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An Analysis of Access to Improved Drinking Water and Sanitation and Distance to the Water Source in a Newly Independent Country, Timor-Leste: Assessing Geographical and Socioeconomic Disparities

Decio Ribeiro Sarmento MPH

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by
Decio Ribeiro Sarmento, MPH
Bachelor of Medical Science, Latrobe University, Australia
Master of Public Health (Tropical Health), University of Queensland, Australia

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30303

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Acknowledgments

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Abbreviations and acronyms

ADB	: Asian Development Bank
AIDS	: Acquired Immune Deficiency Syndrome
AOR	: Adjusted Odds Ratio
AusAID	: Australian Aid Agency for International Development
CDC	: Center for Disease Control and Prevention
CIs	: Confidence Intervals
DHS	: Demographic and Health Survey
GDP	: Gross Domestic Product
GIS	: Geographical Information System
GoTL	: Government of Timor-Leste
H0	: Null Hypothesis
Ha	: Alternative Hypothesis
HESET	: Health, Environment, Social, Economic and Techonology
HIV	: Human Immunodeficiency Virus
JICA	: Japan International Cooperation Agency
JMP	: Joint Monitoring Programme
MDGs	: Millennium Development Goals
OR	: Odds Ratio
PHC	: Population and Housing Census
SAS	: Statistical Analysis System
SDGs	: Sustainable Development Goals
SDP	: Strategic Development Plan
SES	: Socioeconomic Status
TLDHS	: Timor-Leste Demographic and Health Survey
UN	: United Nations
UNDP	: United Nations Development Programme
UN-GLASS	: United Nations Global Analysis and Assessment of Sanitation and Drinking Water
UNICEF	: United Nations Children's Fund
USAID	: United States Aid Program
VIP	: Ventilated Improved Pit
WASH	: Water, Sanitation and Hygiene
WHO	: World Health Organization

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by

Decio Ribeiro Sarmento, MPH

Approved:

Dr Chirstine Elizabeth Stauber, PhD
Committee Chair

Dr Matt Hayat, PhD
Committee Member

May 9, 2015
Date

Abstract

Background: Lack of access to water, sanitation and hygiene (WASH) is of great concern globally as an estimated 748 million people worldwide are without an improved source of drinking water and 2.5 billion people are without adequate access to improved sanitation. Serious disparities exist and the unequal distribution has been recognized globally. However, it is important to further examine the distributions on a national and sub-national scale to understand disparities in access. In Timor-Leste, the determinants of disparities in access to improved drinking water and sanitation systems are poorly understood. Therefore, this present study sought to examine geographical and socioeconomic disparities in access to improved drinking water, distance to water and sanitation in the country.

Methods: This study analyzed 11,463 households and 13,137 women observations from the Timor-Leste Demographic and Health Survey (TLDHS) 2009-2010. Analyses were performed separately for household and individual level. Sampling weights were used to account for complex sampling of the population of interest. Weighted descriptive statistics were computed to display the frequency distribution of outcome variables. Weighted bivariate logistic regression analysis was performed to assess associations between each independent variable (type of residence, municipalities, region, wealth index, education level and literacy) and each outcome variable (improved drinking water source, improved sanitation facility and travel times of 30 minutes or less to the water source). Weighted multivariate logistic regression analysis was performed to examine the associations between independent variables and the outcome variable. This study also utilized spatial data to map out the distribution of drinking water source, sanitation type and distance to the water source in 13 municipalities of Timor-Leste.

Results: Significant predictors in weighted multivariate logistic regression analysis included urban/rural status, region and wealth index for disparities in access to improved drinking water and only wealth index for disparities in access to improved sanitation. Overall, disparities seem to be starker for sanitation than they are for water due to larger values of odds ratio for sanitation outcome, especially when looking across wealth index predictor at both the household and individual level of analysis.

Conclusion: Policies and programming aiming to address disparities should encompass WASH interventions with emphasis on a poverty reduction approach by targeting the poorest population. Future longitudinal model and/or randomized trials are needed to examine the trends and to enable causal inferences.

Keywords: Water; Sanitation; Hygiene; Timor-Leste; Demographic and Health Survey; Access; Geographical; Socioeconomic; Disparity; Inequality.

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Decio Ribeiro Sarmento, MPH
Street Address: 1709 Defoor Avenue Unit A
City, State, and Zip Code: Atlanta, Georgia 30318-7533

The Chair of the committee for this thesis is:
Dr Christine Elizabeth Stauber, PhD
Environmental Health Division, School of Public Health

Georgia State University
School of Public Health
P.O. Box 3995
Atlanta, Georgia 30302-3995

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CHAPTER I

1. INTRODUCTION

1.1 Background

Access to water and sanitation is crucial due to its significant impacts on health, time, dignity and economic losses. Every year, 580,000 children die worldwide due to diarrhea from waterborne diseases (UNICEF, 2014). In Africa, 40 billion working hours a year are spent collecting clean drinking water (UNMP-TWS, 2005). Women and girls are particularly affected by lack of access to water and sanitation services (WHO/UNICEF, 2013). Due to inadequate sanitation, India loses US$53.8 billion per year resulting from decreased working productivity and increased health costs (Water and Sanitation Program, 2010).

Safe drinking water and adequate sanitation are a human right. Yet, water, sanitation and hygiene (WASH) concerns are of great magnitude as indicated by more than 748 million people (over 90% in rural areas) are without improved source of drinking water and even 2.5 billion people (70% in rural areas) are without adequate access to improved sanitation, and of these 1 billion people still resort to open defecation (WHO/UNICEF, 2014). The majority of this burden falls upon individuals who reside in developing countries (Lenton, Wright & Lewis, 2005). Consequently, the United Nations (UN) have declared access to water and sanitation is an essential human right (UN, 2013), individuals and communities may be unable to maintain good health and meeting their development goals without access.

WASH efforts in the developing countries are often balkanized and not sufficiently integrated to ensure sustainable WASH services (Montgomery, 2007). There can be different strategies such as strengthening water resource management and inter-sectorial approaches (education, health and nutrition) to ensure access to safe water and improved sanitation

depending on the country and its social needs. The different strategies may have impacts on reaching the Millennium Development Goals (MDGs) of reducing by half the proportion of the population that lacks access to improved water and sanitation by 2015 (UN, 2000). However, efforts to providing safe water and sanitation on a global basis are challenging.

There are many gaps or challenges that have been identified in providing improved water and sanitation. One of the challenges has been urbanization and water scarcity, which mostly takes place in developing countries (Montgomery, 2007). Rapid urban growth in developing countries is seriously outstripping the capacity of most cities to provide adequate water and sanitation services to their citizens (Cohen, 2006). Water use has risen dramatically in the past 50 years due to population growth, urbanization and demands of irrigation for agriculture purpose (Moe & Rheingans, 2006). Another gap that has been identified is the impact of sustainability of community water supply and sanitation programs, which most of the time is threatened by numerous attitudinal, institutional, infrastructure and economic factors (Pruss-Ustun et al., 2008). Many water and sanitation programs in developing countries have not been sustainable due to such factors as financial cost, no ownership feeling from the communities on the water and sanitation infrastructures, lack of community attitudinal and behavior towards hygiene education and lack of community participation (Cohen, 2006). Other challenges associated with WASH services include lack of investment in community-based and small scale approaches (Bartram et al., 2005), lack of reliable information (critical gap in monitoring system), weak country capacity to implement plans, insufficient funding and the most recent gap has been focused on disparities in access to water and sanitation across global and regional (WHO/UNICEF, 2014).

Undoubtedly, WASH is both complex and an emerging environmental and public health concern faced by communities in developing countries, including Timor-Leste. Timor-Leste is a new country that just gained its independence in 2002 after 450 years under

Portuguese colonialism and 24 years under Indonesian occupation. In Timor-Leste access to clean water and improved sanitation remains a key concern for both populations and the government. According to the Timor-Leste Population and Housing Census 2010, only 66% of people in Timor-Leste had access to drinking water from improved sources and 39% had access to improved sanitation facilities as well as limited hygiene knowledge (National Statistics Directorate, 2013). Lack of access contributes to the mortality and morbidity rates, especially among vulnerable groups including children and women in the country (National Statistics Directorate, 2013). Globally, diarrhea disease is one of the most common infectious diseases and among the top two causes of infant and child mortality (Pruss-Ustun et al., 2014). The Timor-Leste Demographic and Health Survey 2010 reported that diarrhea was responsible for approximately 380 child deaths per year in Timor-Leste as a result of lack access to water, sanitation and hygiene system (National Statistics Directorate, 2010).

Timor-Leste recognizes the human right to water and sanitation in its legislation, which has become one of the measures to address disparities in WASH sector (National Statistics Directorate, 2013). However, academic research to investigate the differences in access to both improved water and sanitation by important variables at household and individual level is still lacking. Also, the role of monitoring and evaluation of actions to reach underserved and disadvantaged groups is limited. These critical gaps in analyzing as well as monitoring and evaluation can impede decision-making and progress for the poorest. Evidence-based practice through surveillance systems can support programs to implement preventive measures, hence to reduce the number of deaths and disease burden associated with WASH risk factors.

1.2 Purpose of study

As stated previously, access to clean water and improved sanitation is a major health and environmental issue in Timor-Leste, affecting about half of population (especially

women and children), and leading to poor health, disability, and death. However, the determinants of water and sanitation system are poorly understood in Timor-Leste. In other words, nationwide, little research has been done by using geographical and socioeconomic measures to examine their relationships with access to improved water and sanitation system. Strengthening the evidence base on the linkages between geographical and socioeconomic factors and disparities in access to improved water and sanitation in the Timor-Leste's population will help support the informed development of policy and guidelines that inform optimal programmatic strategies, actions and monitoring. Therefore, this study sought to determine whether geographical and socioeconomic indicators are associated with disparities in access to water and sanitation system in Timor-Leste by using available data set from the Demographic and Health Survey (DHS) 2009-2010. Specifically, the analysis aimed to examine the disparities in access to improved drinking water and sanitation as well as distance to get to the water source by using specific measures of association, which has not been done before in the country.

1.3 Research questions and hypothesis

This study was conducted to specifically address the following questions:

1. What proportion of the population has access to source of drinking water? Are there any associations between urban/rural residence, municipalities, region, wealth index, education and literacy level and sources of drinking water? Is there a disparity?

Null hypothesis (H0): There is no association between urban/rural residence, municipalities, region, wealth index, education and literacy level and sources of drinking water.

Alternative hypothesis (Ha): There is an association between urban/rural residence, municipalities, region, wealth index, education and literacy level and sources of drinking water.

2. What proportion of the population has access to type of sanitation? Are there any associations between urban/rural residence, municipalities, region, wealth index, education and literacy level and type of sanitation? Is there a disparity?

Null hypothesis (H0): There is no association between urban/rural residence, municipalities, region, wealth index, education and literacy level and type of sanitation.
Alternative hypothesis (Ha): There is an association between urban/rural residence, municipalities, region, wealth index, education and literacy level and type of sanitation.

3. Are there any associations between urban/rural residence, municipalities, region, wealth index, education and literacy level and time to get to the water source? Is there a disparity?

Null hypothesis (H0): There is no association between urban/rural residence, municipalities, region, wealth index, education and literacy level and time to get to the water source.
Alternative hypothesis (Ha): There is an association between urban/rural residence, municipalities, region, wealth index, education and literacy level and time to get to the water source.

CHAPTER II

2. LITERATURE REVIEW

2.1 Brief concept of improved water and sanitation

The concept of improved drinking water and sanitation as essential to health is not a novel idea. The traditional environmental health already focused on sanitation issues including clean water, sewage and waste management (Dannenberg, Frumkin & Jackson, 2011). The global definition of improved water and sanitation has been clearly made and described under the Joint Monitoring Programme (JMP) for Water Supply and Sanitation by the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) (WHO/UNICEF, 2014). These two institutions joined together to establish the JMP, initiating in the year of 2000 with the goals of monitoring global water and sanitation coverage as well as tracking progress towards water and sanitation targets set under MDG 7.

The JMP has defined "improved water "sources as facilities that are protected from environmental contamination, especially fecal contamination such as piped water into a dwelling, plot or yard, protected well or spring and rainwater collection. An "improved sanitation" facility has been defined by the JMP as a facility that separates and removes human excreta from potential human contact. It has specifically been defined that sharing facilities of any type are categorized as unimproved sanitation. The JMP's classification for both improved and unimproved source of drinking water and sanitation facility is presented in Table 1 below.

Table 1. Improved and unimproved drinking water sources and sanitation facility categories as defined by the JMP (*Source: WHO/UNICEF, 2014*)

Improved drinking water source	**Unimproved drinking water source**
Piped water into dwelling, yard or plot Public tap or standpipe Tubewell or borehole Protected dug well Protected spring Rainwater collection	Unprotected dug well Unprotected spring Cart with small tank or drum Tanker truck Surface water (river, dam, lake, pond, stream, canal, irrigation channel) Bottled water
Improved sanitation facility	**Unimproved sanitation facility**
Flush or pour-flush to: • Piped sewer system • Septic tank • Pit latrine Ventilated improved pit (VIP) latrine Pit latrine with slab Composting toilet	Flush or pour-flush to elsewhere (that is, not to piped sewer system, septic tank or pit latrine) Pit latrine without slab/open pit Bucket Hanging toilet or hanging latrine Shared facilities of any type No facilities, bush or field

2.2 Overview of MDGs for WASH component

Improving global access to clean drinking water and adequate sanitation is one of the least expensive and most effective means to enhance public health and save lives (International Vaccine Access Center, 2014). In 2000, 189 world nations came together through the UN Millennium Summit to develop and adopt a global action plan in order to address the worldwide issues affecting development such as poverty, disease, food security and human rights (UN, 2000). One of the goals has been to reduce the number of people without access to improved water and sanitation system. There are 8 goals set under the MDGs to be achieved by those nations: 1) eradicate extreme poverty and hunger; 2) achieve universal primary education; 3) promote gender equality and empower women; 4) reduce child mortality; 5) improve maternal health; 6) combat Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (HIV/AIDS), malaria and other diseases; 7) ensure environmental sustainability; and 8) develop a Global Partnership for Development (UN,

2000).

Under each goal, there are specific targets and quantifiable indicators used to measure progress. Under the scope of environmental sustainability (MDG 7), a target has been set to halve the proportion of people without access to improved sources of drinking water and basic sanitation by the year 2015 (UN, 2000). This specific target has been measured by two important indicators: 1) the number of the world's population using an improved drinking water source; and 2) the number of the world's population using an improved sanitation facility. Accordingly, Clasen (2012) points out that in 2012 the UN made an important announcement that the goal of reducing half the proportion of people without access to improved drinking water had been achieved; yet the achievement or progress for improved sanitation system was not indicated.

Building upon the MDGs, a new process has been put in place after the Rio+20 Conference in order to effectively measure the indicators post 2015 development agenda (UN, 2014). Sustainable Development Goals (SDGs) are the new development framework that will provide opportunity for global leaders and populations to work toward an end to poverty and to transform the world to better meet human needs and the necessities of economic transformation, while protecting our environment, ensuring peace and realizing human rights (UN, 2014). Under this approach, ensuring availability and sustainable use of water and sanitation for all has been listed as one of the proposed SDGs to be attained by 2030. With respect to WASH issue, the goals have been set under proposed goal number 6. The goals include achievement of universal access to safe and affordable drinking water for all by 2030; and achievement of adequate sanitation and hygiene for all, paying special attention to the needs of women and girls (UN, 2014).

2.3 Global trends of access to improved water and sanitation system

Global figures that describe the lack of water and sanitation services are alarming.

More than 748 million people, mostly in developing countries, lack access to safe water sources within a reasonable distance of their home (WHO/UNICEF, 2014). Lack of sanitation is an even larger issue; an estimated 41% of the world's population (2.5 billion individuals) is without improved sanitation (WHO/UNICEF, 2014). According to the most recent progress report by the JMP, global coverage rate for improved drinking water source has increased from 76% in 1990 to 89% in 2012. This illustrates that almost 1.6 billion people now get water through a piped connection and 700 million access water through other improved sources such as public taps, protected wells and boreholes (WHO/UNICEF, 2014). Similarly, the global coverage for sanitation has risen from 49% to 64% from 1990 to 2012. However, there are 2.5 billion people who still do not have access to basic sanitation including flush toilets and covered latrines (WHO/UNICEF, 2014).

Despite this accomplishment, there are many countries, especially low- and middle-income countries showing little or no improvement in access to safe drinking water and improved sanitation (WHO/UNICEF, 2014). These current rates of improvement suggest the MDG goal particularly set for water and sanitation system will not be likely to be achieved by 2015 in some of those developing countries (Clasen, 2012).

2.4 Water and sanitation in developing countries

In many low- and middle-income countries, water and sanitation services are still severely lacking. An estimate shows that access to improved water sources ranges from 56% in sub-Saharan Africa to about 70% in Asia to almost universal access in high-income countries (Skolnik, 2012; UNICEF, 2014). In terms of sanitation, access to improved sanitation is estimated to range from about 80% in South America to only about 30% in sub-Saharan Africa (World Resources Institute, 2009).

With respect to developing countries in Asia and Oceania regions, even though access to water supply and sanitation has been steadily improving over the past two decades, the

regions still lag behind some other developing regions. In Southeastern Asia, the coverage rate for access to improved drinking water gained from piped on to premises has increased from 17% in 1990 to 30 % in 2012, access to improved sanitation has risen from 47% to 71% from 1990 to 2012 (WHO/UNICEF, 2014). Conversely, in Oceania countries, the coverage of improved drinking water source gained from piped on to premises has declined from 27% in 1990 to 25% in 2012, whereas the sanitation coverage has remained the same at 35% from 1990 to 2012 (WHO/UNICEF, 2014). As a result of these measures, it seems that some countries in Asia and Oceania region are unlikely to meet the MDGs of halving the share of the population without access to safe drinking water and sanitation between 1990 and 2015. There are, however, large disparities among countries in low- and middle-income status and between the urban and rural areas within the regions.

2.5 Disparities in access to improved water and sanitation system

Generally, a disparity has been defined as a great difference or inequality as in access to water and sanitation system. Factors associated with disparities such as in access to improved water and sanitation system can include geographical areas (region, urban/rural), social class (rich and poor), race, ethnicity and gender (Dannenberg, Frumkin & Jackson, 2011).

Even though significant and substantial progress has been made in meeting many targets as set under the MDGs (UN, 2014), stark disparities or inequalities with respect to access water and sanitation exist across region, between urban and rural areas, and between the rich and the poor and marginalized. In addressing the concern, few academic research and numerous government and non-government programs have been implemented with an emphasis focused on these disparities in access to improved water and sanitation in developing countries.

At global scale, disparities in access to improved water and sanitation can exist along

geographical and socioeconomic level (UNICEF, 2014). Using the DHS, a study was carried out to determine the relationship between socioeconomic status (SES) and lack of access to improved water and sanitation (Blakely et al., 2005). The study found a positive relationship between socioeconomic determinants such as income status and access to improved water and sanitation system and suggested the existence of disparities in economic lines.

In addition to disparities along socioeconomic lines, disparities in access to improved water and sanitation are also apparent along geographical lines. At regional scale, almost half of the two billion people and four out of ten people who have gained access to improved drinking water source and sanitation live in China and India, whereas coverage is lowest in sub-Saharan Africa and Oceania (WHO/UNICEF, 2014). For improved sanitation access alone, unmet needs are highest in sub-Saharan Africa and Oceania (WHO/UNICEF, 2014). The proportion of global population using improved water and sanitation, showing disparities across the world's geographical region is illustrated in Figures 1 and 2 below.

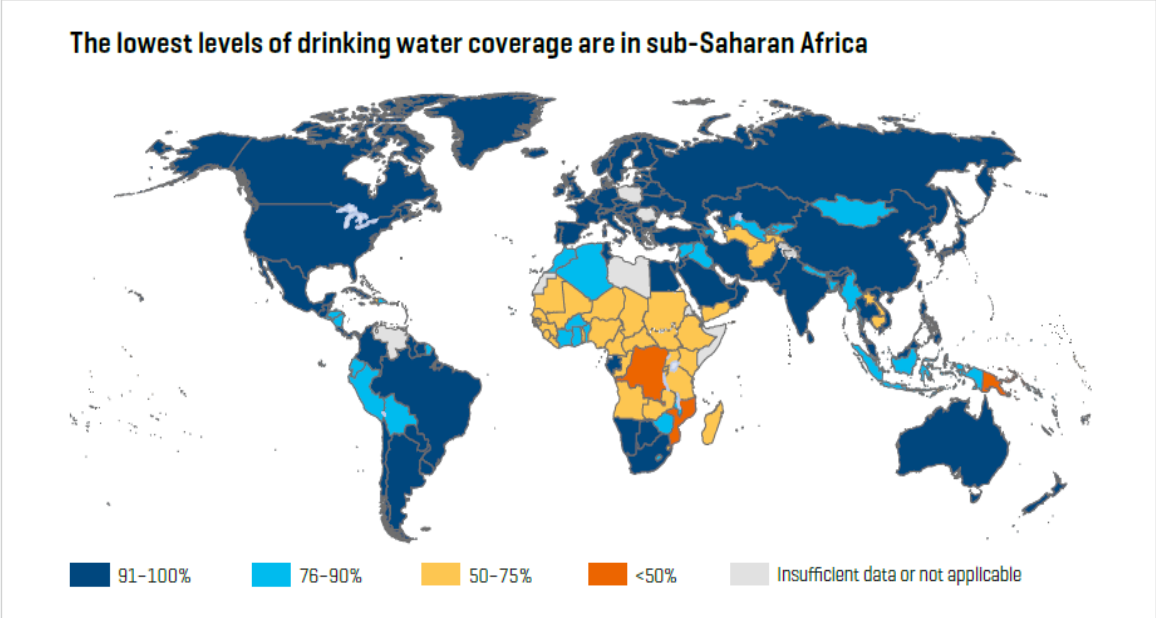


Figure 1. Proportion of population using improved source of drinking water, showing disparities in access at regional scale (*Source: WHO/UNICEF, 2014*)

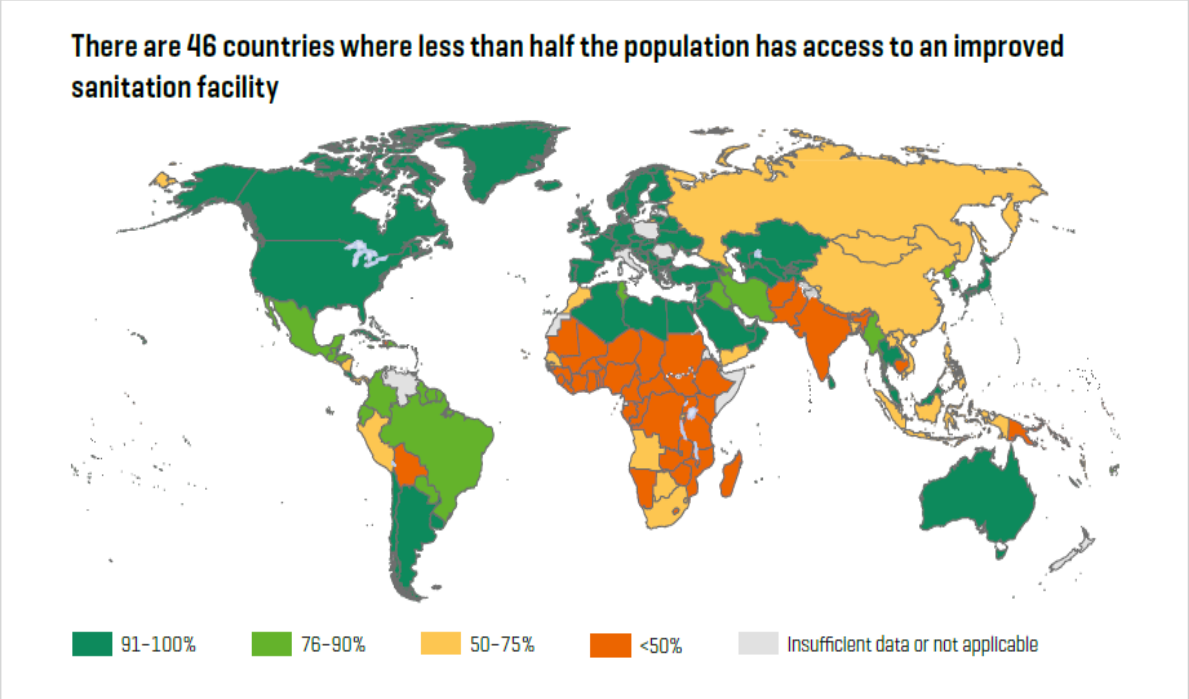


Figure 2. Proportion of population using improved sanitation, showing disparities in access at regional scale (*Source: WHO/UNICEF, 2014*)

In terms of urban/rural disparities, access to improved drinking water source and sanitation is much higher in urban areas than in rural areas. Worldwide, 1.1 billion people who gained access to improved water from piped water on premises reside in urban areas, compared to 438 million residing in rural areas (WHO/UNICEF, 2014). There are a billion more people without improved sanitation in rural areas (1767 million) than in urban areas (756 million) (WHO/UNICEF, 2014). In Southeast Asia region, the urban drinking water coverage for improved water supplies is 92%, while the coverage of improved drinking water supplies in rural areas is 81% (WHO/UNICEF, 2014). Likewise, the coverage for access to improved sanitation in the region is higher in urban (78%) than in rural (58%) (WHO/UNICEF, 2014). Besides, disparities in access also exist along the line of intra-urban settings with those living in low-income, informal or illegal settlements are likely to have lower levels of access to improved water and sanitation (WHO/UNICEF, 2014). Urban populations are likely to have better access to improved drinking water source and sanitation compared with rural populations due to the fact that within rural areas, remote and difficult to

reach areas, basic infrastructures such as roads are the main challenges to connect rural populations to these improved water and sanitation services.

Indeed, mounting of community-based research has documented disparities in access to improved water and sanitation in low- and middle-income countries. Pullan et al. (2014) conducted a mapping and spatial analysis of cross-sectional survey data to investigate geographical inequalities in sub-Saharan Africa and found that countries with higher levels of inequality relative to coverage in use of an improved drinking water source also experienced higher levels of inequality in use of improved sanitation. The study concluded that there were substantial geographical inequalities in predicted use of water and sanitation that exceeded urban-rural disparities (Pullan et al., 2014). Similarly, in Latin America and the Caribbean, the access to drinking water services by rural population was much more restricted than that of the urban population for groups having similar income as well as families without a household water supply system spent a considerable amount of time getting water supply (Soares et al. 2002). A survey study was carried out in 1015 households in 33 sites in Uganda, Tanzania and Kenya in 1997 to assess diarrhea and effects of different water sources, sanitation and hygiene behaviour (Tumwine et al, 2002). The study found that out of 50% of the households in those East African countries having access to a piped water connection, only 5% of household in rural areas had piped water, against 80% of urban households.

2.6 Vulnerable groups in access to water and sanitation

In many developing countries, collecting water is primarily the responsibility of women. Women's lives are further impacted by lack of water and sanitation because they are responsible for the care of children, who are affected by some WASH related diseases (Water and Sanitation Program, 2010). Women do not always have the financial resources to pay for water purchases, treatment, or new investments (UNICEF, 2014). However, it is not just

access to water that is a problem. The lack of sanitation means that, in some places of developing countries especially in rural areas, women and girls must wait until nightfall to defecate (UNICEF, 2014). These disparities have additional implications for health, education, and human rights. In some developing countries, more than 50% of girls drop out of school due to the lack of toilets (Water and Sanitation Program, 2010). In sub-Saharan Africa, almost 82% women bear the main responsibility for collecting water (UNICEF, 2014). Thus, women and children place a higher value on water and sanitation.

2.7 Burden of diseases associated with WASH

The adverse health impacts attributable to lack of water, sanitation and hygiene are significant. Since 768 million people globally use a drinking-water source that is contaminated with feces (Pruss-Ustun et al., 2014), the transmission of infectious, water-related diseases such as diarrhea, cholera, dysentery, intestinal worms, trachoma, typhoid and schistomiasis is significant (WHO/UNICEF, 2014). On top of that, poor or inadequate sanitation has been a huge contributing factor to malnutrition (Skolnik, 2012). Altogether, unimproved drinking water, inadequate sanitation and hygiene are the most influential risk factors for diarrheal disease (WHO, 2009). It is estimated that 580,000 global diarrheal deaths were caused by unsafe drinking water and 280,000 deaths by poor sanitation (Pruss-Ustun et al., 2014). Inadequate drinking water and sanitation also caused 361,000 diarrheal deaths in children under 5 years old worldwide each year (Pruss-Ustun et al. 2014). In addition to diarrheal disease, 881,000 global deaths from schistosomiasis and lymphatic filariasis were attributed to WASH (Pruss-Ustun et al., 2014).

In developing countries, diarrheal disease has been the second most common contributor to the disease burden (Pruss & Havelaar, 2001) and is a leading cause of mortality and malnutrition in children under 5 years of age (WHO, 2009). The WHO states that in

2004, WASH were responsible for 1.8 million deaths from diarrhea in developing countries, in which 90% were children under 5 (WHO, 2004).

Modifying the risk factors attributed by WASH may prevent around 10% of the total burden of disease worldwide (Pruss-Ustun et al., 2008). Although 1.8 million deaths among children under 5, the burden of diarrhea has gone down but still remains important (UNDP, 2006). Therefore, providing clean water, adequate sanitation and hygiene services play a big role in reducing morbidity and mortality, which the WHO has listed them among the key measures to prevent diarrheal disease (WHO, 2009). Improved water supply and sanitation have been historically documented to benefit health and improve life expectancy (Huttly, 1990; van Poppel & van der Heijden, 1997). Improvements in water supply and sanitation have been found to reduce diarrhea morbidity by 21% and 37% respectively as well as simple act of washing hands at critical times can reduce the number of diarrheal cases up to 35% (WHO/UNICEF, 2014).

2.8 Timor-Leste

2.8.1 Demographic

Timor-Leste is located in Southeast Asia and Pacific, northwest of Australia and the east end of the Indonesian archipelago. The country has a land area of 14,954 square kilometers and a total population of 1.2 million (National Statistics Directorate, 2010). Most people (70% of the population) live in rural areas, whereas only 30% reside in urban areas. Administratively, Timor-Leste counts 13 municipalities, 65 administrative posts, 2,336 hamlets and the government has just recently approved the resolution for a special economic zone in one of the municipalities called Oecusse. The country's boundaries include the eastern half of the island of Timor, the Oecusse enclave in West Timor and the islands of Atauro and Jaco (Figure 3). Timor-Leste is currently adopting a centralized government system, however, much of the decentralization agenda has been put in place and led by the

Ministry of State Administration with the support from international agencies working on local government support program (Kuehn, 2011).

Timor-Leste gained its independence after 25 years of Indonesian occupation through a referendum made in September 1999. More than half of the Timorese are under 18 years of age. Based on the Asian Development Bank (ADB) ranking that in purely economic terms, Timor-Leste is a middle-income economy and one of the most oil dependent economies in the world (ADB, 2013). According to the International Monetary Fund (IMF) statistics, Timor-Leste's Gross Domestic Product (GDP) in 2012 was estimated to be US$4.173 billion, with GDP per capita of approximately US$3,730 (IMF, 2013). The high fertility rate, where on average women give birth to 5.7 children throughout their lifetime is a key contributing factor to the high annual population growth rate of 2.7% (National Statistics Directorate, 2010). This high population growth may hamper increased access to improved water and sanitation.

Figure 3. A map of Timor-Leste showing all 13 administrative municipalities **(***Source:* [*http://www.mapsofworld.com/timor-leste/maps/timor-leste-political-map.jpg*](http://www.mapsofworld.com/timor-leste/maps/timor-leste-political-map.jpg))

While much of the country remains agrarian, a phenomenon of rapid urbanization has been reported where about 22% of the population lives in the urban areas (World Bank, 2013). Poverty incidence remains high at approximately 41% (World Bank, 2013). Rural poverty is much higher than urban poverty owing to low agricultural productivity and limited access to basic infrastructures such as roads and markets (IMF, 2012). Regional poverty disparities also exist, with poverty being worst in the central region. The health status at the community level remains low and for many children and women life remains a day-to-day struggle for survival including access to clean water supply and adequate sanitation system. Maternal height and pre-pregnancy weight has enormous influence over birth outcomes. Shorter and lighter women are more likely to have babies with low birth weight. These women are also most likely to experience difficulties in childbirth and could likely die.

Maternal and under-five mortalities remain high: maternal mortality is 557 per 100,000 live births and under-five mortality is 64 per 1,000 live births (National Statistics Directorate, 2010).

2.8.2 Situation analysis of WASH in Timor-Leste

In Timor-Leste, poor access to water and sanitation is still a nationwide issue. All municipalities of Timor-Leste, particularly rural areas, regularly face water crisis (National Statistics Directorate, 2010). In the countryside, water is most often fetched from rivers that in many cases are contaminated by mud and animal or human feces. More than 40% of Timor-Leste's 1.2 million people lives below the poverty line, in conditions where access to clean drinking water source and adequate sanitation are often nonexistent (World Bank, 2013).

In 2010, 63% of households in Timor-Leste had access to improved source of drinking water, while 36% used unimproved sources of drinking water (National Statistic Directorate, 2010). There is a big difference between urban and rural households in access to sources of drinking water with rural households account for 88% not having access to improved water supply, while urban residents make up 56% without access to improved water source respectively. The latest figure from the JMP shows that the proportion of the population using an improved drinking water source increased from 48% in 2001 to 69% in 2011 (Figure 4), yet this trend demonstrates that Timor-Leste will not achieve its MDG target of 78% for this indicator by 2015 (Ministry of Finance, 2014).

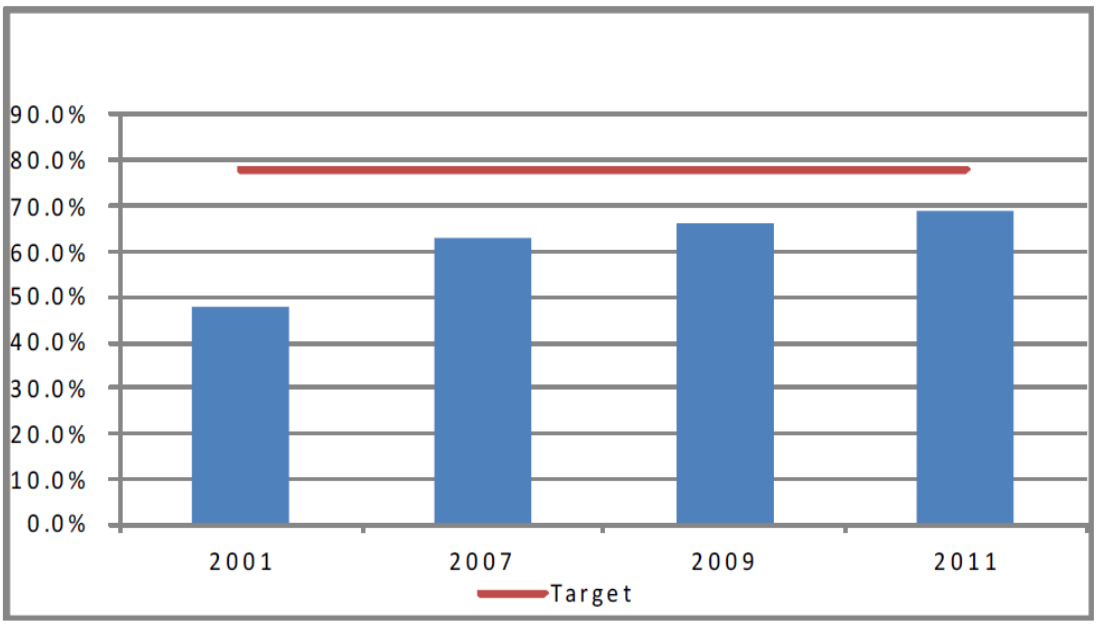


Figure 4. Proportion of the population with access to improved drinking water source (%) in Timor-Leste from 2001 to 2011 (*Source: Ministry of Finance, 2014*)

As far as sanitation is concerned, the coverage and achievement of sanitation in Timor-Leste is still low and there are marked disparities by urban and rural residence. Overall, 41% of households used improved sanitation facility in 2010 and out of this, 65% were in urban households and 34% were in rural household (Ministry of Finance, 2014). On the other hand, 37% of households in Timor-Leste in 2010 had no access to sanitation system with 45% in rural areas and only 14% in urban areas (Ministry of Finance, 2014). According to the JMP recent figure the proportion of population using an improved sanitation facility increased from 31% in 2001 to 39% in 2011 (Figure 5). Again, Timor-Leste is not likely to achieve the MDG target of 60% of the population having access to an improved sanitation facility by 2015 (Ministry of Finance, 2014).

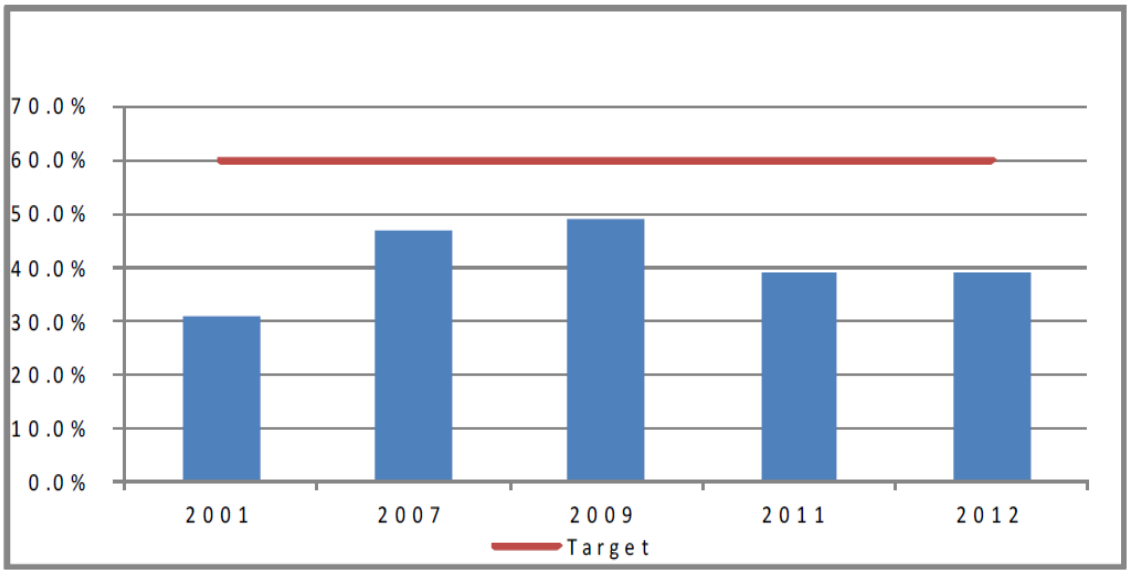


Figure 5. Proportion of the population with access to improved sanitation (%) in Timor-Leste from 2001 to 2012 (*Source: Ministry of Finance, 2014*)

From the literature review above, an analysis is significant to be carried out in order to help inform critical thinking about disparities in access to water and sanitation. In the case of Timor-Leste, evidence is still lacking on the determinants of water and sanitation system. Therefore, this study aimed to assess whether geographical and socioeconomic indicators are associated with disparities in access to improved drinking water and adequate sanitation in Timor-Leste. Results are potentially imperative to support the informed development of policy and guidelines that inform optimal programmatic strategies, actions and monitoring in this new independent country.

CHAPTER III

3. METHODOLOGY

3.1 Data Source

This study used data from the Timor-Leste Demographic Health Survey (TLDHS) 2009-2010 – standard DHS Phase VI obtained from the United States Agency for International Development (USAID) website http://www.dhsprogram.com/data/dataset_admin/download-datasets.cfm. The data was collected by using questionnaire (survey) at both household and individual level. The target population was nationally representative Timor-Leste sample of men and women age 15-49. This survey was designed to provide estimates for the whole country (national level), for urban and rural areas (residence level), and for the 13 districts (regional level). The sample frame of TLDHS was obtained from 2010 Population and Housing Census (PHC).

3.2 Study design and participants

TLDHS used a cross-sectional study design (National Directorate Statistics, 2010). The sample of TLDHS was based on a stratified two-stage cluster design. In the first stage, 455 enumeration areas were selected (116 urban and 339 rural). In the second stage, systematic sampling of households from each cluster was selected with final sample of 12,128 households. Selected households were visited and interviewed, eligible women age 15-49 were interviewed and eligible men age 15-49 were interviewed in one-third of the households (Figure 6).

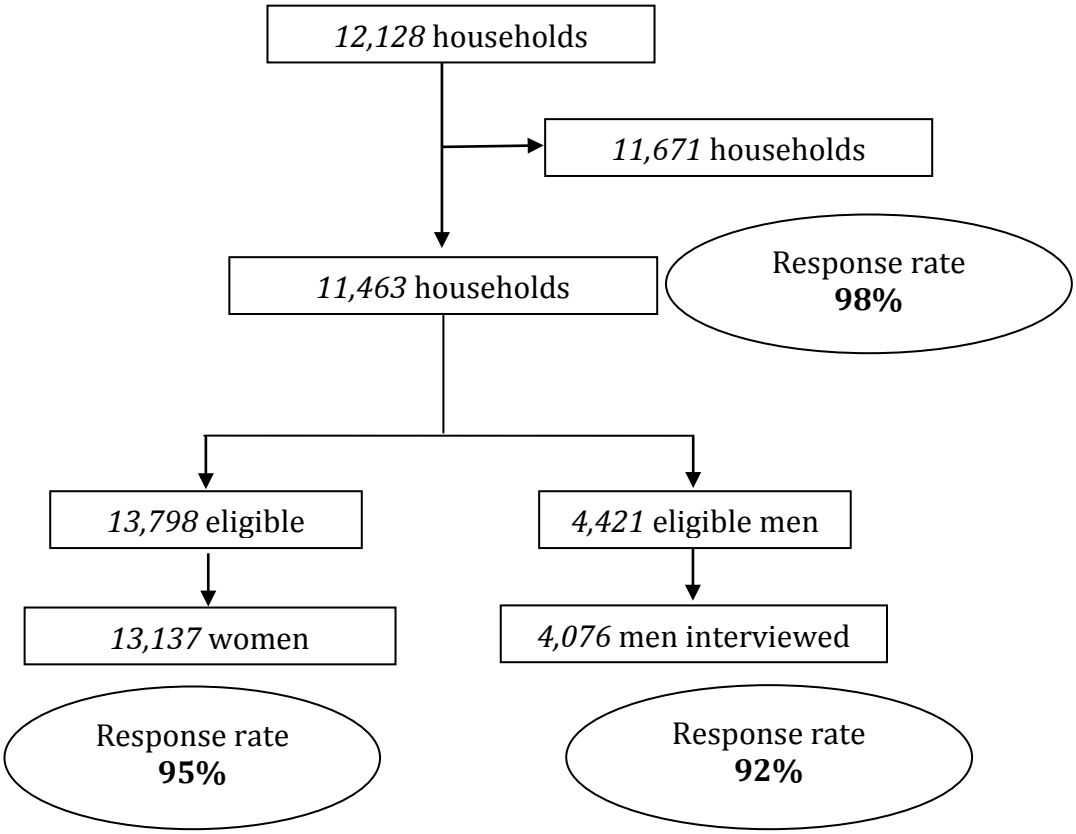


Figure 6. Sampling Flow Diagram from TLDHS 2009-2010

3.3 Unit of analysis

This analysis considered two units, as follows:

1. Household level (n=11,463) was unit of analysis to examine disparities by geographical indicators (urban/rural residence, municipalities and region) and wealth index.

2. Individual level – woman (n=13,137) was unit of analysis to examine disparities by socioeconomic indicators (education level, literacy and wealth index) and type of residence (urban/rural residence).

3.4 Selection of variables

The outcome or dependent variables in this study were generated based on three main pieces of information: source of drinking water, type of toilet facility and time to get to water

source. Drinking water sources and sanitation facilities were identified as improved and unimproved according to the JMP definition (refer back to Table 1). For drinking water source variable, the value "other" responses were categorized as missing and not included in the analysis. For sanitation, the variable of shared facilities of any types was included as unimproved type of sanitation and the response "other" was treated as missing value. Therefore, the final variable for sanitation was generated to include the type of sanitation facility and whether or not it was shared. The variable of time to get to water source measured respondent-reported round trip travel to their source of drinking water. This variable was a continuous (measured in minutes from 0-360), however, the responses were categorized into two levels as having a trip of 30 minutes or less and more than 30 minutes. Responses indicating that the water source was on premises were considered as having trip times of 30 minutes or less and "Don't Know" responses were not included in the analysis.

The independent variables in the study included households' type of place of residence (urban/rural), municipalities, region and wealth index, and women's education level, literacy level and type of place of residence (urban/rural). The choice of these variables was based on the objective of the study and theoretical considerations. In this analysis, the study examined datasets at the household and then separately at the individual level. The following variables were considered as independent variables in the analysis of data at the household level: type of residence (urban and rural), municipalities (Aileu, Ainaro, Baucau, Bobonaro, Covalima, Dili, Ermera, Lautem, Liquica, Manatuto, Manufahi, Oecusse and Viqueque), region (Central, Eastern and Western) and wealth index (poorest, poorer, middle, wealthier and wealthiest). The variable region represents the administrative municipalities that are grouped based on geographical location with Central consists of Dili, Aileu, Ainaro and Manufahi; Eastern consists of Baucau, Lautem, Manututo and Viqueque; and Western consists of Bobonaro, Covalima, Ermera, Liquica and Oecusse. For analysis of data at the

individual level, the following variables were included: highest level of educational attainment (higher, secondary, primary and no education), literacy level (illiterate and literate), type of residence (urban and rural) and wealth index (poorest, poorer, middle, wealthier and wealthiest).

The descriptive list of variables of interest for this study is presented in the Table 2.

Table 2. Descriptive list of all variables considered for the study

No	Variable description	Dependent/ Independent	Variable name	Data type
Household level				
1	Source of drinking water	Dependent variable (outcome variable)	HV201	Categorical
2	Type of toilet facility household members use	Dependent variable (Outcome variable)	HV205	Categorical
3	Share toilet with other households	Dependent variable (Outcome variable)	HV225	Categorical
4	Time to get to water source	Dependent (Outcome variable)	HV204	Continuous
5	Type of place of residence	Independent variable	HV025	Categorical
6	Region	Independent variable	HV024	Categorical
7	Wealth index	Independent variable	HV270	Categorical
Individual level (women)				
1	Source of drinking water	Dependent variable (outcome variable)	V113	Categorical
2	Type of toilet facility	Dependent variable (outcome variable)	V116	Categorical
3	Toilet facility shared with other households	Dependent variable (Outcome variable)	V160	Categorical
4	Highest educational level	Independent variable	V106	Categorical
5	Literacy	Independent variable	V155	Categorical
6	Type of place of residence	Independent variable	V025	Categorical
7	Wealth index	Independent variable	V190	Categorical

3.5 Statistical methods

All the analyses of this study were performed using the Statistical Analysis System (SAS) software program version 9.4. The measure of health inequalities used for the analyses was measures of association (Odds Ratio and 95% Confidence Intervals). The level of significance was $\alpha=0.05$. This study also utilized ArcCatalog and ArcMap from Geographical Information System (GIS) program to display and map out the distribution of drinking water source, sanitation type and distance to the water source in 13 municipalities of Timor-Leste.

Descriptive analysis was performed to examine the frequency distribution (valid and missing observations). In addition, since all outcome variables of interest were classified as binary, logistic regression model was performed to assess associations between the independent variables and outcomes of interest. The statistical modeling process was completed in two stages. The first stage was a *bivariate* logistic regression analysis. In bivariate analysis, logistic regression was performed to assess associations between each independent variable (type of residence, municipalities, region, wealth index, education level and literacy) and each outcome variable (improved drinking water source, improved sanitation and travel times of 30 minutes or less) resulting in odds ratios (OR) and its 95% confidence intervals (CIs). The second stage of the analysis was *multivariate* logistic regression model. Individual multivariate models were fit for each dependent variable, an all independent variables were considered for inclusion.

In the DHS surveys, complex sampling was used. Thus, sampling weights were applied to account for the probabilities of inclusion for households and individuals in the study sample. For this analysis, sampling weights (taken from variables HV005 of household data and V005 of individual data) were applied to each analysis in order to adjust for differences in probability of sample selection.

CHAPTER IV

4. RESULTS

4.1 Descriptive statistics

This study examined the DHS data from Timor-Leste from 2009-2010. A total of 11,463 household observations and 13,137 individual (woman) observations were included. The weighted number of valid and missing observations for each outcome variable is displayed in Table 3. As can be seen that some of the outcome variables at household and individual level examined in this study were missing less than 2 % of their total observations.

Table 3. Weighted number of observations for outcome variables in the study

	Source of drinking water	**Type of sanitation**	**Time to get to water source**
Household level			
Valid	11,373	11,463	11,342
Missing (%)	90 (0.7)	0	121 (1.1)
Total	11,463	11,463	11,463
Individual level			
Valid	12,917	13,137	12,895
Missing (%)	220 (1.7)	0	242 (1.8)
Total	13,137	13,137	13,137

The independent variables used in the study and their distribution in terms of access to source of drinking water, type of sanitation and travel time to the water source are presented in Table 4. At the household level, most households in urban areas had access to improved drinking water and sanitation (81% and 65% respectively) and travel times of 30 minutes or less to the water source (96%). By municipalities, Dili municipality (the capital city) had the highest proportion of households with access to improved drinking water and

sanitation (87% and 74%) and travel times of 30 minutes or less to the water source (98%). On the other hand, Ainaro municipality had the lowest proportion of households with access to improved drinking water and sanitation (37% and 18%), yet most of the households in this municipality had a round trip travel time of 30 minutes or less to the water source (91%). The distribution of access to improved drinking water and sanitation in other municipalities were below 70% and 50% respectively. When these municipalities were grouped into region, Central region had higher proportions of households with access to improved drinking water (69%), improved sanitation (56%) and travel times of 30 minutes or less to the water source (92%) than Eastern and Western region. Furthermore, the wealthiest households had the highest proportion of access to improved drinking water (82%), improved sanitation (82%) and travel times of 30 minutes or less to the water source (97%).

Analysis for individual women respondents is also shown in Table 4. Most women in urban areas had access to improved drinking water and sanitation (80% and 69% respectively) and travel times of 30 minutes or less to the water source (96%). When examined across education attainment, women who had higher level of education attainment had the highest proportion of access to improved drinking water and sanitation (75% and 80%) and travel times of 30 minutes or less t the water source (98%). By literacy level, most women who were literate also had access to improved drinking water (68%), improved sanitation facility (54%) and travel times of 30 minutes or less to the water source (86%). In terms of wealth index, the wealthiest women had the highest proportion of access to improved drinking water (81%), improved sanitation (97%) and travel times of 30 minutes or less to the water source (98%).

Table 4. Independent variables used in the study and their weighted distribution in terms of access to source of drinking water, type of sanitation and distance to water source in Timor-Leste

Independent variables	Source of drinking water		Type of sanitation		Travel time to water source	
	Improved N (%)	Unimproved N (%)	Improved N (%)	Unimproved N (%)	≤ 30 minutes N (%)	> 30 minutes N (%)
Household level (geographical indicator)						
Total N	7,035 (61)	4,338 (38)	4,736 (41)	6,727 (59)	9,394 (82)	1,948 (17)
Residence						
Rural	4,858 (56)	3,825 (44)	2,973 (34)	5,795 (66)	6,820 (79)	1,845 (21)
Urban	2,177 (81)	513 (19)	1,763 (65)	932 (35)	2,574 (96)	103 (4)
Municipalities						
Aileu	199 (46)	237 (54)	200 (45)	245 (55)	357 (80)	87 (20)
Ainaro	249 (37)	421 (63)	120 (18)	553 (82)	607 (91)	62 (9)
Baucau	626 (47)	712 (53)	354 (26)	984 (74)	931 (70)	405 (30)
Bobonaro	796 (73)	299 (27)	439 (40)	658 (60)	918 (84)	174 (16)
Covalima	375 (56)	299 (44)	267 (39)	417 (61)	523 (84)	99 (16)
Dili	1,659 (87)	250 (13)	1,417 (74)	494 (26)	1,864 (98)	34 (2)
Ermera	719 (60)	488 (40)	593 (47)	661 (53)	1,043 (84)	196 (16)
Lautem	465 (73)	173 (23)	347 (54)	293 (46)	546 (86)	88 (14)
Liquica	447 60)	299 (40)	223 (30)	528 (70)	545 (73)	203 (27)
Manatuto	214 (43)	278 (57)	164 (33)	331 (67)	386 (79)	105 (21)
Manufahi	324 66)	166 (34)	224 (46)	266 (54)	393 (80)	97 (20)
Oecusse	488 (60)	329 (40)	198 (24)	618 (76)	631 (77)	184 (23)
Viqueque	473 (55)	387 (45)	190 (22)	679 (78)	651 (75)	213 (25)
Region						
Central	2,432 (69)	1,073 (31)	1,962 (56)	1,558 (44)	3,220 (92)	280 (8)
Eastern	1,178 (53)	1,551 (47)	1,051 (32)	2,287 (68)	2,514 (76)	811 (24)
Western	2,825 (62)	1,714 (38)	1,719 (37)	2,882 (63)	3,660 (81)	856 (19)
Wealth index						
Poorest	1,072 (44)	1,338 (56)	144 (6)	2,289 (94)	1,703 (71)	705 (29)
Poorer	1,099 (47)	1,220 (53)	486 (21)	1,869 (79)	1,747 (75)	583 (25)
Middle	1,391 (62)	847 (38)	919 (41)	1,335 (59)	1,847 (83)	374 (17)
Wealthier	1,650 (76)	525 (24)	1,353 (62)	834 (38)	1,932 (89)	227 (11)
Wealthiest	1,822 (82)	407 (18)	1,835 (82)	400 (18)	2,164 (97)	58 (3)
Individual level (socioeconomic indicator)						
Total N	8,255 (63)	4,662 (35)	5,923 (45)	7,214 (55)	10,774 (82)	2,121 (16)
Education level						
None	2,125 (56)	1,671 (44)	1,211 (31)	2,643 (69)	2,982 (79)	816 (21)
Primary	1,837 (62)	1,134 (38)	1,126 (37)	1,879 (63)	2,399 (81)	564 (19)
Secondary	3,970 (69)	1,746 (31)	3,229 (55)	2,601 (45)	4,972 (87)	731 (13)
Higher	324 (75)	111 (25)	357 (80)	91 (20)	421 (98)	10 (2)
Literacy level						
Illiterate	3,060 (57)	2,262 (43)	1,770 (33)	3,631 (67)	4,221 (79)	1,095 (21)
Literate	5,178 (68)	2,396 (32)	4,145 (54)	3,570 (46)	6,534 (86)	1,023 (14)
Wealth index						
Poorest	1,021 (45)	1,257 (55)	155 (8)	1,832 (92)	1,592 (70)	689 (30)
Poorer	1,173 (49)	1,241 (51)	633 (31)	1,416 (69)	1,816 (75)	614 (25)
Middle	1,593 (63)	950 (37)	1,296 (56)	1,004 (44)	2,072 (82)	455 (18)
Wealthier	1,990 (76)	644 (24)	2,071 (81)	482 (19)	2,325 (89)	298 (11)
Wealthiest	2,478 (81)	569 (19)	2,942 (97)	90 (3)	2,970 (98)	66 (2)
Residence						
Rural	5,510 (58)	3,996 (42)	3,564 (37)	6,133 (63)	7,499 (79)	2,001 (21)
Urban	2,745 (80)	666 (20)	2,359 (69)	1,080 (31)	3,275 (96)	120 (4)

4.2 Spatial data

This study utilized the ARCGIS program to present the spatial data of the distribution of drinking water source, sanitation type and distance travelled to the water source. The maps of Timor-Leste with its 13 administrative municipalities with the proportion of those with access to improved drinking water and sanitation type and travel times less than 30 minutes are shown in Figures 7, 8 and 9. The pie charts clearly indicate differences in distribution. For drinking water source (Figure 7), nine municipalities (Dili, Liquica, Bobonaro, Ambeno (Oecccuse), Covalima, Manufahi, Lautem, Viqueque and Ermera) have higher proportion of households with access to improved water source (indicated in shaded). On the other hand, for sanitation facilities (Figure 8), almost all municipalities, except for Dili and Lautem, have higher proportion of households with access to unimproved sanitation facilities (indicated in black). In terms of distance travelled to the water source (Figure 9), all 13 municipalities in Timor-Leste have higher proportion of households with travel times of 30 minutes or less to the water source (indicated in shaded).

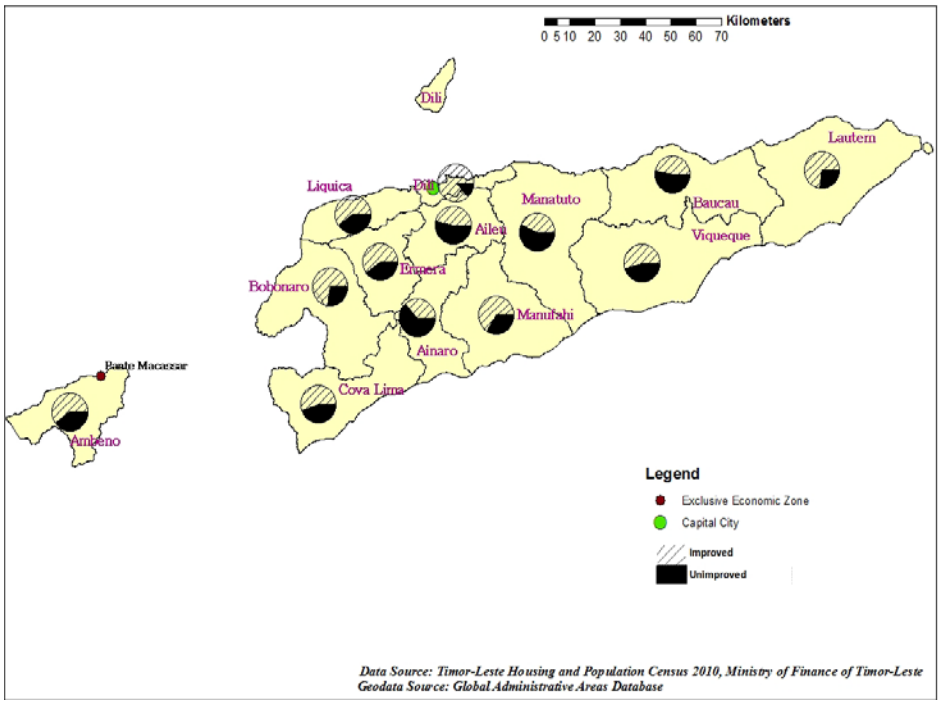


Figure 7. The proportion of having access to source of drinking water across the 13 municipalities of Timor-Leste

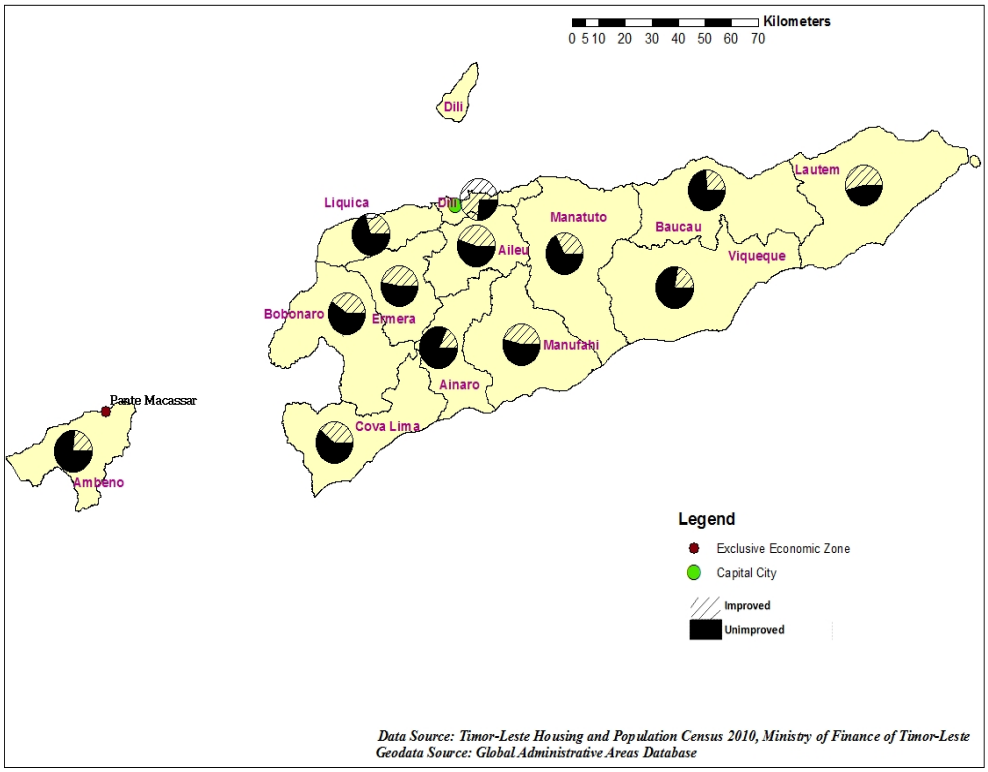


Figure 8. The proportion of having access to sanitation facilities across the 13 municipalities of Timor-Leste

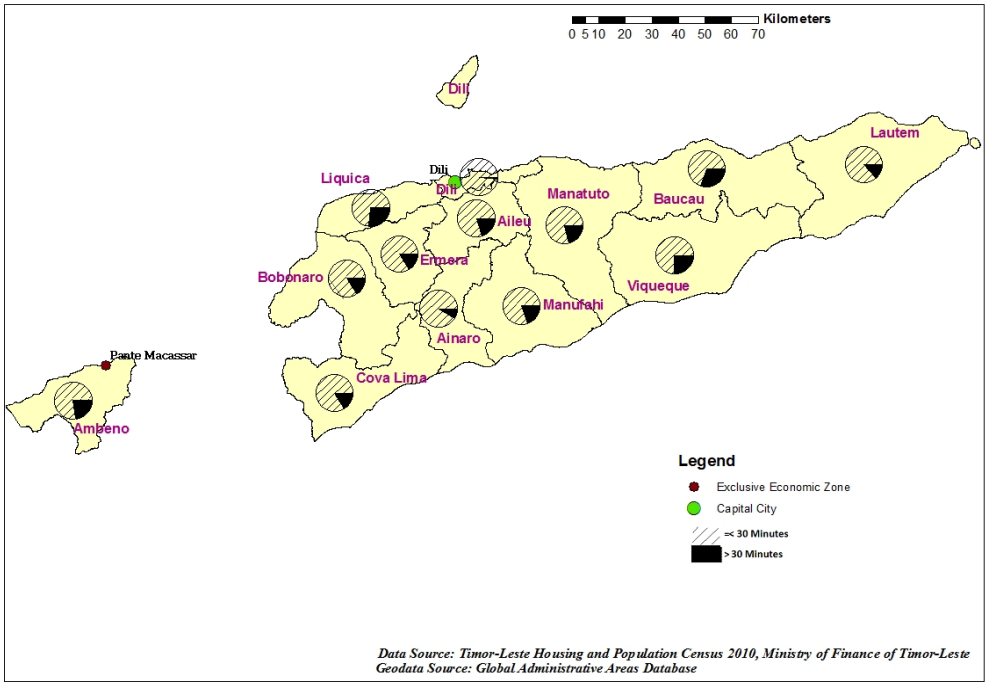


Figure 9. The proportion of travelling time to the water source across the 13 municipalities of Timor-Leste

4.3 Bivariate analysis

4.3.1 Household level bivariate result

The results of weighted bivariate logistic regression analysis of the associations between independent variables and access to improved drinking water and sanitation and travel time of 30 minutes or less to the water source at the household level in Timor-Leste are displayed in Table 5. Each independent variable was found to be statistically significantly associated with access to improved drinking water, improved sanitation and travel times of 30 minutes or less to the water source (1 was not included in the interval). In terms of residence status, the odds ratio for having access to improved drinking water in urban households was 3.3 (95% CI: 3.0-3.7) as compared to rural households. The odds ratio for improved sanitation in urban households was 3.7 (95% CI: 3.4-4.0) as compared to rural households. The odds ratio for travel times of 30 minutes or less to the water source was 6.8 (95% CI: 5.5-8.3) as compared to rural households. By municipalities, the odds ratio of having access to improved drinking water source and improved sanitation were larger in households located in Dili municipality as compared to households in the other 12 municipalities. The odds ratio for having access to improved drinking water in households from other municipalities ranged from 0.09 to 0.40 and the odds ratio for having access to improved sanitation in households from other municipalities ranged from 0.08 to 0.41. The odds ratio of having round trip travel times of 30 minutes or less to the water source was also larger in Dili compared to other municipalities. By region, the odds ratio of having access to improved drinking water, improved sanitation and travel times of 30 minutes or less to the water source were larger in households located in Central region compared to households in Eastern and Western region. In terms of wealth index, the wealthiest households were 5.58 times as likely to have access to improved drinking water compared to the poorest households and 72.8 times as likely to have access to improved sanitation compared to the

poorest households. They were also 15.5 times likely of having travel times of 30 minutes or less to the water source than households with the poorest status (Table 5).

Table 5. Weighted bivariate logistic regression analysis of the associations between independent variables and access to improved drinking water and sanitation and distance to water source with 30 minutes or less at the household level in Timor-Leste

Independent variables	Improved drinking water source	Improved sanitation	≤ 30 minutes travel time to the water source
	Unadjusted Odds Ratio (95% CIs)	**Unadjusted Odds Ratio (95% CIs)**	**Unadjusted Odds Ratio (95% CIs)**
Residence			
Rural	Reference	Reference	Reference
Urban	3.3 (3.0-3.7)	3.7 (3.4-4.0)	6.8 (5.5-8.3)
Municipalities			
Dili	Reference	Reference	Reference
Aileu	0.13 (0.10-0.16)	0.29 (0.23-0.35)	0.08 (0.05-0.11)
Ainaro	0.09 (0.07-0.11)	0.08 (0.06-0.10)	0.18 (0.12-0.27)
Baucau	0.13 (0.11-0.16)	0.13 (0.11-0.15)	0.04 (0.03-0.06)
Bobonaro	0.40 (0.33-0.48)	0.23 (0.20-0.27)	0.10 (0.07-0.14)
Covalima	0.19 (0.15-0.23)	0.22 (0.19-0.27)	0.10 (0.07-0.15)
Ermera	0.22 (0.19-0.26)	0.31 (0.27-0.36)	0.10 (0.07-0.14)
Lautem	0.40 (0.32-0.50)	0.41 (0.34-0.50)	0.11 (0.08-0.17)
Liquica	0.22 (0.19-0.27)	0.15 (0.12-0.18)	0.05 (0.03-0.07)
Manatuto	0.12 (0.09-0.15)	0.17 (0.14-0.21)	0.07 (0.05-0.10)
Manufahi	0.30 (0.23-0.37)	0.29 (0.24-0.36)	0.07 (0.05-0.11)
Oecusse	0.22 (0.19-0.27)	0.11 (0.09-0.14)	0.06 (0.04-0.09)
Viqueque	0.18 (0.15-0.22)	0.10 (0.08-0.12)	0.06 (0.04-0.08)
Region			
Central Region	Reference	Reference	Reference
Eastern Region	0.51 (0.46-0.56)	0.37 (0.33-0.41)	0.27 (0.23-0.31)
Western Region	0.73 (0.66-0.80)	0.47 (0.43-0.52)	0.37 (0.32-0.43)
Wealth index			
Poorest	Reference	Reference	Reference
Poorer	1.12 (1.00-1.26)	4.13 (3.40-5.02)	1.24 (1.09-1.41)
Middle	2.05 (1.82-2.30)	10.9 (9.0-13.2)	2.05 (1.78-2.36)
Wealthier	3.92 (3.45-4.45)	25.8 (21.3-31.1)	3.52 (2.99-4.14)
Wealthiest	5.58 (4.88-6.38)	72.8 (59.6-88.9)	15.5 (11.8-20.4)

Note: CIs=Confidence Intervals

4.3.2 Individual level bivariate result

The results of weighted bivariate logistic regression analysis of the associations between independent variables and access to improved drinking water and sanitation and travel time of 30 minutes or less to the water source at the individual level in Timor-Leste are

illustrated in Table 6. Each independent variable was found to be statistically significantly associated with access to improved drinking water, improved sanitation and travel times of 30 minutes or less to the water source (1 was not included in the interval). Women in urban areas had 3.0 of having access to improved drinking water, 3.8 odds ratio of having access to improved sanitation, and 7.3 odds ratio of having travel times of 30 minutes or less to the water source as compared to women in rural areas. When women's educational attainment was examined, women who attended primary, secondary and higher education were 1.3, 1.8 and 2.3 times more likely to have access to improved drinking water than those who had no education at all. Women having primary, secondary and higher education level had higher odds ratio (1.3, 2.7 and 8.5, respectively) of having access to improved sanitation compared to those without any education, and 1.2, 1.9 and 11.3 odds ratio of having travel times of 30 minutes or less to the water source compared to those without any formal education. In addition, the analysis of the literacy level indicated that women in Timor-Leste with ability to read (literate) were 1.6, 2.4 and 1.7 times more likely than illiterate women to have access to improved drinking water and sanitation and travel times of 30 minutes or less to the water source. In terms of wealth index, the wealthiest women were 5.36 times as likely to have access to improved drinking water compared to the poorest women and 388.5 times as likely to have access to improved sanitation facility compared to the poorest women. The odds ratio for wealth index of improved sanitation is so large (388.5) because of weighted counts are disproportionate (8% for the poorest compared to 97% for the wealthiest) (refer back to Table 4). The wealthiest women were also 19.5 times more likely of having travel times of 30 minutes or less to the water source than the poorest women (Table 6).

Table 6. Weighted bivariate logistic regression analysis of the associations between independent variables and access to improved drinking water and sanitation and distance to water source with 30 minutes or less at the individual level in Timor-Leste

Independent variables	Improved drinking water source	Improved sanitation	≤ 30 minutes travel time to the water source
	Unadjusted Odds Ratio (95% CIs)	Unadjusted Odds Ratio (95% CIs)	Unadjusted Odds Ratio (95% CIs)
Residence			
Rural	Reference	Reference	Reference
Urban	3.0 (2.3-3.3)	3.8 (3.5-4.1)	7.3 (6.0-8.8)
Education level			
None	Reference	Reference	Reference
Primary	1.3 (1.2-1.4)	1.3 (1.2-1.4)	1.2 (1.1-1.3)
Secondary	1.8 (1.6-1.9)	2.7 (2.5-3.0)	1.9 (1.7-2.1)
Higher	2.3 (1.8-2.9)	8.5 (6.7-10.8)	11.3 (6.0-21.0)
Literacy level			
Illiterate	Reference	Reference	Reference
Literate	1.6 (1.5-1.7)	2.4 (2.2-2.6)	1.7 (1.5-1.8)
Wealth index			
Poorest	Reference	Reference	Reference
Poorer	1.16 (1.04-1.31)	5.29 (4.38-6.40)	1.28 (1.13-1.46)
Middle	2.06 (1.84-2.32)	15.3 (12.8-18.4)	1.97 (1.72-2.26)
Wealthier	3.80 (3.37-4.29)	50.8 (42.0-61.6)	3.38 (2.91-3.93)
Wealthiest	5.36 (4.74-6.06)	388.5 (297.5-507.1)	19.5 (15.0-25.3)

Note: CIs=Confidence Intervals

4.4 Multivariate analysis

4.4.1 Household level multivariate result

The results of weighted multivariate logistic regression model including all independent variables (residence type, municipalities and wealth index) at the household level are presented in Table 7a. When all the independent variables were included, some associations changed. By residence settings, after adjusting for other variables, households in urban areas had 1.5 odds ratio of having access to improved drinking water and 2.27 odds ratio of having travel times of 30 minutes or less to the water source than households in rural areas when controlling for residence type, municipalities and wealth index. After adjusting for other variables, households in urban areas had 0.98 odds ratio of having access to improved sanitation as compared to households in rural areas, but the association was not

statistically significant (95% CI: 0.85-1.14). After adjusting for other variables, by municipalities, Dili municipality had a larger odds ratio of having access to improved drinking water and travel times of 30 minutes or less to the water source compared to the other municipalities. For improved sanitation, Ainaro municipality had the smallest odd ratio as compared to the other municipalities that had statistically significant results. In terms of wealth index, after adjusting for other variables, the wealthiest households were 2.8 times likely to have access to improved drinking water compared to the poorest households. The wealthiest households had 67.2 and 6.68 odds ratio of having access to improved sanitation and travel times of 30 minutes or less to the water source compared to the poorest households after including residence type and municipalities as covariates after adjusting for other variables (Table 7a).

Table 7a. Adjusted odds ratio from weighted multivariate logistic regression of the predictors (residence, municipalities, wealth index) of access to improved drinking water, improved sanitation and travel times of 30 minutes or less at the household level in Timor-Leste

Predictors	Improved drinking water source	Improved sanitation	≤ 30 minutes travel time to the water source
	AOR (95% CIs)	**AOR (95% CIs)**	**AOR (95% CIs)**
Residence			
Rural	Reference	Reference	Reference
Urban	1.5 (1.3-1.8) *	0.98 (0.85-1.14)	2.27 (1.80-2.87) *
Municipalities			
Dili	Reference	Reference	Reference
Aileu	0.30 (0.20-0.40) *	1.80 (1.37-2.38) *	0.38 (0.24-0.60) *
Ainaro	0.22 (0.18-0.29) *	0.48 (0.36-0.62) *	0.96 (0.61-1.54)
Baucau	0.33 (0.27-0.41) *	0.67 (0.54-0.84) *	0.21 (0.14-0.32) *
Bobonaro	0.86 (0.68-1.10)	0.90 (0.73-1.12)	0.41 (0.27-0.62) *
Covalima	0.38 (0.30-0.61) *	0.79 (0.62-1.00) *	0.39 (0.25-0.60) *
Ermera	0.49 (0.40-0.61) *	1.56 (1.26-1.92) *	0.45 (0.30-0.69) *
Lautem	0.87 (0.68-1.12)	1.90 (1.48-2.44) *	0.48 (0.31-0.75) *
Liquica	0.50 (0.40-0.63) *	0.67 (0.53-0.85) *	0.22 (0.14-0.33) *
Manatuto	0.26 (0.20-034) *	1.00 (0.76-1.30)	0.31 (0.20-0.48) *
Manufahi	0.62 (0.48-0.81) *	1.11 (0.85-1.45)	0.31 (0.20-0.48) *
Oecusse	0.60 (0.47-0.74) *	0.79 (0.61-1.00)	0.33 (0.22-0.50) *
Viqueque	0.49 (0.39-0.61) *	0.56 (0.44-0.72) *	0.30 (0.20-0.46) *
Wealth index			
Poorest	Reference	Reference	Reference
Poorer	1.13 (0.01-1.28) *	3.80 (3.12-4.64) *	1.16 (1.02-1.33) *
Middle	1.86 (1.64-2.10) *	9.71 (8.02-11.76) *	1.82 (1.57-2.11) *
Wealthier	3.06 (2.67-3.50) *	23.7 (19.5-28.8) *	2.73 (2.30-3.23) *
Wealthiest	2.80 (2.38-3.30) *	67.2 (53.7-83.9) *	6.68 (4.97-9.00) *

Note: AOR=Adjusted Odds Ratio, calculated by including all independent variables in the multivariate model; CIs=Confidence Intervals; * indicates statistically significant association result (1 is not included in the interval)

The results of weighted multivariate logistic regression model including all independent variables where region was used in place of municipalities are presented in Table 7b. When all the independent variables were included, some associations changed. By residence settings, households in urban areas had 1.96 odds ratio of having access to improved drinking water and 2.65 odds ratio of having travel times of 30 minutes or less to the water source than households in rural areas when controlling for residence type, region and wealth index. After adjusting for other variables, households in urban areas had 0.93 odds ratio of having access to improved sanitation compared to households in rural areas, but

the association was not statistically significant (95% CI: 0.88-1.10). After adjusting for other variables, by region, households in Central region were 0.87 and 0.51 times likely to have access to improved sanitation and travel times of 30 minutes or less to the water source compared to households in Eastern region. Households in Central region had 0.95 odds ratio of having access to improved drinking water compared to households in Eastern region, but the association was not statistically significant (95% CI: 0.85-1.10). On the contrary, households in Central region were 1.25 and 0.65 times likely to have access to improved drinking water and travel times of 30 minutes or less to the water source compared to households in Western region. Although households in Central region had 0.98 odds ratio of having access to improved sanitation, the association was not statistically significant (95% CI: 0.87-1.10). In terms of wealth index, after adjusting for other variables, the wealthiest households had 3.92 and 73.7 and 7.71 odds of having access to improved drinking water, improved sanitation facility and travel times of 30 minutes or less to the water source respectively as compared to the poorest households (Table 7b).

Table 7b. Adjusted odds ratio from weighted multivariate logistic regression of the predictors (residence, region, wealth index) of access to improved drinking water, improved sanitation and travel times of 30 minutes or less at the household level in Timor-Leste

Predictors	Improved drinking water source	Improved sanitation	≤ 30 minutes travel time to the water source
	AOR (95% CIs)	AOR (95% CIs)	AOR (95% CIs)
Residence			
Rural	Reference	Reference	Reference
Urban	1.96 (1.72-2.23) *	0.93 (0.81-1.05)	2.65 (2.13-3.30) *
Region			
Central Region	Reference	Reference	Reference
Eastern Region	0.95 (0.85-1.10)	0.87 (0.76-0.99) *	0.51 (0.44-0.59) *
Western Region	1.25 (1.12-1.39) *	0.98 (0.87-1.10)	0.65 (0.56-0.75) *
Wealth index			
Poorest	Reference	Reference	Reference
Poorer	1.12 (0.10-1.25) *	4.14 (3.40-5.03) *	1.23 (1.08-1.40) *
Middle	1.96 (1.72-2.23)	10.9 (9.01-13.1) *	1.93 (1.68-2.23) *
Wealthier	3.45 (3.03-3.92) *	25.8 (21.2-31.1) *	2.89 (2.45-3.41) *
Wealthiest	3.92 (3.37-4.57) *	73.7 (59.3-91.4) *	7.71 (5.77-10.3) *

Note: AOR=Adjusted Odds Ratio, calculated by including all independent variables in the multivariate model; CIs=Confidence Intervals; * indicates statistically significant association result (1 is not included in the interval)

4.4.2 Individual level multivariate result

The results of weighted multivariate logistic regression model including all independent variables at the individual level are illustrated in Table 8. When all the independent variables were included, some associations changed. Educational attainment and literacy level were no longer statistically significantly associated with any outcome variables after including all covariates (1 was included in the interval). After adjusting for other variables, women in urban areas had 1.73 and 2.91 odds ratio of having access to improved drinking water and travel times of 30 minutes or less to the water source as compared to women in rural areas. On the other hand, after controlling for other variables, women in urban areas had 0.98 odds ratio of having access to improved sanitation, but the association was not statistically significant (95% CI: 0.88-1.10). Across the wealth index, after controlling for other variables, women in the wealthiest households had 3.98, 67.6 and 10.8 odds ratio of having access to improved drinking water, improved sanitation facility and

travel times of 30 minutes or less to the water source respectively than women from the poorest households (Table 8).

Table 8. Adjusted odds ratio from weighted multivariate logistic regression of the predictors of access to improved drinking water, improved sanitation and travel times of 30 minutes or less at the individual level in Timor-Leste

Predictors	Improved drinking water source	Improved sanitation	≤ 30 minutes travel time to the water source
	AOR (95% CIs)	**AOR (95% CIs)**	**AOR (95% CIs)**
Residence			
Rural	Reference	Reference	Reference
Urban	1.73 (1.55-1.95) *	0.98 (0.88-1.10)	2.91 (2.37-3.57) *
Education level			
None	Reference	Reference	Reference
Primary	1.13 (0.99-1.27)	0.97 (0.84-1.11)	1.09 (0.93-1.27)
Secondary	0.71 (0.54-0.95)	1.03 (0.84-1.25)	1.17 (0.94-1.45)
Higher	1.07 (0.90-1.28)	1.37 (0.10-1.87)	1.94 (0.98-3.81)
Literacy level			
Illiterate	Reference	Reference	Reference
Literate	0.98 (0.84-1.14)	1.02 (0.86-1.21)	0.85 (0.70-1.02)
Wealth index			
Poorest	Reference	Reference	Reference
Poorer	1.15 (1.02-1.29) *	4.40 (3.61-5.36) *	1.26 (1.11-1.44) *
Middle	2.00 (1.78-2.25) *	11.1 (9.13-13.4) *	1.90 (1.66-2.18) *
Wealthier	3.44 (3.03-3.90) *	25.6 (21.1-31.0) *	2.86 (2.45-3.35) *
Wealthiest	3.98 (3.43-4.61) *	67.6 (54.6-83.8) *	10.8 (8.11-14.5) *

Note: AOR=Adjusted Odds Ratio, calculated by including all independent variables in the multivariate model; CIs=Confidence Intervals; * indicates statistically significant association result (1 is not included in the interval)

CHAPTER V

5. DISCUSSION AND CONCLUSION

5.1 Disparities in access to improved drinking water in Timor-Leste

This study demonstrates that the self-reported access to improved drinking water among households and women in Timor-Leste varies by geographical and socioeconomic factors. This information is very useful for the policy-makers in Timor-Leste to review existing strategies to improve coverage for water supply system and to reduce inequality in access to this essential service. This study confirms that access to improved drinking water is significantly associated with factors such as type of place of residence (urban/rural setting), region and wealth. This study found that 81% of households in urban areas had access to improved drinking water compared to 56% of rural dwellers. Households located in Central region were almost 2 times more likely to have access to improved drinking water. In addition, after adjusting for urban/rural and geographic region, wealthiest households were almost 4 times more likely to have access to improved drinking water compared to the poorest households. Similarly, at the individual level of analysis, wealthiest women were also almost 4 times more likely to have access to improved drinking water compared to the women in the poorest households after adjusting for urban/rural, education level and literacy.

Discussions over the positive relationship between geographical indicators and disparities in access to improved drinking water have been well documented. People in urban settings are twice more likely to have access to improved drinking water than those in rural settings in an analysis done in Indonesia (Prasetyoputra & Irianti, 2013). At global level, the disparity in urban/rural status is obvious where in 2010, improved drinking water coverage for urban areas was 96%, while the coverage for rural improved drinking water was 81%

(WHO/UNICEF, 2014). It is, therefore, evident that urban/rural disparity in access to improved drinking water exists, and what is more concern is that the urban/rural disparity at the global scale has persisted overtime (Wolf et al., 2013). In Timor-Leste, the access of the rural people to improved drinking water service is much more restricted than that of urban people. One of the main reasons for urban/rural disparity in access to improved drinking water in Timor-Leste is because of the reliance on surface water sources such as rivers and lakes especially by rural dwellers (National Statistics Directorate, 2010). On top of that, economic status can also be a significant factor for rural people, especially those who are poor to rely on water source from unprotected dug well, while rich people mostly in urban areas are likely to have piped water connection into their households as they can afford to buy materials such as pipes.

This study found that in Timor-Leste, households from municipalities located in Central region of the country tend to have better access to improved drinking water, whereas households from municipalities located in Western region as well as Eastern region remain disadvantaged in gaining access to this essential service. Central region covers Dili, the capital city of the country where most people live as well as other municipalities that have more urban areas (National Statistics Directorate, 2013). On the other hand, most municipalities located in Western and Eastern region have more rural, remote and difficult reach areas where basic infrastructures such as roads are the main challenges to connect rural populations to improved water service. Another potential driver for this regional disparity is due to inadequate water supply system provided by the government. Being a newly independent country, Timor-Leste has an inadequate infrastructure and limited human resources that may partly attribute to the apparently disparities in access to improved drinking water. In rural areas where approximately 76% of the population lives and in municipalities located in Western and Eastern region, water supply systems are owned, maintained and

operated by communities. The systems rely heavily on the support of international development agencies and non-governmental organizations for financing. The capacity of community to operate and maintain this community water supply systems is very limited due to lack of funding for operation and maintenance. A similar regional disparity in access to improved drinking water has also been observed in other countries like in South Africa where disparities in improved drinking water coverage were found across provinces of the country (Kirigia & Kainyu, 2000).

In addition to differences in access to improved drinking water based on urban/rural status and geographical areas, this study also found dramatic differences in access to improved drinking water when comparing wealth status of the population. A finding from a global study on the distribution of risk factors by poverty level revealed that the risk of households living under US$1 per day of being exposed to unimproved drinking water was almost eightfold as compared to those living over US$2 per day (Blakely et al., 2005). This study found that in Timor-Leste, the proportion of having access to improved drinking water is much higher among the wealthiest population, approximately 82% as compared to only 45% for poorest people. The reason can be due to the fact that wealthiest population can afford water supply system from improved sources such as piped water on premises, which is more convenient and has positive impacts on health and well-being.

5.2 Disparities in access to improved sanitation facility in Timor-Leste

In comparison to improved drinking water, the findings of this study indicate that access to improved sanitation in Timor-Leste is significantly associated with the wealth index factor. This study found that disparities in access to improved sanitation exist between people of different socioeconomic levels in the society and coverage does not necessarily only depend on where they live. The study found that after adjusting for urban/rural and geographic region, wealthiest households were almost 70 times more likely to have access to

improved sanitation compared to poorest households. Likewise, after adjusting for urban/rural, education and literacy level, wealthiest women were almost 68 times more likely to have access to improved sanitation than poorest women. Therefore, the differences seem to be starker for sanitation than they are for water. A similar disparity is found between the poor and non-poor in which the richest are almost five times more likely to use improved sanitation facilities compared to the poorest in an analysis done in sub-Saharan Africa (WHO, 2010). The differences in access to improved sanitation signify that the wealthier the population is, the more likely they will gain access to proper sanitation facility without sharing, and the higher health awareness of this group on diseases associated with WASH risk factors.

There are some factors associated with socioeconomic disparity in access to improved sanitation among households and women in Timor-Leste. One of the main associated factors is the high cost to build a proper sanitation facility with connection to a sewer system, which cannot be afforded by poorest households, approximately cost of US$100 or above (WaterAid, 2010). The poorest population is, therefore, more likely to rely on unimproved toilet facilities such as pit latrines. Besides, because of economic status, many poorest households do not have toilet facilities and the members tend to practice open defecation, which was estimated about 27% in Timor-Leste (WHO/UNICEF, 2014). Another associated factor has been due the fact that poor population tends to practice the behavior of sharing toilet facility within household members or between households, which has been categorized as unimproved facilities by the JMP (WHO/UNICEF, 2014).

This inequality in access to improved sanitation across economic factor has reflected the reality of Timor-Leste for being off-track in achieving the MDG target of at least 60% for improved sanitation by 2015 (Ministry of Finance, 2014). This phenomenon is also true at the global level, especially across the low- and middle- income countries where the proportion of

people without access to improved sanitation should be reduced to 25% (WHO/UNICEF, 2014). Furthermore, access to improved sanitation especially by the poorest women no matter they reside should be prioritized in any intervention in Timor-Leste. Women should precisely be engaged in planning, implementation and evaluation of infrastructure projects, especially water and sanitation in Timor-Leste. This strategic approach is aligned with the UNICEF strategy to ensure women are directly involved in planning and management of WASH program (UNICEF, 2014). Therefore, women's participation in sanitation program (in conjunction with water supply program) can be conceived as a platform for sustainability and social inclusion (Nguyen & Tam, 2012), which should be considered by the government as one component in poverty reduction strategies.

5.3 Distance to get to the water source in Timor-Leste

Distance to get to the water source has become a separate and an important topic worldwide and in Timor-Leste it still remains a big challenge in regards to access to clean water and adequate facilities for proper hygiene. This study has found a very strong association between geographical and socioeconomic factors and distance to the water source in Timor-Leste. It is emphasized that households located in Eastern region (24%) from the poorest economic income (29%) located in rural areas (21%) are more likely to spend more than 30 minutes to get to the water source (refer back to Table 4). Likewise, the poorest women (30%) living in rural areas (21%) walk farther than 1 km or spend more than 30 minutes to get to the water source (refer back to Table 4). These associations can explain that distance to collect water may have an impact on quality of life of many poor households and women in some municipalities located in less developed regions and rural areas of Timor-Leste. Groups of people who usually collect drinking water in Timor-Leste are adult females age 15 and older (36%) and female children (7%) (National Statistics Directorate, 2010). This phenomenon has also been globally observed such as in sub-Saharan Africa where many poor

people, usually women and young girls residing in rural areas often walk long distances to get to water source (UN, 2014).

It is a common sense that water is necessary for hygiene and the amount of water use can vary with distance from the water source. Where people must spend more than 30 minutes for total water collection time, per capita water use declines to between 5 and 10 liters per day (Moe & Rheingans, 2006). This suggests that at this level of service, adequate hygiene is not possible. As a consequence, many water and sanitation related diseases, which was described as "water-washed" diseases in old days (Bradley, 1977), may rise due to inadequate quantities of water available for washing hands, food, laundry and cooking utensils. In Timor-Leste, the prevalence of WASH related diseases such as diarrhea and parasitic helminth infections are much higher among populations who reside in rural areas of some municipalities due to distance to collect water for daily use as well as unhygienic practices in food preparation (National Statistics Directorate, 2010). Therefore, it is argued that an appropriate intervention is required to prevent these diseases by bringing closer improved water supply through basic infrastructure such as roads. This, then, can provide more water quantity and improve microbiological water quality in the country.

5.4 Factors associated with disparities in access to improved water and sanitation in Timor-Leste

There are some possible explanations for the disparities in access to improved water and sanitation system with regards to geographical and socioeconomic factors in Timor-Leste. The key bottlenecks that currently impede progress in Timor-Leste's water and sanitation sector mainly relate to institutional capacity and absence of technical support services, accountability and incentives for sustaining services. For improved drinking water, lack of funding to pay for water supply operations and no clear strategy to effectively support maintenance in rural areas has been the main reason (AusAID, 2013). This lack of national

investments has resulted in a disproportionate water supply intervention to be more concentrated in some urban municipalities located in Central region through the Government of Timor-Leste (GoTL) owned programs, while investments to rural water supply are mostly assisted by international aid development initiatives such as from the Australian Aid Agency (AusAID), the US Aid program (USAID), Japan International Cooperation Agency (JICA), Asian Development Bank (ADB) and European Union (Buhl-Nielsen et al., 2009). It is argued that this sector governance has created a big division in terms of allocating human resources capacity towards water supply program, with some municipalities located in Eastern and Western region having lack of local expertise such as engineers, technicians and skilled workers in implementing water supply programs (Bond et al., 2009). According to the recent UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLASS Report) that lack of human resources can constrain the implementation of WASH program and result in inequality in access to improved drinking water and sanitation within geographical indicators (WHO, 2014).

On the other hand, disparities in access to improved sanitation mainly across economic factor in Timor-Leste can be explained by the difficulty of obtaining sanitation goods and services by poorest population. Many of the poorest households cannot afford to spend much money for sanitation hardware such as septic tank, porcelain pan and fiber glass pan (WaterAid, 2011). The estimated cost for installation a subsided latrine can range from US$100 to US$300 (WaterAid, 2010). Not only cost is an issue, but also the availability of those materials is very limited in most municipality towns due to limited demand (WaterAid, 2010). Despite international aid commitments for sanitation program in the country has increased, the aid paradigm has focused more on infrastructure provision than on supporting poverty reduction and sustainable services delivery (Independent Review Team, 2010).

Not only in Timor-Leste, but also homogeneous reasons for geographical and socioeconomic disparities in access to improved drinking water and sanitation system have persisted in other settings of the world, particularly in developing countries. Although having achieved the MDG 7 target for improved access to drinking water, the national average has masked sub-national disparities in access to improved drinking water in the Philippines (Fehr et al., 2013). A geospatial analysis found that the northern region of the Philippines had higher access to improved drinking water source than the central and southern regions of the country (Fehr et al., 2013). Some of the potential reasons were due to complexity of national governance for water sector, mismanagement of all water resources by the government, limited in scope for water policies and regulations, and inadequate investment in WASH infrastructure allocated towards the central and southern regions of the Philippines (Barba, 2002; Pasimio, 2011). Furthermore, considerable differences in access to improved water and sanitation remain a significant issue across urban and rural as well as among provinces in Indonesia (Preseyoputra & Irianti, 2013). The proportion with access to improved sanitation in Indonesia was 69% in urban areas as compared to 34% in rural areas (ADB, 2012). One of the reasons accounted for this geographical disparity is because of lack of investment in sanitation system from both public and private sectors in Indonesia (Water and Sanitation Program, 2011).

5.5 The effects of lack access to water and sanitation on vulnerable groups

Lack access to improved drinking water and sanitation and the disparities can have a bigger influence on the health and well-being of vulnerable groups, especially children who are from poor families. In poor urban areas where inadequate water supply and sanitation coverage combine with overcrowded conditions, the possibility of fecal contamination can increase the risk of spreading water-borne diseases including diarrhea among young children (UNICEF, 2014). In rural areas, widespread open defecation practices and the lack of

awareness and practice of safe hygiene behaviors such as hand washing with soap can put children from poor families at a high risk of fecal-oral disease (UNICEF, 2014). The findings of this study suggest that children from poorest families with unimproved drinking water and sanitation services may suffer more morbidity and mortality from water-related diseases such as diarrhea. Children's well-being are highly dependent on both the quality and the availability of water as well as how adequate sanitation facility is obtained (Checkley et al., 2004). In Timor-Leste, diarrhea remains one of major public health problems due to WASH risk factors (National Statistics Directorate, 2013). Among children, this problem is even bigger and among the top two causes of infant and child mortality in this country (National Statistics Directorate, 2010). Dehydration is one of the conditions caused by severe diarrhea, which is a major cause of morbidity and mortality among young children in Timor-Leste (Deen et al., 2013). Children from poor families who have lack access to improved drinking water and adequate sanitation tend to be at high risk of exposing to diarrhea-causing agents in the form of using of contaminated water and practicing unhygienic disposal of excreta (National Statistics Directorate, 2010). Diarrhea alone is responsible for approximately 380 of child deaths per year in Timor-Leste (National Statistics Directorate, 2010) and accounted for second top causes of years of life lost and disability-adjusted life years due to premature mortality and disability in the country in 2010 (Institute for Health Metrics and Evaluation, 2010).

Not only in Timor-Leste, diarrhea diseases associated with WASH risk factors have also been estimated as one of the leading causes of death among children worldwide, about one in nine child deaths (Centers for Disease Control and Prevention/CDC, 2015) and caused approximately 1181 thousands of deaths in Southeast Asia region in 2010 (CDC, 2011). In India, diarrhea alone was estimated to kill over 700,000 people due to unsafe drinking water (DeNormandie & Sunita, 2002) and poor sanitation (Clasen et al., 2014). WASH practices

are also evident to be linked with linear childhood growth by affecting nutritional status resulting in childhood stunting (Ngure et al., 2014). For instance, poor WASH practices have been estimated to cause approximately 50% of child stunting in India (Rah et al., 2014).

The incidence of other diseases such as parasitic helmith infections linked to WASH risk factors is also highest among the poor, especially school-aged children in Timor-Leste. Poor hygiene conditions and toilet facilities in schools and in the home environment have exposed many poor children in Timor-Leste to soil-transmitted helminths infections. The overall prevalence of soil-transmitted helminths infections in Timor-Leste is 29%, which has been attributed by limited access to clean water and sanitation factors (Martins et al., 2012). This soil-transmitted helminths infections often lead to severe consequences such as cognitive impairment and anemia in which the prevalence are also high among children under five years of age from poor families in Timor-Leste (Agho et al., 2008).

Apart from health issues, lack of access to improved drinking water and sanitation can also have impact on children's education. In Timor-Leste, it is evident that children from poor families living in rural areas often miss school days because they must help their parents to collect water or because they are sick from diarrhea (National Statistics Directorate, 2010). Moreover, young girls from poor families who have menstrual cycle during their puberty period are likely to drop out from school due to lack of adequate and private sanitation facilities in the households (National Statistics Directorate, 2013). Approximately 25% of children in Timor-Leste drop out from school (National Statistics Directorate, 2010). This shows that lack access to improved drinking water and adequate sanitation facilities can directly impact the educational success of school-age children, especially among children from poor families. As a consequence, the cycle of poverty in Timor-Leste can be perpetuated due to failure of next generation in an education attainment.

5.6 Policy implications and recommendations

Findings from this study have demonstrated some significant implications for the efficacy of public health programs and environmental epidemiology interventions in Timor-Leste. In this analysis, geographical (urban/ rural residence and region) and socioeconomic (wealth index) factors were the strongest predictors of disparities in access to improved drinking water and sanitation services in Timor-Leste. The findings clearly indicate that in Timor-Leste, lack of improved drinking water is predominantly in rural settings and inadequate sanitation facilities are more poverty-related phenomenon. More than 65% people without access to improved sanitation live in rural areas of the country (Table 4). The rich people are more likely to have piped water on the premises or toilets connected to a sewer system, while the poor often use communal sources or need to buy their water from vendors, share public facilities or rely on pit latrines. Besides, the coverage of access to improved drinking water and sanitation is much lower within municipalities located in Eastern and Western region of Timor-Leste (Table 4). These populations are the hardest to reach because of barriers such as the location where they live (the most remote rural areas where roads are almost impassable), the nature of geographical conditions (most municipalities in these regions are located between mountains and hills), the availability of surface water (rivers, lakes and creeks) and characters of sharing toilet facilities among household members or the practice of open defecation. Consequently, priority interventions should target poor people living in rural and the most remote areas located in Eastern and Western region of the country.

As water and sanitation are related to poverty-related phenomenon, the discussion of social and economic policies on poverty alleviation is tremendously important to be considered. However, one of the current difficulties faced by the GoTL is the lack of data and reliable indicators on the situation of the country. The last official data the country has on

poverty dated back to 2009, which reported that poverty was still widespread in Timor-Leste with 41% of the population living below the poverty line of US$0.88 cents per capita per day (World Bank, 2013). Poverty remains persistently high in Timor-Leste, particularly in the rural areas where the majority of the population lives (World Bank, 2013). This basically means that the benefits of economic growth have not reached everyone equally.

One of the latest poverty alleviation strategies of the GoTL is the Strategic Development Plan (SDP) 2011-2030, which is a form of framework for identifying and assessing priorities to transition Timor-Leste from a low income to upper middle income country, with a healthy, well-educated and safe population by 2030 (Democratic Republic of Timor-Leste, 2011). With this official SDP framework, the GoTL plans to invest heavily in infrastructure, agriculture, rural development and social capital. In specific to water and sanitation sector, the SDP has linked this sector to the global MDG-7 target. Specifically, it states that improvement in coverage of clean and safe water supply (81% in urban areas and 75% in rural areas) and improved sanitation facilities (64% in urban areas and 55% in rural areas) has to be achieved by 2020 (Democratic Republic of Timor-Leste, 2011). Timor-Leste's government has, therefore, made a big and ambiguous commitment to improve coverage and reduce inequalities in access to improved water and sanitation for all its citizens.

To ensure the measurement of the indicators for achieving the target of improved drinking water and sanitation as mentioned above in the SDP, the effectiveness of existing monitoring system in the country has to be maximized. Currently, the monitoring system in Timor-Leste is not well functioned, which is a major challenge. Even though the SDP has been launched for almost 4 years now, the inequalities in access to improved water and adequate sanitation still remain obvious, mainly due to the current GoTL's system that allocates less investment and resources on monitoring system as well as towards sustainable

development program with emphasis on the poor people (see Appendix A the problem tree for water supply and sanitation in Timor-Leste). According to the recent UN- GLASS Report that Timor-Leste has been included in the list of country that allocates less national investment in terms of financing resources towards water and sanitation sector, with emphasis on rural WASH programs (WHO, 2014). In the context of Timor-Leste, intervention and monitoring must not go beyond the income inequality. This strategy must capture issues from both economic and other factors that can block poor people living in disadvantaged areas from access to improved drinking water and sanitation. Other factors referred here include discriminatory laws, cumbersome administrative procedures, lack of access to information, social mores, prejudice and practices and cultural taboos. In doing so, it will require substantial and fair economic resources, sustainable technological solutions and courageous political will from the government in order to achieve the sustainable development goals as set globally for water and sanitation services in the next decade.

Moreover, as discussed earlier that most WASH intervention programs in Timor-Leste have been delivered by the GoTL in partnership with many international aid agencies such as AusAID, USAID, World Bank, ADB, JICA, WaterAid, Oxfam, UNICEF, Plan International and EU (Buhl-Nielsen et al., 2009; Ministry of Finance/UNICEF, 2014). The main government Ministries responsible for different aspects of water, sanitation and hygiene in communities, schools and health institutions are Ministry of Education, Ministry of Health and Ministry of Public Works. Also, the Ministry of State Administration implements small-scale water projects in rural communities under the decentralized development program (Ministry of Finance/UNICEF, 2014). This demonstrates that the overall implementation of WASH programs in Timor-Leste seems to be fragmented. A task force under the leadership of National Directorate for Water and Sanitation of the Ministry of Public Works has, then, been established to oversee and coordinate all WASH programs in the country (AusAID,

2011). Two coordination mechanisms are currently in place through WASH forum and Sanitation Working Group (Ministry of Finance/UNICEF, 2014). However, the coordination system does not function properly because of the current GoTL's centralization system that hampers institutional and delivery capacity at the national, municipalities and administrative posts levels (Kuehn, 2011). To deal with this issue, there is a need to accelerate the decentralization of this system, which the resolution has been approved by the Timor-Leste's Parliament under the Ministry of State Administration in order to minimize bureaucracy system across all the GoTL programs for development (Kuehn, 2011). With this new system, it is recommended that the Ministry of Public Works in close collaboration with Ministry of Health at national and municipality level, both need to provide overall guidance and oversight of the WASH programs based on local needs. This action will ultimately ensure effective coordination that should eventually align with the GoTL strategic priorities to address the issue of geographical and socioeconomic disparities in access to WASH among the poorest populations. Indeed, the GoTL must not only provide improved drinking water and basic sanitation to those who currently lack these fundamental services, but also to ensure that these services provide safe drinking water, adequate quantities of water for health, hygiene, agriculture and development as well as sustainable sanitation approaches to protect health and the environment. Again, this service delivery should be supported by a good coordination system from different government agencies delivering WASH programs as well as a strong commitment from local government, private sectors and non-governmental organizations (NGOs) that also play important role in filling service deliver gaps in WASH sector.

Literally, the current concept of measure of inequality associated with WASH in Timor-Leste has been focused on geographical determinants such as urban/rural setting and region. Most development aid agencies working on WASH sector in Timor-Leste have

reported on urban/rural status and region determinants of disparities in access to improved water and sanitation services (ADB, 2011; AusAID, 2011; AusAID, 2013; World Bank, 2013), while less information being reported on wealth index determinant. Therefore, given the significant existence of wealth index predictor of disparities in access to improved water and sanitation system, the findings of this study can serve as a significant evidence-based information to recommend the GoTL in collaboration with other stakeholders to invest and allocate more efforts to effectively plan, implement and evaluate WASH program by considering economic factor. This action will definitely improve the health and elevate the quality of life of all citizens of Timor-Leste.

To achieve those targets, however, an integrated approach by engaging infrastructure, public health and education sectors, should be more focused on rural development and the intervention must target the poorest population. According to Wratten (1995) that improving water and sanitation has become one component to a holistic and integrated approach for poverty alleviation. As illustrated by findings of this study that the significant associations between wealth index factor and households' and women's access to improved water and sanitation have clearly shown there is evidence for intervention among the poor households and women residing in disadvantaged region and in the rural areas of the country.

Finally, since this study has just analyzed dataset from a cross-sectional study design, further studies that use longitudinal models and/or randomized trials are critical to be carried out in the future in order to determine the trend of the geographic and socioeconomic disparities of access to improved water and sanitation in Timor-Leste and to enable causal inferences. Given that access to adequate sanitation remains significantly poor in the country, tackling this specific issue requires further studies with emphasis on health, environment, social, economic and technology (HESET) to provide evidence on integrated sanitation management and environmental health impact modeling in Timor-Leste, hence, to inform the

development and implementation of proper intervention and maintenance policy. Investment in sanitation will be absolutely an investment in health, education, the environment and poverty reduction in Timor-Leste.

5.7 Limitations of the study

The findings of this study should be interpreted in light of some limitations. One limitation has been the design of DHS study, which is a cross-sectional study that only allows the analysis of association not the cause and effect. Causality cannot be analyzed or determined. Another limitation has been the potential of recall bias due to the data is self-reported. This recall bias cannot be ruled out as possible explanation for the findings of this study. Also, this study has not included variable of non-drinking water source for analysis as this indicator may give rise to inequality in access by households and women in Timor-Leste. Another limitation is the year in which the DHS was conducted in Timor-Leste, which was six years ago. Disparities in access to improved drinking water and proper sanitation facilities may persist over time as condition of households and women who took part in the survey may have changed substantially over the last six years resulting from existing interventions. Finally, despite the limitations, the findings of this study can be used as baseline information to strengthen the worldwide evidence on the importance of equity of coverage for improved drinking water and proper sanitation facilities for the lives of all people, with specific attention to the poor. This study has identified that geographical and socioeconomic disparities in access to improved water and sanitation systems are strongly linked to the overall health status of the people of Timor-Leste. The findings of this study can then serve as an evidence-based measurement for the Ministry of Health of Timor-Leste to better plan, implement and evaluate WASH programs to reduce the number of deaths and disease burden associated with WASH risk factors.

5.8 Conclusion

In conclusion, even though some parts of the world have made encouraging progress in meeting the MDGs target for safe drinking water and basic sanitation, serious inequalities still remain challenges. In large portions of Asia, lack of access to improved drinking water source is still a serious issue where an estimated of 675 million people do not have access to safe drinking water (UNICEF/WHO, 2014). In sub-Saharan Africa, an estimated of only 36% of the population have access to adequate sanitation (UNICEF/WHO, 2014).

This study has examined geographical and socioeconomic disparities in access to improved water and sanitation systems in Timor-Leste using the DHS data. Residence setting, region and wealth index have been found to be significant factors associated with disparities in access to improved water, while wealth index alone is found to be a significant factor for disparities in access to improved sanitation. The findings of this study concord with the notion that having unimproved drinking water and inadequate sanitation and being long distance to get to the water source are some of the characteristics of being poor and living in disadvantaged region and in rural areas. Reducing the geographical and socioeconomic indictors of disparities by providing the poor improved water and sanitation system and bringing the safe water system closer to them is enormously imperative and will bring about improvement in their livelihoods. Hence, universal intervention has to be put in place to reduce the disparities in access; to improve health status of the poor; and eventually to improve their economic livelihoods.

Improving the sustainability of WASH program in terms of infrastructure and service delivery is critical area of need in Timor-Leste. The GoTL should take into account these inequality indicators of water and sanitation services and work in cooperation with other stakeholders to address this issue by increasing the national investments towards WASH program and integrating this to a poverty reduction strategy to reach the most disadvantaged

populations. Timor-Leste is a young democratic country and still a political fragile state with associated challenges for the WASH sector, including a shortfall in administrative and human resource capacity to implement policies and programs. With the new reformation or reshuffling of the Timor-Leste Constitutional Government structure that has just been made recently in February 2015, it is really hopeful that more clarification of institutional arrangements for ongoing management and maintenance of water and sanitation systems will be made to ensure dedicated national investments in monitoring system and sustainable service provision by taking vows for poverty.

Reference

Agho, K. E., Dibley, M. J., D'Este, C., & Gibberd, R. (2008). Factors associated with hemoglobin concentration among Timor-Leste children aged 6-59 months. *Journal of Health Population and Nutrition, 26* (2), 200-209.

Asian Development Bank/ADB (2012). *Indonesia: water supply and sanitation sector assessment, strategy, and road map*. ADB Office: Philippines.

Asian Development Bank/ADB (2013). *Asian Development Outlook 2013 Update: Governance and Public Service Delivery*. ADB: Manila.

Asian Development Bank/ADB (2013). *Country Partnership Strategy, Timor-Leste 2011-2015*. ADB Timor-Leste: Dili.

Australian Aid Agency for International Development/AusAID (2011). *Rural Water and Sanitation in Timor-Leste: Concept Note*. AusAID Timor-Leste: Dili.

Australian Aid Agency for International Development/AusAID (2013). *Independent Completion Report for Rural Water, Sanitation and Hygiene (RWASH) Program in Timor-Leste*. AusAID Timor-Leste: Dili.

Barba, P. (2002). *The challenges in water resources management in the Philippines*. National Water Resources Board of the Philippines: Quezon City.

Bartram, J., Lewis, K., Lenton, R., & Wright, A. (2005). Focusing on improved water and sanitation for health. *Lancet, 365*, 820-812.

Blakely, T. S., Hales, C., Kieft, N. W., & Woodward, A. (2005). The global distribution of risk factors by poverty level. *Bulletin of the World Health Organization, 83* (2), 118-126.

Bond, M., Tyndale, B. P., & Whalen, M. (2009). *Human resource capacity in the water sanitation and hygiene sector in East Timor*. FDH Designs: Timor-Leste.

Boshi-Pinto, C., Velebit, L., & Shibuya, K. (2008). Estimating child mortality due to diarrhea in developing countries. *Bulletin of the World Health Organization, 86*, 710-717.

Bradley, D. (1977). *Health aspects of water supplies in tropical countries*. John Wiley and Sons. Chiscester: UK.

Buhl-Nielsen, E., Giltner, S., Dutton, P., & Donohoe, J. (2009). *Draft country working paper: independent evaluation of Australian Aid to water supply and sanitation services*. AusAID: Timor-Leste.

Centers for Disease Control and Prevention/CDC (2011). *Defeating diarrheal disease: tracking the source of foodborne infections*. Division of Foodborne, Waterborne and Environmental Diseases: USA.

Centers for Disease Control and Prevention/CDC (2015). Diarrhea: common illness, global killer. US Department of Health and Human Services: USA. [Online] Available from http://www.cdc.gov/healthywater/pdf/global/programs/Globaldiarrhea_ASIA_508c.pdf [Accessed February 2015].

Clasen, T. F. (2012). Millennium Development Goals water target claim exaggerates achievement. *Tropical Medicine and International Health, 17* (10), 1178-1180.

Clasen, T., Boisson, S., Routray, P., Torondel, B., Bell, M., Cumming, O., Ensink, J., Freeman, M., Jenkins, M., Odagiri, M., Ray, S., Sinha, A., Suar, M., & Peter-Schmidt, W. (2014). Effectiveness of a rural sanitation programme on diarrhea, soil-transmitted helminth infection, and child malnutrition in Odisha, India: a cluster-randomized trial. *Lancet Global Health, 2,* e645-e653.

Cohen, B. (2006). Urbanization in developing countries: current trends, future projections, and key challenges for sustainability. *Technology in Society, 28,* 63-80.

Dannenberg, A., L. Frumkin, H., & Jackson, R. J. (2011). *Making healthy places: Designing and building for health, well-being, and sustainability*. Island Press: USA.

Deen, J., da Conceicao Matos, L., Temple, B., Jiunn-Yih, S., da Silva, J., Liberato, S., da Silva, V., Soares, A. I., Joshi, V., Moon, S., Tulloch, J., Martins, J., & Mulholland, K. (2013). Identifying national health research priorities in Timor-Leste through a scoping review of existing health data. *Health Research Policy and Systems, 11* (8), 1-13.

Democratic Republic of Timor-Leste (2011). *Timor-Leste Strategic Development Plan 2011-2030*. Dili: Timor-Leste.

DeNormandie, J., & Sunita, J. (2002). Combating diarrheal disease in India through safe drinking water. WHO Dehli: India. [Online] Available from http://www.who.int/mediacentre/multimedia/2002/ind_sanitation/en/ [Accessed February 2015].

Esrey, S. A., Potash, J. B., Roberts, L., & Shiff, C. (1991). Effects of improved water supply and sanitation on ascariasis, diarrhea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. *Bulletin of the World Health Organization, 69* (5), 609-621.

Fehr, A., Sahin, M., & Freeman, M., C. (2013). Sub-national inequities in Philippine water access associated with poverty and water potential. *Journal of Water, Sanitation and Hygiene for Development, 3* (4), 638-645.

Fewtrell, L., & Colford, J. (2004). *Water, sanitation, and hygiene: interventions and diarrhea – A systematic review and meta-analysis*. Health, Nutrition and Population Discussion Paper. World Bank: Washington DC.

Grimes, J. E. T., Croll, D., Harrison, W. E., Utzinger, J., Freeman, M. C., & Templeton, M. R. (2014). The relationship between water, sanitation and schistosomiasis: A systematic review and meta-analysis. *PLOS Neglected Tropical Disease, 8* (12), 1-12.

Huttly, S.R. (1990). The impact of inadequate sanitary conditions on health in developing countries. *World Health Stat Q, 43*, 118-126.

Independent Review Team (2010). *Australia-Timor-Leste Rural Water Supply & Sanitation Program – Be, Saneamento no Igiene iha Komunidade (BESIK).* Report of the Mid-Term Independent Progress Review: Dili.

Institute for Health Metrics and Evaluation (2010). *Global Burden Disease Profile: Timor-Leste*. Seattle: USA. [Online] Available from: http://www.healthdata.org/sites/default/files/files/country_profiles/GBD/ihme_gbd_country_report_timor_leste.pdf [Accessed February 2015].

International Monetary Fund/IMF (2012). *IMF Country Report No. 12/24 Democratic Republic of Timor-Leste*. Washington DC: USA.

International Monetary Fund/IMF (2013). *World Economic Outlook Database*. [Online] Available from: http://www.imf.org/external/pubs/ft/weo/2013/01/weodata/index.aspx [Accessed January 2015].

International Vaccine Access Center (2014). *Pneumonia and diarrhea progress report 2014*. Baltimore: USA.

Kirigia, J., M. & Kainyu, L. (2000). Predictors of toilet ownership in South Africa. *East African Medical Journal*, *77* (12), 667-672.

Kuehn, S. (2011). *Briefing Note on the decentralization process in Timor-Leste*. Joint UNDP-UNCDF for Timor-Leste Local Governance Support Programme: Dili.

Lenton, R., Wright, A. M., & Lewis, K. (2005). *Health, dignity, and development: what will it take? UN Millennium Project Task Force on Water and Sanitation 2005*. Earthscan: London.

Lozano, R., Naghavi, M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., Abraham, J., Adair, T., Aggarwal, R., Ahn, S. Y., et al. (2012). Global and regional mortality from 235 causes of death for 20 age groups in 1990-2010: A systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, *380*, 1095-2128.

Martins, N., McMinn, P., de Jesus Gomes, M. S., Freitas, L. T., Counahan, M., & Freitas, C. (2012). *Timor-Leste national parasite survey 2012: Report and recommendation.* Ministry of Health: Timor-Leste.

Ministry of Finance (2014). *Timor-Leste: The Millennium Development Goals Report 2013*. Ministry of Finance: Timor-Leste.

Ministry of Finance/UNICEF (2014). *Situation Analysis of Children in Timor-Leste*. National Statistics Directorate: Dili.

Moe, C. L., & Rheingans, R. D. (2006). Global challenges in water, sanitation and health. *Journal of Water and Health*, *4*, 41-57.

Montgomery, M. A. (2007). Water and sanitation in developing countries: Including health in the equation. *Environmental Science & Technology, 1*, 17-24.

National Statistics Directorate (2010). *Timor-Leste Demographic and Health Survey 2009-10*. Ministry of Finance: Timor-Leste.

National Statistics Directorate (2013). *Timor-Leste Population and Housing Census 2010*. Ministry of Finance: Timor-Leste.

Ngure, F. M., Reid, B. M., Humphrey, J. H., Mbuya, M. N., Pelto, G., & Stoltzfus, R. (2014). Water, sanitation, and hygiene (WASH), environmental enteropathy, nutrition, and early childhood: Making the links. *Annals of the New York Academic of Sciences, 1308*, 118-128.

Nguyen, T., & Tam, T. P. (2012). Participation of women in rural water supply and sanitation projects: Visible or invisible actors? The case of the sub-district of Maubara (Liquica, Timor-Leste). *International Journal of Multidisciplinary Thought, 2* (4), 149-170.

Pasimio, H. (2011). *Turning the tide: improving water resource management in the Philippines.* Government of the Philippines Senate Economic Planning Office: Philippines.

Prasetyoputra, P. & Irianti, S. (2013). Access to improved sanitation facilities in Indonesia: an econometric analysis of geographical and socioeconomic disparities. *Journal of Applied Sciences in Environmental Sanitation, 8* (3), 215-224.

Pruss, A., & Havelaar, A. (2001). *The global burden of disease study and applications in water, sanitation and hygiene*. IWA Publishing: London.

Pruss-Ustun, A., Bartram, J., Clasen, T., Colford Jr, J. M., Cumming, O., Curtis, V., Bonjour, S., Dangour, A. D., De France, J., Fewtrell, L., Freeman, M. C., Gordon, B., Hunter, P. R., Johnston, R. B., Mathers, C., Mausezahl, D., Medlicott, K., Neira, M., Stocks, M., Wolf, J., & Cairncross, S. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a retrospective analysis of data from 145 countries. *Tropical Medicine and International Health, 19* (8), 894-905.

Pruss-Ustun, A., Bos, R., Gore, F., & Bartram, J. (2008). *Safe water, better health: costs, benefits and sustainability of interventions to protect and promote health.* WHO: Geneva.

Pullan, R. L., Freeman, M. C., Gething, P. W., & Brooker, S. J. (2014). Geographical inequalities in use of improved drinking water supply and sanitation across Sub-Saharan Africa: Mapping and spatial analysis of cross-sectional survey data. *PLOS Medicine, 11* (4), 1-17.

Rah, J. H., Cronin, A. A., Badgaiyan, B., Aguayo, V. M., Coates, S., & Ahmed, S. (2014). Household sanitation and personal hygiene practices are associated with child stunting in rural India: a cross-sectional analysis of surveys. *British Medical Journal (BMJ), 5*: 1-10.

Skolnik, R. (2012). *Global Health 101 (2nd edition)*. Jones & Bartlett Learning: USA.

Soares, L. C. R., Griesinger, M. O., Dachs, J. N. W., Bittner, M. A., & Tavares, S. (2002). Inequities in access to and use of drinking water services in Latin America and the Caribbean. *Revista Panamericana de Salud Publica/Pan American Journal of Public Health, 11* (5/6), 386-396.

Tumwine, J. K., Thompson, J., Katua-Katua, M., Mujwajuzi, M., Johnstone, N., Wood, E., & Porras, I. (2002). Diarrhoea and effects of different water sources, sanitation and hygiene behavior in East Africa. *Tropical Medicine and International Health, 7* (9), 750-756.

UNICEF (2014). *Diarrheal disease*. [Online] Available from: http://data.unicef.org/child-health/diarrhoeal-disease [Accessed March 2015].

UNICEF (2014). *Water, Sanitation and Hygiene Annual Report 2013*. UNICEF: New York.

UNICEF/WHO (2008). *A snapshot of drinking water and sanitation in South-eastern Asia and the Pacific*. UNICEF/WHO: New York.

United Nations Development Program/UNDP (2006). *Human Development Report 2006: Beyond scarcity power, poverty and global water crisis*. [Online] Available from: http://hdr.undp.org/en/reports/global/hdr2006 [Accessed January 2015].

United Nations/UN (2014). Sustainable Development Knowledge Platform. [Online] Available from: https://sustainabledevelopment.un.org/index.php?menu=1561 [Accessed March 2015].

United Nations/UN (2000). *United Nations Millennial Declaration*. General Assembly: New York.

United Nations/UN (2013). *The Millennium Development Goals Report 2013*. UN: New York.

United Nations/UN (2014). *The Millennium Development Goals Report 2014*. UN: New York.

United States Agency for International Development/USAID (2014). The Demographic and Health Survey Program. [Online] Available from: http://www.dhsprogram.com/data/dataset_admin/download-datasets.cfm [Accessed December 2014].

van Poppel, & van der Heijden, C. (1997). The effects of water supply on infant and childhood mortality: a review of historical evidence. *Health Transit Rev, 7*, 113-148.

WaterAid (2010. *WaterAid in Timor-Leste: Country Strategy 2010-2015*. WaterAid: Timor-Leste.

WaterAid (2011). *Lesson learned from sanitation marketing in Timor-Leste*. WaterAid: Timor-Leste.

Water and Sanitation Program (2010). *Working Paper: Mainstreaming gender in water and sanitation. Gender in Water and Sanitation*. World Bank: Washington DC.

Water and Sanitation Program (2011). *Economic Assessment of Sanitation Interventions in Indonesia: A six-country study conducted in Cambodia, China, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative*. World Bank: Washington DC.

WHO (2010). *Access to safe drinking water improving; sanitation needs greater efforts*. [Online] Available from: http://www.who.int/mediacentre/news/releases/2010/water_20100315/en/ [Accessed March 2015].

WHO (2009). *Diarrheal disease*. [Online] Available from: http://www.who.int/mediacentre/factsheets/fs330/en/ [Accessed January 2015].

WHO (2014). *Investing in water and sanitation: increasing access, reducing inequalities. UN-Water Global Analysis and Assessment of Sanitation and Drinking Water (GLASS) 2014 Report*. WHO: Geneva.

WHO/UNICEF (2013). *Progress on sanitation and drinking water 2013 update*. WHO: Geneva.

WHO/UNICEF (2014). *Progress on drinking water and sanitation 2014 update*. WHO: Geneva.

Wolf, J., Bonjour, S. & Pruss-Ustun, A. (2013). An exploration of multilevel modeling for estimating access to drinking-water and sanitation, *Journal of Water and Health*. *11* (1), 64-77.

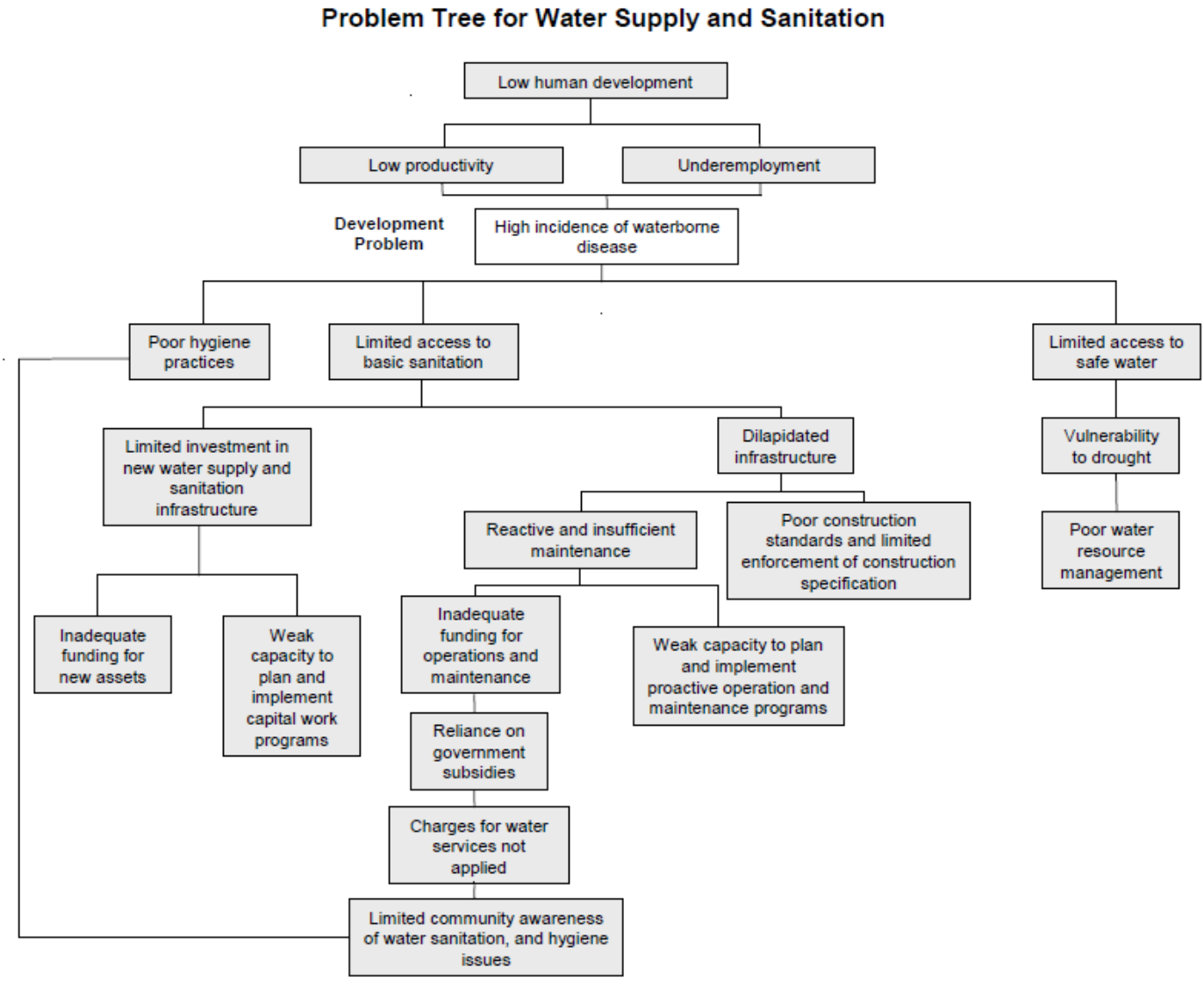
World Bank (2013). *Timor-Leste-Country partnership strategy for the period FY2013-2017*. World Bank: Washington, DC.

World Resources Institute (2009). *Mapping a healthier future. How spatial analysis can guide pro-poor water and sanitation planning in Uganda*. Health Planning Department, Ministry of Health: Uganda.

Wratten, E. (1995). Conceptualizing urban poverty. *Environment and Urbanization, 7* (1), 11-38.

Appendices

Appendix A - Problem tree for water supply and sanitation



This problem tree is adapted from the management for development results workshop conducted in July, 19-20, 2010 in Dili. Participants included representatives of government agencies, civil societies, development partners, and the private sector (*Source, ADB, 2013*)