki, ametengana Ukiwa)	Kiwango cha elimu (Sijasoma, Msingi, Sekondari, Masomo ya juu)	Kazi Nimeajiriwa Sijaajiriwa Biashara	Kiwango cha mapato kwa mwezi (0-50,000TZS, 50,001-100,000 TZS, Above 100,000 TZS)	Namabari ya simu ya mkono

Muda mzuri wa kupiga simu_____