SUSTAINABILITY INDEX OF WATER, SANITATION AND HYGIENE (WASH) INTERVENTIONS IN FREETOWN OF WESTERN SIERRA LEONE

A DISSERTATION

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in this dissertation entitled, **"SUSTAINABILITY INDEX OF WATER, SANITATION AND HYGIENE (WASH) INTERVENTION IN FREETOWN OF WESTERN SIERRA LEONE"**, in partial fulfillment of the requirement for the award of the Degree of Master of Technology in Water Resources Development and submitted in the Water Resources Development and Management Department of the Indian Institute of Technology Roorkee, under the supervision of Prof. M. L. Kansal, Water Resources Development and Management, Indian Institute of Technology Roorkee (India).

The matter presented in the thesis has not been submitted for the award of any other degree or any other institute.

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CERTIFICATION

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ABSTRACT

This dissertation looks at the synthetic sustainable of Water, Sanitation and Hygiene services and its likely impacts on society and the environment. WASH sustainable interventions are assessed based on the developments that are sustainable for social, environment and economic. These dimensions are fully accessed by looking at the institutional performance, management style, financing and appropriate technology. Sustainable WASH interventions are crucial to inter-generational equity for all. Sustainable growth caters to the current population, keeping in mind opportunities for the future societal perceptions, technological and scientific progress. Several papers were reviewed that relate to sustainable WASH interventions. The Study identified issues and challenges of WASH and its benefit to society and the environment. Accessing adequate and quality WASH services mostly adapted to control diseases that cause morbidity among children in countries that are developing.

Freetown, Sierra Leone's capital, on the Southern bank of the river's estuary with latitude 8˚ 29' 2.39'' and longitude 13˚ 14' 2.40''. The population have grown tremendous after the 11 years of civil unrest and serves as an economic, cultural, educational and political hub of Sierra Leone. It has expanded into delicate zones and broken the catchment for water into pieces. The extensions have coursed the city to be congested and unplanned with many areas lacking WASH services.

Sustainable WASH interventions cater to improving water supply, water quality, sanitation and hygiene through good policy, political will, adequate investment and sustainable environment. The methodology involved developing the assessment tools that are the Sustainability Index Tool (SIT), catering for all interventions in Freetown. The study synthesised information which was evaluated to give a low sustainability index for WASH services in Freetown. 32 indicator questions were developed to access institutional, management, financial and technical. Sustainable WASH index on interventions is 46.7% for 2017, showing a low sustainability as compared with the international H_2O (USAID and Rotary International).

The demand for WASH is on the increase whose measures can improve HDI. WASH services are human right related, yet more people are still faced with the challenge of haven access to adequate and quality WASH services because of weak policies, inadequate water

management laws and institutional framework, and weak public sectors. Improving WASH services could enhance the educational sector, health, economy and raise the life expectancy. It is, therefore, desired to explore sustainable WASH services to Freetown. Keeping this in mind, the present study has been carried out. The study identifies and access the issues and challenges relating to WASH services and suggests measures for the sustainable WASH services which can better human lives and the environment.

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ABBREVIATIONS AND ANNOTATIONS

ABBREVIATION	TITLE
WASH	Water, Sanitation and Hygiene
UNICEF	United Nations International Children's Emergency Fund
SDGs	Sustainable Development Goals
UNDP	United Nations Development Programme
ONU	Ohio Northern University
AfDB	Africa Development Bank
WHO	World Health Organisation
GVWC	Guma Valley Water Company
NGOs	Non-Governmental Organisations
MDGs	Millennium Development Goals
GDP	Gross Domestic Product
SIT	Sustainability Index Tool
O&M	Operations and Maintenance
LCCA	Life Cycle Cost Analysis
PCA	Principal Components Analysis
SPSS	Statistical Package for the Social Sciences
IBM	International Business Machines
CM	Covariance Matrix
I	Institutional
M	Management
F	Financial
T	Technical

SI	Sub-Institutional
SM	Sub-Management
SF	Sub-Financial
ST	Sub-Technical
ODF	Open Defecation Free
USAID	United State Agency for International Development
WSI	WASH Sustainability Index

CHAPTER –1

INTRODUCTION

1.1 BACKGROUND

Sustainable interventions in WASH services, improve the health of people and provide the ability to fight diseases in communities (Plates 2016). When Governments invest more in WASH helps to reduce related illness, children's death, sexual assaults/rape and encourage girl child education. An adequate WASH of acceptable quality globally promote economic gains, HDI measures and provide resilience against climatic impacts and rising population on the continent (UNICEF 2016b, Caruso et al. 2013).

Access to quality WASH services has benefit to many people through the reduction of diseases and averted health-related costs more especially when services are within reach. According to the WHO, it is cost-effective to invest as small as a dollar on WASH components and in turn, provide a cost benefit of $3 to $34 (Oates et al. 2014). Extensions in the interventions of WASH components, reduce poverty, improve the HDI, girl child education and economic growth.

WASH services in places, like schools, health centres, commercial and other institutions (workplaces) can impact the public health, environmental health, education, lifestyle, human productivity (income generation) etc. (Prüss-Ustün et al. 2014). Limited WASH components create the issue of access as more time is wasted in seeking water or sanitation facilities or better hygiene practices which can account for billions of economic lost and social impact on the poor (Plates 2016, Hutton and Chase 2016). About 361,000 under five children died in 2012, from limited WASH coverage in Africa and Asia (Prüss-Ustün et al. 2014). Diarrhea disease is common in many African and Asian countries, accounts for 502,000 deaths from poor quality water and 280,000 deaths from unimproved sanitation, with a total of 1.50 million reported deaths in 2012 globally. Similarly, hygiene practices caused the death to rise by about 842,000 taken 1.5% increase in total (Prüss-Ustün et al. 2014).

A development is sustainable when it is capable of providing needs of the current population, keeping in mind the requirement of the future population. Sustainable WASH services, ensure reliable WASH interventions that meet the current population requirements thinking about the future population. WASH services that considered the social, economic and environmental criteria is said to be sustainable as seen in figure 1 (Emas 2015). Sustainable WASH development focuses on society (education, health, safety and opportunities), economy (in terms of money, jobs trade and business) and environment (in terms of air, water land, plants and animals) seen in figure 2 and can have impact on communities in the world (UNICEF 2016b).

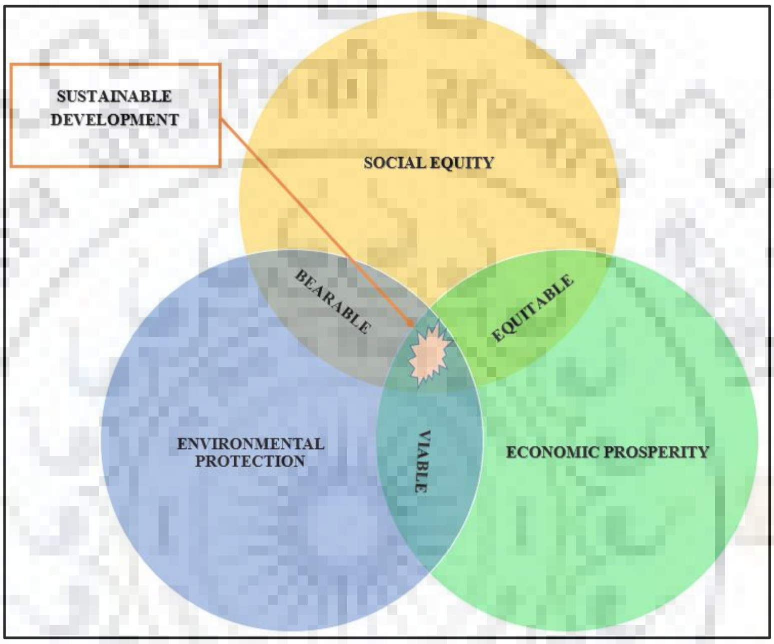


Figure 1: Sustainable Development

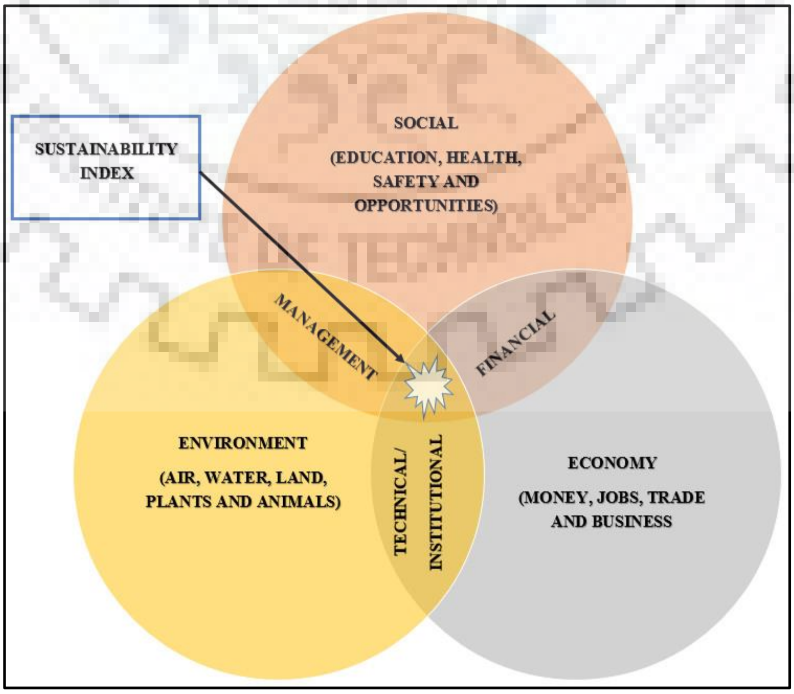


Figure 2: WASH Sustainability

In September of 2015, SDGs with 17 goals and 169 targets were lunched in the United Nations' assembly. The set goals and targets meant to provide sustainable human development considered the provision of sanitation and water for all by 2030 seen in figure 3 (Schwemlein, Cronk, and Bartram 2016).

Figure 3: Sustainable Development Goals (www.snrd-asia.org)

Development is said to be sustainable when the challenges associated with society, economic and environment are addressed. Measuring the sustainable development progress made by individual countries, set of indicators are established to access the goals. Several countries have generated tools in monitoring the progress through of the SDGs index. Monitoring the SDGs started by considering 150 indicators which have evolved to 230 at present (Bizikova and Pinter 2017, Vaughan 2016). The SDGs goal 6 made provision for access to sanitation and water to all by 2030. In countries with low and average income levels, access to WASH services continues to be a crucial challenge. This is affecting their way of life, health and the environment poses a huge challenge, expected to be more severe with the variation in climate (UNDP 2015). The goal number 6, is meant to tackle challenges associated with sanitation and water availability for the rising populations seen in figure 4. Sustainable WASH services can impacts the lives through health care delivery, education and reduction in poverty in countries that are developing. About 5.2 billion (71%) of the population in the world get water from protected sources and 2.9 billion (39%) can access improved sanitation services. Similarly, around 2 billion people live in water stress zones like Northern Africa and Asia (ONU 2017).

Figure 4: Sustainable Development Goals (Access to WASH) (www.google.com)

Governments in African are investing a huge amount of financial resources to strengthen institutions charged with the responsibility to deliver WASH services, yet the majority of the population still remain unserved. The lack of WASH services in Africa have generated issues around public health, environmental sanitation, access to education, and poverty (Schreier and Cohen 2013). It is commonly acknowledged that majority of those that are "served," compared with those "unserved," is on the decreased and even those that are severed experience major operational failure in WASH service delivery. Urban WASH infrastructures lag behind population growth due to rising urbanization, informal settlements, limited WASH infrastructures, and weak institutions including cost recovery, poor governance, and degenerating water sources (AfDB 2015). Similarly, inadequate maintenance, breakdowns, poor construction quality with managerial skills have underpinned quality WASH services in developing countries. Quality WASH services in communities can promote girl child education and economic empowerment.

West Africa has the lowest WASH coverages as compared in Africa and even in the world. The health, education and economic status of the population can be affected by low WASH coverages, threatening the human and environment health (Plates 2016). In West

Africa, diarrheal diseases continue killing more people, especially under five children (Fewtrell and Colford 2005). About 80% of all illnesses around the world are WASH related. West African suffers from high infants' death compared with the other African Regions. In Sierra Leone, about 161 death is reported for children in every 1,000 child birth which seem to be terrific and worrying due to poor WASH conditions (Babovic and Vukovic 2014). In West Africa, only 27% that is 105 million people can boost with improved sanitation and 291 million have no access at all. In West Africa, most of the under-five death are attributed to diarrheal disease, taken the lives of 760,000 children yearly (WHO, 2013). Diarrheal disease prevalent is preventable through the provision of quality WASH services in communities. Inadequate WASH components availability in communities cause women particularly girl child to spend several hours each day in seeking WASH service, limiting the opportunities for schooling.

Despite the abundant water resources potential of Sierra Leone, many people are yet to have access to adequate WASH services, affecting the health, environment and economic status seen in plate 1.

Plate 1: Challenges of WASH services in Freetown

Sierra Leone, the West African country, experience the lowest WASH services leading to high under five and maternal death in the world. After the ten-years of war, the government had struggled to implement effective WASH reform policy to improve services and institutions. Almost, all the WASH components were destructed or looted leaving the country in poor WASH status. Sierra Leone has the highest reported cases of diarrheal in West Africa accounting for about 75% death among the under-five children. This is linked to the poor quality WASH service delivery in the country. The country experiences a number of the under-five death due to diarrhea as reported by the Disease Surveillance Unit at the Ministry of Health and Sanitation.

Accessing WASH facilities are crucial to health, development (education, life expectancy and income) and wellbeing of children (Caruso et al. 2013). Lacking WASH services is crucial to school attendance and performance of girl child, safety and security of women and girls, economic growth and the social status of the population (Gender Tool Box 2015). WASH availability empowers physical, mental, social prosperity, health economic, political and environmental conditions of communities.

1.2 DESCRIPTION OF STUDY AREA

Sierra Leone, the West Africa country, has an area of 73,300 km^2 and population of 7,092,113 (2015 national population census) with an annual growth ratio of 3.2% from 2004 to 2015 (Statics Sierra Leone 2016). Sierra Leone has Guinea on the north-East and Liberia on the south-east seen in figure 6. Geographically, the country has the plains in the west at an altitude less than 100m and hills on the east with altitude at between 100m to 1950m. Sierra Leone, a tropical region with a maximum annual average temperature of 32^o and average annual humidity of 80.8% (Leone and Company 2017). Annual rainfall varies from 1800mm north to 5,000mm west. The country is exposed to two seasons, the rainy season ranging from May to October and the dry season from November to April (Water and Policy 2010).

Sierra Leone suffered 11 years of civil conflict (1991-2002) and almost all the WASH infrastructures were invariably destroyed. The outburst of the war contributed to the poor WASH conditions causing much death from the diarrheal disease. Sierra Leone has a national water supply coverage at 47% and sanitation at 13% as recorded in the national WASH policy (Water and Policy 2010). Currently, the coverage is estimated at 58% and sanitation at 40% nationwide showing a reasonable improvement.

With the huge water resource potentials contained in over Twenty-Six rivers across the country. These include Rokel, Moa, Sewa, Little Scarcies, Pampana, Great Scarcies, and Mano etc. with lengths ranging from 40 kms to 290 kms. The Rivers have a total mean annual runoff of 160 km^3. Four of these rivers namely, Moa, Little Scarcies, Mano, and Great Scarcies are coming from neighboring countries of Guinea, Ivory Coast and Liberia (Water and Policy 2010). Despite the huge availability of water sources in the country, water supply still remains a challenge for both urban and rural settlers as demand keeps increasing.

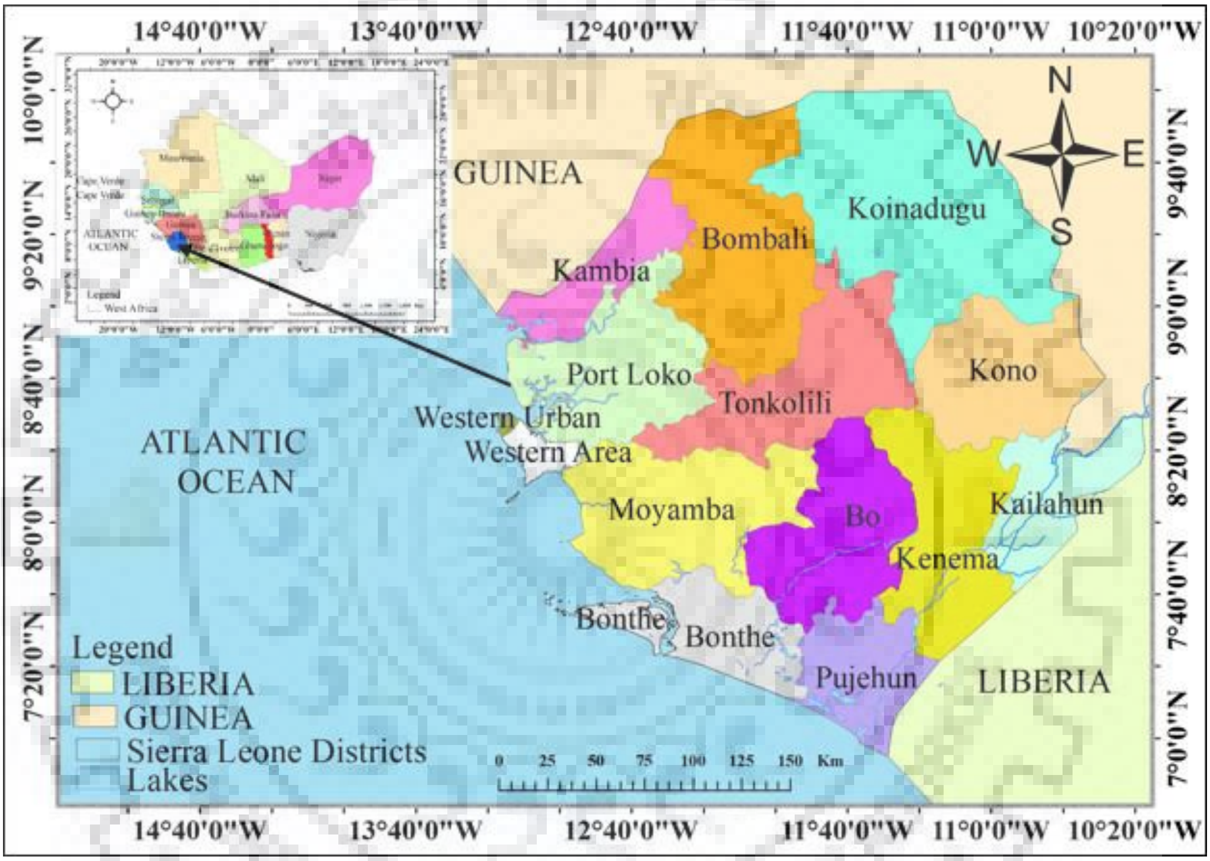


Figure 5: District Map of Sierra Leone

Freetown, the major urban, economic, cultural, educational and political hub of the country has the deepest natural harbour in Africa. It has experiences large anthropogenic activities from the growing population due to urbanization. The natural harbour and torism are the major economic activities. Freetown has parallel ranges of highlands of about 30 km in the southward and hills having elevations ranging from 200m to 1 000m above mean sea level. It is situated on the River's estuary and with latitude $8^{\circ}\ 20'\ 0''$ and longitude $12^{\circ}\ 45'\ 0''$ seen in figure 7. Administratively, Freetown is divided into 8 zones (Central I and II, East I, II and III, and West I, II and III) and a population of approximately 1.1 million.

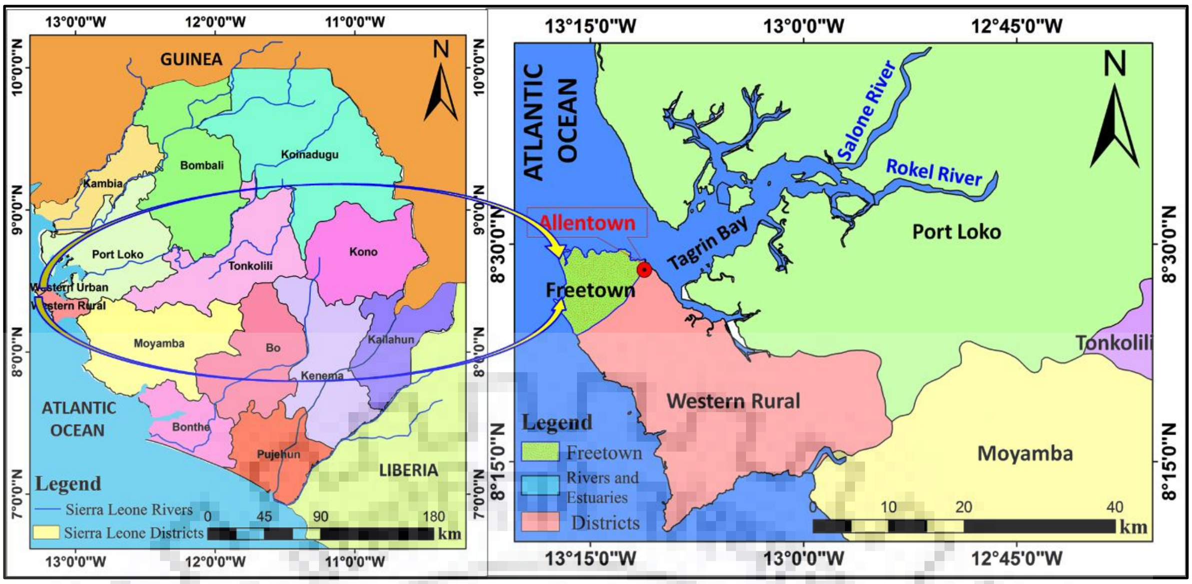


Figure 6: Map of Freetown

The climatic condition is tropical with two seasons: raining season from May to October, and a dry season from November to April. The average annual rainfall varies between 2500 mm to 5,000 mm and average monthly temperature varies from 24.6˚C to 27.8˚C with a maximum temperature of 32˚C in the month of March seen in figure 8. The average annual relative humidity of Freetown is 80.8% and the average monthly relative humidity ranges from 72% in February to 89% in September.

The Freetown peninsular has high topography and rise to nearly 1000m. A chain of hills aligned in a Northwest-Southeast direction (Allen Town Ridge (174m), Spike Hill (324m), Charlotte Hill (505m), Porcupine Ridge (492m), Gloucester Hill (539m) and Havlock Plateau (364m) form the first main internal watershed. A higher range in the west called Sugar Loaf maintains (898m) seen in figure 9. The main Orugu valley lies in between the main ranges and sizeable numbers of catchments (Guma and Sussex) that lie on the western side of the higher range. Towards the foot of these highlands is isolated small natural hills at Wellington, Wellington Knoll and Tower Hill (Leone and Company 2017).

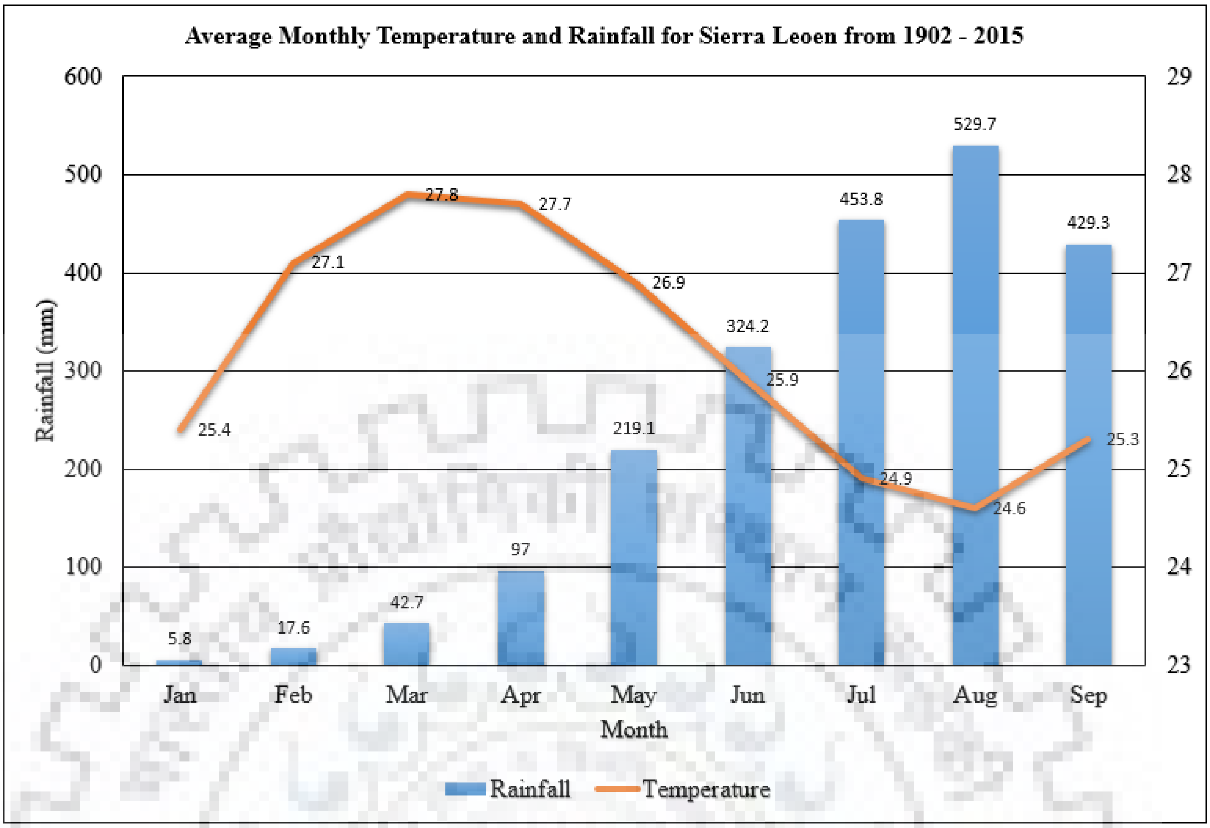


Figure 7: Average monthly temperature and rainfall from 1901 – 2015

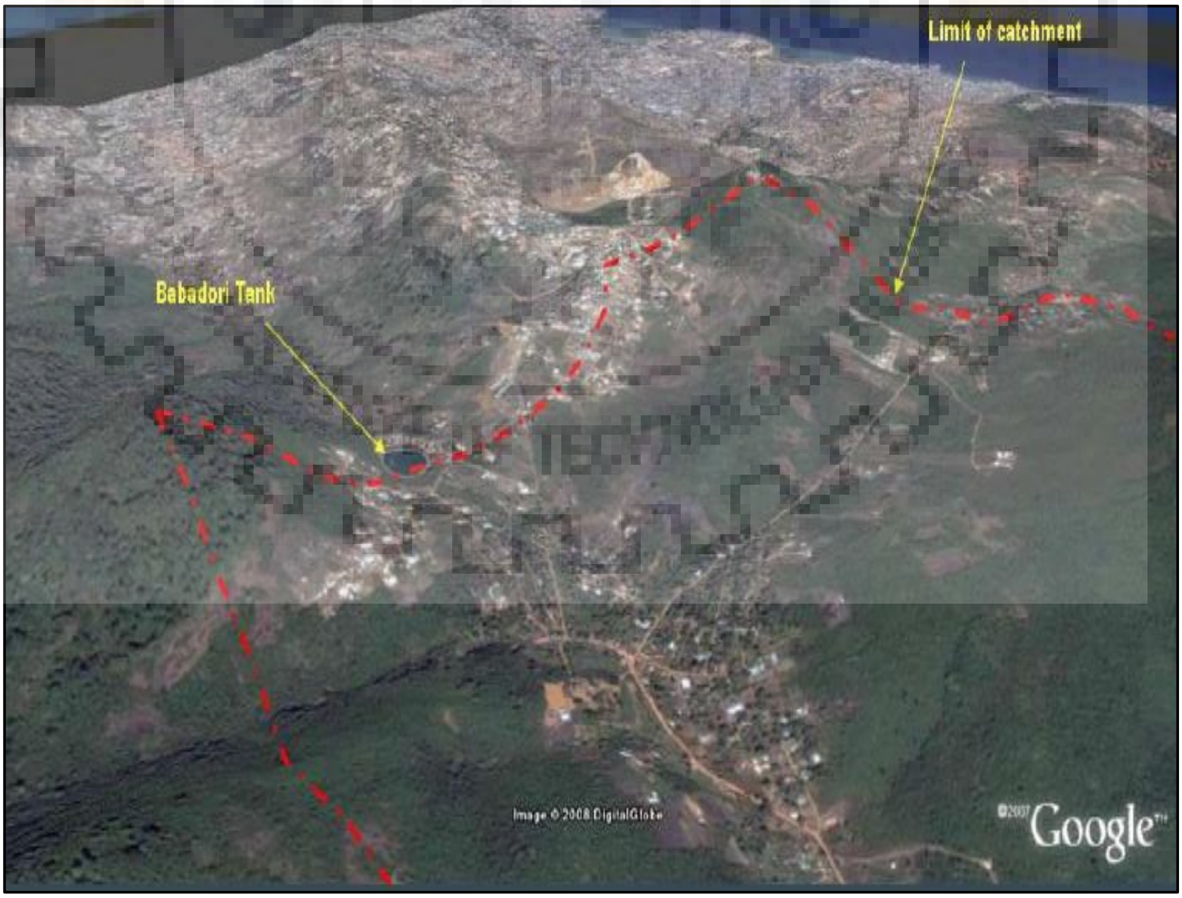


Figure 8: Topographic view of Freetown

1.3 GUMA VALLEY WATER COMPANY LIMITED

The GVWC was established in 1961 under the GVWC Ordinance which gave it responsibility for supply water and sanitation in Freetown covering Allen Town to Hamilton in the West. In the act, an operational guide for GVWC are set and these have remained largely unchanged to date, whilst the cityscape has changed significantly. The GVWC Ordinance covered staff appointments, land purchase, finance (borrowing, tariffs, and taxation), and quality of water and level of service. The GVWC is a parastatal organization which is 99% ownership of the central government and 1% to the FCC. It is, however, a wholly autonomous operated water body that does not receive any support from the government. It is expected to financial itself from income generated revenue from tariff (The et al. 2010). The GVWC uses the Guma Lake, Charlotte, Kongo, and Takayama sources to supply water to Freetown which is currently under tremendous pressure as demand keeps growing seen in figure 10.

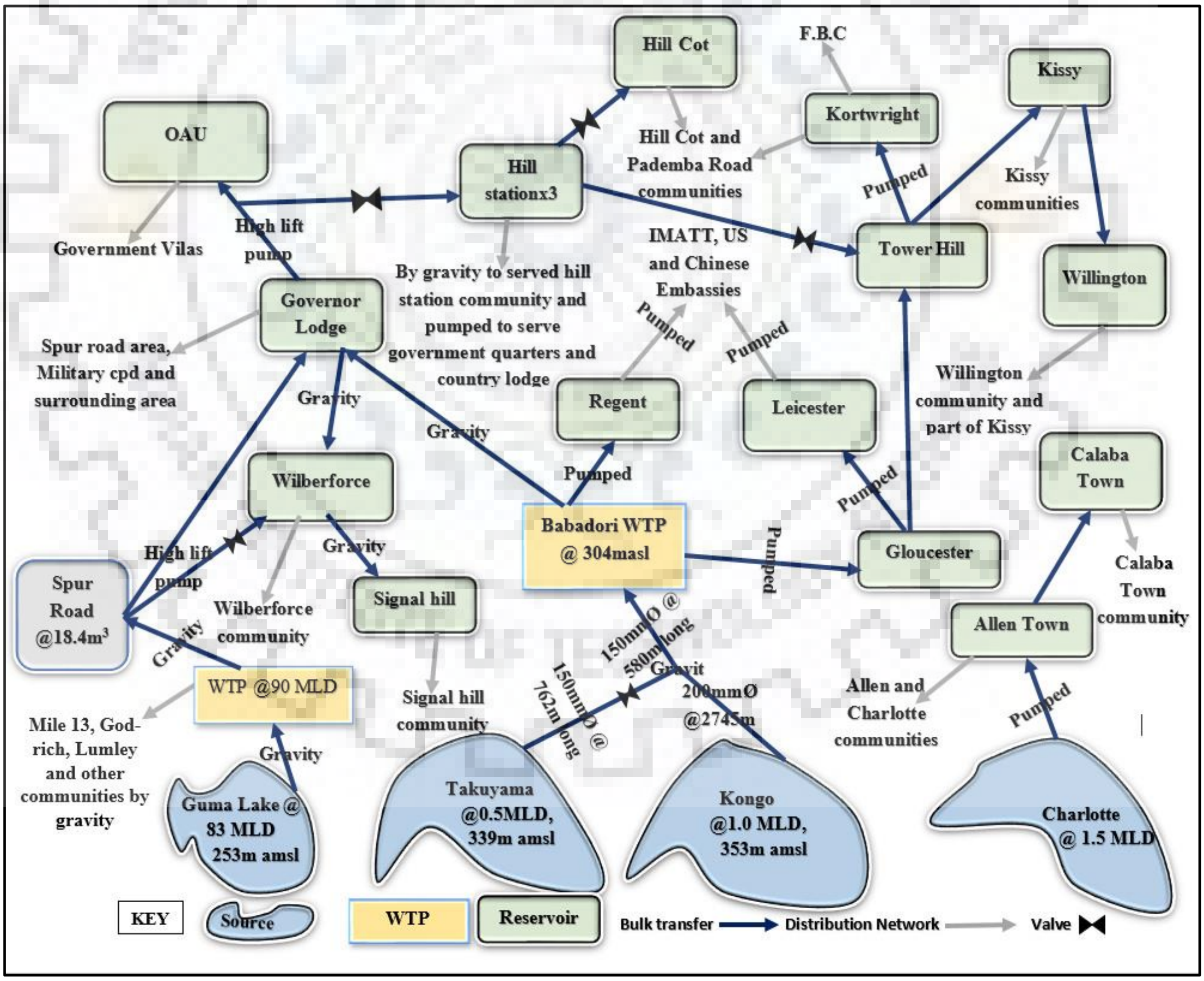


Figure 9: Water Supply Network Plan for Freetown

Water and sewage management are managed by the GVWC and can only supply about 18 million gallons per day (mgd) against an average daily demand of 35 mgd. The Guma reservoir has a capacity of approximately 22300 million liters (4905.4 mgd) with an area approximately 17km^2. The treatment capacity of the Guma treatment works is 90Ml/day and the current deployable output is 77Ml/d in a drought year and 83.5Ml/d in the drying season seen in plate 2 (Water and Policy 2010).

Plate 2: Guma Valley Supply Sources and Treatment Works

Water is rationed for the most parts of Freetown and no customer is able to get 24-hour service. In poor urban (kissy, Wellington etc.) areas customers receive supplies once every month or no service at all. With the rapid and uncoordinated expansion, the majority of the population continues to depend on vendors and tanker services, at a higher cost for water services.

Sanitation is important and critical for economic growth, human health and education in Freetown. It needs serious attention if the development is to be sustainable and promoting economy, health, education and life expectancy. Sanitation cannot go alone without effective water management in Freetown. Improvement sanitation is an imperative intervention for promoting good health and reduce poverty which can enhance or boost economic growth for the population. An improvement in sanitation requires an integrated developmental strategy on water being that the two are inseparable.

Freetown is faced with huge sanitation problems, ranging from low level coverage and quality to inadequate legislative-institutional framework including low investments. The lack of WASH awareness are the root causes of poverty, affecting mostly women and children, who suffer from diseases. Hygiene promotion can enhance sanitary practices and provide for good health and environment. In Freetown, hygiene awareness is minimal which treating the living conditions of the population (Water and Policy 2010).

Lacking sanitation services had a serious economic impact on household economies, causing poverty, poor health, uneducated and income lost. Government and development partners including NGOs have implemented and documented pilot sanitation projects model. Despite the efforts, the sanitary condition assessed by UNICEF in 2005 showed that the coverage of sanitation services still lags behind water supply, meaning more investment is required in promoting sanitation interventions. The majority people in Freetown, about 70% have no access to sanitation and the city considered to have the poorest sanitary practices as compared with other West African cities seen in plate 3 (Water and Policy 2010). The GVWC is not doing much in promoting sanitation services and the city's poor sanitary condition has affected the living conditions largely affected.

Plate 3: Sanitation Status in Freetown

1.4 STUDY GAPS

The following are gaps identified for study area:

1) Data on WASH meant for policymakers to strategic plan and implement are absent.
2) The challenges of WASH that are connected with public health, environmental health, quality water and socio-economic development.
3) The WASH specialists and technicians' capacity, weak institutional frameworks, weak WASH policy and inadequate financing of WASH services.
4) The continuous lack of WASH infrastructures in the city.
5) Weak techniques in wastewate reuse and recycling, pollution and quality water surveillance.

1.5 SCOPE AND OBJECTIVES

The scope relating to the study is to measure the sustainability index of WASH in Freetown, Western Sierra Leone. WASH sustainability is critical to the development of both rural and urban communities. WASH sustainability index can be generated from indicator questions measuring the progress in sustainability. Indicator questions covering the institutions, management, financing, and technical aspect. The four main indicators considered the Social, Economy and Environmental aspect which for the bases for sustainable development. This study was conducted in communities across Freetown, collecting data on the legislative – institutional framework, management, financial and technicalities. Keeping these in mind, the objectives have been set.

1) To evaluate issues and challenges concerning WASH in Freetown and its likely impact on the SDGs.
2) To develop the SIT through indicator questions on WASH for the study area and replicate in a similar environment.
3) To measure the progress of WASH in Freetown considering the contributions from the institutional framework, management style, WASH financing and technology (Sustainable WASH index) and compare with the HDI.
4) To evaluate the WASH performance as reliable, resilience and vulnerable to the current WASH conditions in Freetown and to measure its performance in future.

5) To suggest measures on how to improve WASH service delivery and make them sustainable in future.

1.6 APPROACH IN ACHIEVING THE OBJECTIVES

The flow diagram shows the steps adopted in achieving the objectives seen in figure 11.

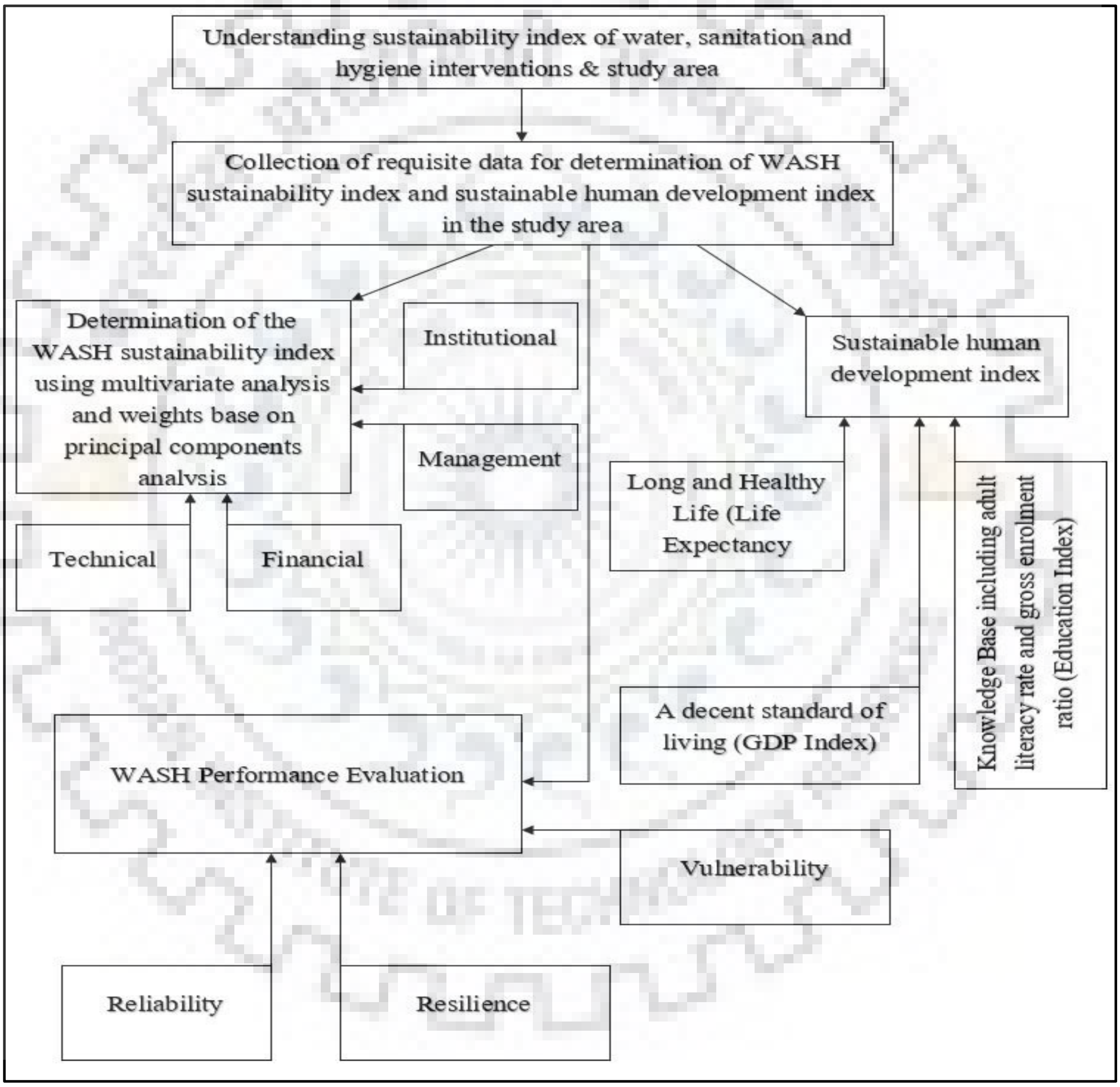


Figure 10: Approach to achieving the set objectives

1.7 ORGANISATION OF THESIS

The thesis has been organized in the layout as demonstrated below:

Chapter 1:

A brief discussion on the general background, WASH conditions and outlines of the research gaps and objectives. The approaches and organization are discussed in the work.

Chapter 2:

General idea on WASH as related to works undertaken by other in different areas. Conducted brief discussions on sustainable WASH interventions considering the institutions, management, financing and technical aspects. There are brief discussions around water, sanitation and health, environmental health, climatic impacts on WASH, issues and challenges of WASH services and conclusions.

Chapter 3:

Describes the general methodology of the thesis, SIT considering target groups like the service provider levels, community levels and national levels. It further looks at the multi-variance analysis considering Cronbach coefficient alpha and weight based principal components analysis, the WASH performance criteria, HDI measuring the life expectancy index, education index and income index, and conclusions.

Chapter 4:

Generally looks at why is it necessary to have quality WASH services to communities, the results, discussions and conclusions.

Chapter 5:

Presents the available options to be adopted in improving WASH interventions globally but particularly the study area and possible recommendations for quality WASH services.

CHAPTER – 2

LITERATURE REVIEW

2.1 GENERAL

Services are Sustainable when they are able to cater for the society, economic and environment of any nation. An agreeable and precise definition of sustainability is yet to be harmonised, however, the concept that established the interconnections of society, economic and environmental and how theses can serve the current and future population (Milman and Short 2008). Measuring progress in sustainable development for nations across the world, have series of indicator questions to monitor progress made on the economy, environment and social dimensions. WASH services are fundamental to human right and dignity, yet many communities' members have daily challenges in securing basic WASH services. Efficient and effective WASH services become crucial in the health of under-five children, forced migration, disease outbreaks, human health and natural disasters. These interventions are increasingly needed to assistance those in great need of WASH to better the lives, environment and economy (UNICEF 2016b).

WASH services in places like health care units and households are crucial for education, health, environment and economic growth. Providing WASH at childbirth in developing countries stay to be extremely low. WASH diseases can be prevented by improving services and access in communities. This can significantly reduce the disease burden thereby preventing the over-use of antimicrobial drugs (UNICEF 2016b). Good WASH services can integrate the benefit of better policy formulation, proper project appraisal, sound water management laws and institutional performance, decision-making processes and freshwater resources extraction and diversion. Effective and efficient WASH are crucial to achieving SDGs which caters for good health and equity (Mills et al. 2016). About 80% of those population unserved or have limited access to WASH services are found in sub-Saharan Africa, South Asia or East Asia (Andersson, Dickin, and Rosemarin 2016).

Achieving the SDGs mean developing WASH infrastructures in a safe, affordable and functional manner. To achieve this, WASH players need a better understanding of the disturbances, continuous breakdowns and inequalities in service deliver to communities.

Quality WASH services protect and promote human and environmental health, through economic viability, socially acceptable, technical, institutional and managerial appropriateness (Andersson, Dickin, and Rosemarin 2016). Improving WASH services become vital to lives transformations and enhance the health, education and income generation. When the standard of WASH services are adequate, the rights are protected, there is peace, equity and reliable services are assured, contributing to the SDGs (UNICEF 2017).

2.2 SUSTAINABLE WASH INTERVENTIONS

SDGs measures can give a clear opportunity on the achievement regarding WASH and as well the lesson learnt in making WASH services sustainable. For the MDGs, there has been great achieving or successful stories in WASH service delivery. During the period for the MDGs, about halve of the population were able to have access to quality WASH services (Marshall and Kaminsky 2016). Whether or not systems continue to work overtime to meet daily demand and continue reliable output or efficiency in the future, relate to its resilience. Considering the social dimensions of sustainable services, a focus on people and processes, motivations and appreciable levels of service including over time (Marshall and Kaminsky 2016).

Water, hygiene and sanitation-related interventions are beneficial to healthcare delivery and promote quality education, economic and environmental sanitation. About 1.8 billion people are getting water from contaminated sources which seriously affect their health. Similarly, about 2.4 billion people do not have access improved sanitation services globally, posing a health risk to the existence of mankind (United Nations 2016). Globally, about 2 million reported yearly death are linked with the prevalent of diarrheal disease due to poor water quality and sanitation services, with most of the death reported are children (United Nations 2016). The Economic impact of not financing WASH is 4.3% GDP in sub-Saharan Africa which goes into curative measures than preventive measures. Poor WASH infrastructures and management styles, have continuously caused the death of many each year and affected the biodiversity and ecosystems, the economy, environment, with efforts for sustainable services affected as well (United Nations 2016).

WASH services improvement in communities brings income generation, health, environmental sanitation and quality education. Better health of individuals and nutrition particularly of children encourages productive, in school and at workplace enabling their earning potential aiding sustainable development. Reducing the time spent in seeking WASH services are critical to economic and educational empowerment for women and girls. Promoting sanitation services and hygiene awareness are highly cost effective, more especially when combined with other health components interventions (Growth and May 2013).

WASH sustainability progress is measured through indicators, which consider the role of institutions, management, a financial and technical aspect which can measure WASH conditions in Freetown. In general, they are useful tools for strategic WASH plans and management and easier to apply for sustainable WASH interventions, comprehensive and globally applicable (Cortés et al. 2012). SIT measures the WASH progress on project implemented, showing whether there is the success of failure (Schreier and Cohen 2013).

2.2.1 Wash Institution

In 2030, WASH facilities, extending beyond households, to cover schools, commercial centres, work places and in health centres. With this, the chances of WASH service delivery to be made available to people, who may have particular needs or vulnerabilities can be possible. Inadequate WASH services can reduce school attendance and affect the educational achievement and hinder health care services (UNICEF 2017). People may avoid going to schools or health facilities altogether when they realized the institutions do not have quality water, sanitary services or hygiene facilities (Thomson and Koehler 2016). Stronger institutional sustainability is due, in part, to the well-developed enabling environment, in developing the required policies, strategies, guidelines, and protocols involve in implementing structural changes at all the levels. The WASH levels of interventions may vary depending on the intervention type and country context and can be in the form of community levels, service provider levels (i.e. the water committee, utility or school), and national levels (Schreier and Cohen 2013).

If we are to maximize viability of WASH services, the institutions need to be strong and ready to take the lead for effective collaboration and coordination with sector players (Rana et al. 2011). WASH professionals need to understand institutional issues and their implications for sustainable WASH interventions (Nedjoh 2016). Institutional development is key for WASH services, looking at the issues and opportunities relating to poverty-focused approach, constraints, institutional, legal or legislation, regulations and management styles (Nedjoh 2016). In practices, WASH institutions are appraisals base on the strength of the institutions, and the necessary support to strengthen them can be provided.

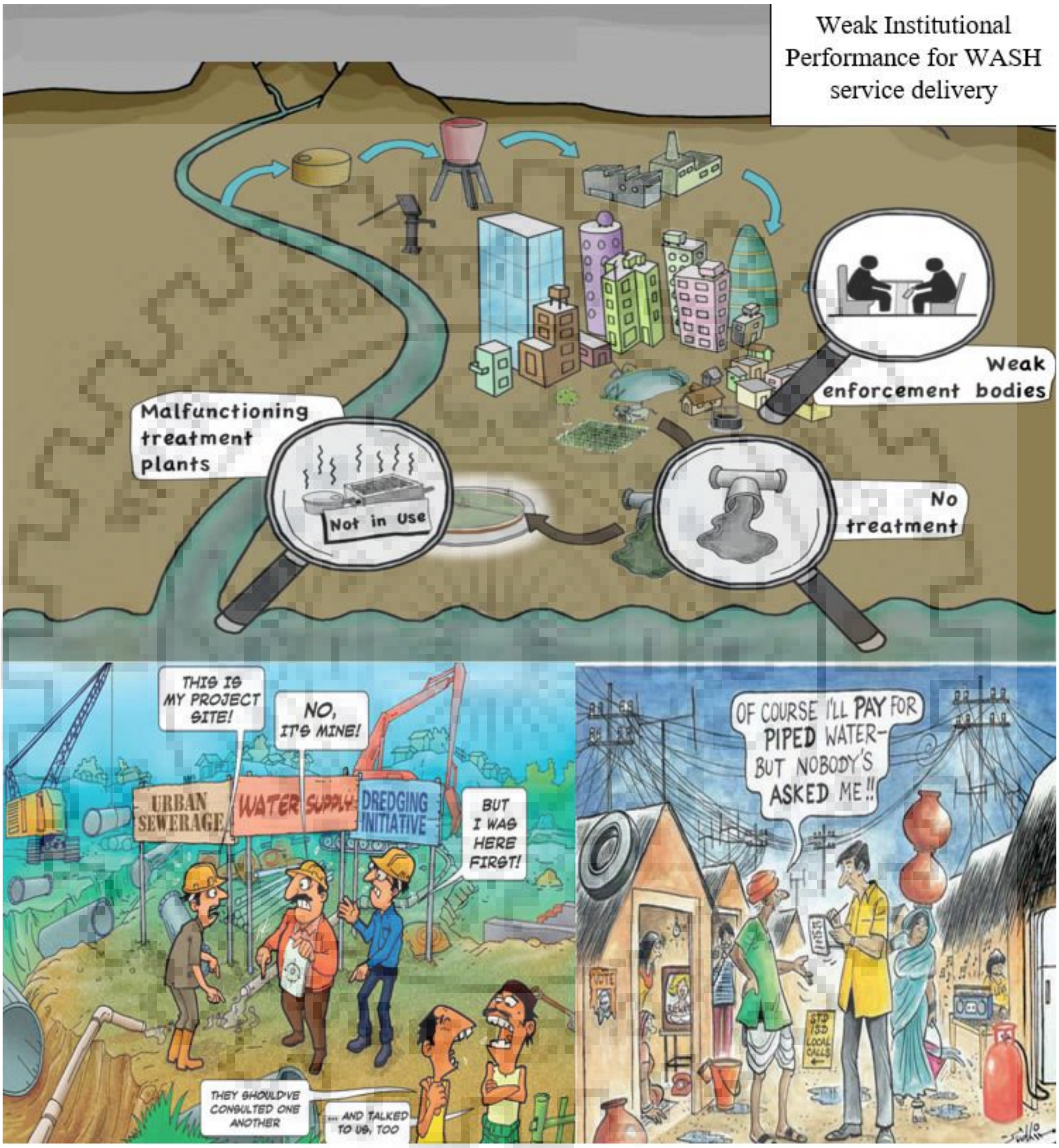


Figure 11: Weak institutions and enforcing bodies (www.wsp.org/userfiles/image)

WASH services are disrupted on a regular base because of weaknesses in the human capacity, administrative structures, bureaucratic procedures and low motivations. The WASH institutions lack the necessary mechanisms for cost recover and plan to handle operational or management costs, which has cause majority to failure. Roles and responsibilities for WASH services are not clear with challenges in knowing who does what, when and where. This fragmentation and overlapping affect the collaboration and coordination thereby creating conflict among WASH sector stakeholders seen in figure 12 above.

Institutional development has the tendency of improving and creating more transparent management practices resulting in the equitable use of WASH and enhancing human health and economic activities. This can create the necessary skills, good working environment, with self-sustain development in sustainable WASH service delivery. The basic WASH strategic plans on sustainability come as a two-way approach for improving institutional performance, through the interconnections that exist among WASH stakeholders including policy, regulatory laws and availability of components (Framework 2016).

WASH institutional or organizational autonomy is critical to organizations or institution's ability to manage its customers' needs and service deliveries. Municipal or local authority WASH departments, which are not able to hire staff or raise tariffs for costs recovery, are faced with frequent break downs. These actions can make the communities WASH conditions unsafe causing a disease outbreak. Effective and efficiency organizational autonomy make way for decision making on WASH budgets, tariffs, revenues, hiring staff, paying and providing incentives, control personnel, institutional policies and systems, plan projects, and institutional or organizational goals. Better regulatory mechanism instituted by the government to regulate functions, performance and monitor targets regularly. The regulatory governance, legislation and the institutions associated with the regulation and the decision-making processes (Framework 2016).

The WASH institutions can device regulations that are intellectual and technical including the economic regulations like tariff review or regulatory accountancy, quality and social regulations including social and gender equity. When the regulations are implemented, enhances sustainable investment and encourage reliable WASH infrastructures. WASH services required both top-down and bottom-up approach if sustainable services are delivered. The top-down approach considers institutional reforms and legislation and bottom-up approach, consider the involvement of individuals, communities members and stakeholders with the required energy, vision and creativity. Sustainable WASH contributes to human development, improved health and rising wealth in the place of the good institutional framework. Strong institutions can enhance service delivery and promote quality health in communities (Partners in Population and Development 2013).

2.2.2 Wash Management

The management style for WASH components varies from centralised government systems or structures to local community management structures for sustainable services. In some countries, they have central state or institutions, district or local authority (Sierra Leone), and village administration or management team involved in the day to day management of WASH components in communities. With centralised management style often contributes to O&M dependence on limited government financial resources (Fulazzaky 2014).

Urbanisation makes WASH management crucial for developed and developing countries. In developed countries, many of the cities are struggling with high O&M costs for running WASH services, causing an infrastructural breakdown. When a city extends beyond its limited and people are forced to live in slum areas, the extension of WASH services to the areas becomes impossible. Conventional urban WASH management is generally characterised by an unsustainable utilisation of WASH facilities are non-functional. Managing WASH sustainably reduces poverty reduction, environmental stability, social development, and gender equality (Aguasan 2017).

Urban settlers usually have higher consumption rate compared with the rural settlers. The water demand increased as urban population grows due to urbanisation and the consumption rate will rise. In many developing countries including Sierra, Leone urbanization is not the only challenge in WASH service delivery. Creating an informer settlement in urban cities poses a huge challenge for extending WASH services to these areas. Around 72% of the population in urban cities across Africa live in slums. In Asia about 43% live in the slum and Pacific, 32% for Latin America and 30% live in the Middle East and Northern Africa (Aguasan 2017). Well-Designed management structures for WASH provide sustainable services in communities. About 800 million are not having access to quality water and 2.6 billion people have no improved sanitation globally. Inadequate WASH services account for 80% of all illnesses in the world because of poor WASH management (Post 2015).

2.2.3 Sustainable Wash Financing

For the last three decades, government and international development partners have invested so much in trying to improve WASH infrastructures in Africa and Asia with little success. With sustainable financial best practice, the trend moves from supply driven that is a government-led program to demand-driven approaches that depend on community participation and management. However, even though progress has been made, yet many of the people in communities cannot boost of adequate access to WASH services (Ellert et al. 2013). Investment in WASH infrastructures is limited and the initial gains or progress made are not sustainable. Consistently, this cab is rated as "high critical importance" in "the issue of cost recovery" and "some form of external post construction support" from either governments or development partners. Other factors of "critical importance" include the management capacity of community teams, user satisfaction for WASH services, motivation, maintenance, spare parts availability, continued training and support for hygiene promoters and environmental factors (Ellert et al. 2013).

In many African communities, a fixed monthly cash payment per household is usually charged to sustainable WASH services. In some other cases, the tariff is collected on a seasonal or annual basis where consideration is given to volumetric usage (per jerry can or bucket) including payment in-kind. The revenues that could be collected likely fall short (as low as 25-30%) of the theoretical total, due to poverty-related exemptions and most community members not ready to commit payment to WASH services (Ellert et al. 2013).

Estimation of the true life cycle costs indicates that the average actual revenue expected will only cater for minor repairs and basic Operation & Maintenance costs. When breakdown occurs in WASH services, communities can then turn to external support either from their governments or development partners. The supports from the government or international development partners are limited and not readily available to support WASH infrastructures. In Africa, WASH investment has never being a priority whereas the value placed on WASH is very high. There is a complete mismatch between peoples' expressed demand for WASH services and the readiness to pay for services. Lacking sustainable WASH financing will leave many vulnerable people and public institutions without WASH components by 2030. With limited investment, serious implications to successfully achieve viable outcomes that can support human health and nutrition, education and reduce poverty are hampered. Making appropriate and effective WASH financial plans for service delivery can minimise the gaps in access between rich and poor (Shrestha, Murali, and Shrestha 2015).

WASH services need to be affordable such that the population served can be able to pay the required tariffs for Operation & Maintenance of WASH facilities. For communities to consider who WASH is important to their livelihood, demand assessment and awareness raising activities should, therefore, be taken into consideration prior to any interventions. This will cause the communities to accept and taking ownership. WASH systems rehabilitation and extension costs due to population growth or increased demand are often not accounted for in cost recovery (Osumanu, Abdul-Rahim, and Songsore, 2010).

Sustainable financing in WASH activities considers the approach called Life Cycle Cost Analysis (LCCA). Life-cycle cost analysis (LCCA) consider the all the aggregated costs for pre and post WASH implementation services. Analysing the financial sustainability of WASH, all the costs items are considered when planning WASH interventions. Cost of capital (cost of borrowing money or invest in the service instead of another investment opportunity), capital expenditure (Initial costs for putting new WASH services into place), expenditure indirect support (costs of planning and policy making at governmental level including capacity building of professionals and technicians), expenditure direct support (pre and post-construction support costs not directly related to implementation, e.g. training of community members or private sector operators or user groups), capital maintenance (occasional huge maintenance costs for the renewal, replacement, and rehabilitation of a system) and operation and minor maintenance (routine maintenance and operation costs that are crucial to keep WASH services running, e.g. wages, fuel, or any other regular purchases) (Mack 2012). The cost and financial plans are integrated as part of the sustainable WASH interventions seen in figure 13.

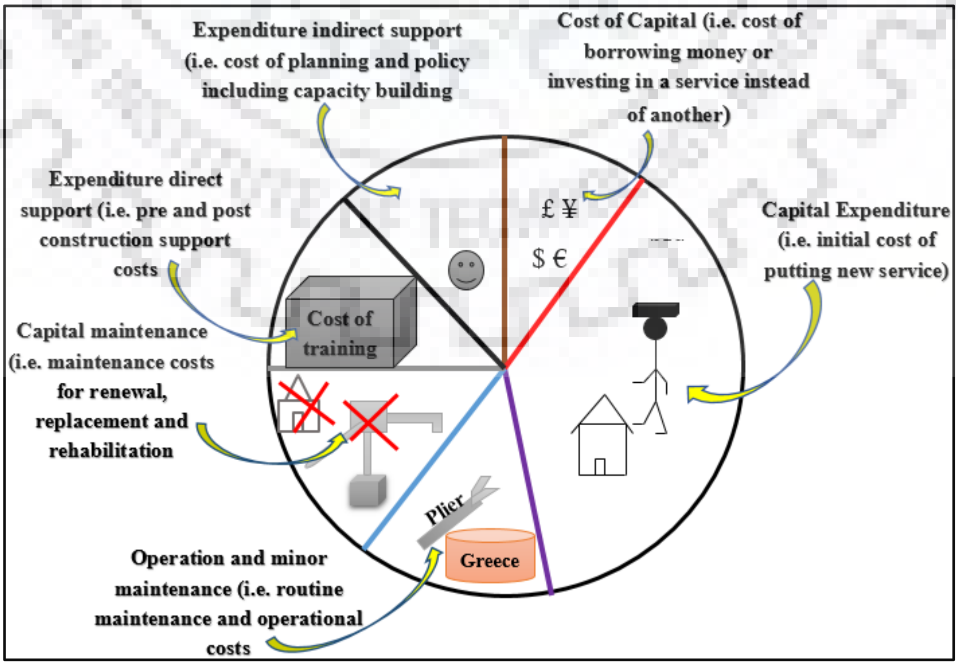


Figure 12: Life Cycle Cost Analysis

Managing WASH services in a proper manner with the right incentives will ensure financial sustainability. Currently, government supported schemes do not provide the incentives for WASH systems to be run properly causing an early breakdown of facilities in low-income communities. Most of the financial supports are generated from the public coffer which is used to deliver WASH services. When financial support from either government or international development partners decrease, public finance can improve significantly to maintain current expenditure levels and expand future investments. This will ensure both quality and equity in services in the sectors. Similarly, when the available resources are efficient to such a level, service quality can be of benefits to all incuding the very poor and marginalised (UNICEF 2016a). Dalliance or insufficient in financial support can delay the installation and maintenance works relating to WASH services. Similarly, poor monitoring and limited funds to maintain WASH components cause deterioration and even permanent break down (Shrestha, Murali, and Shrestha 2015).

There are still more WASH services that are underfunded which are haven serious consequences for the users, particularly the poor people. In many places around the world, people are spending quite a reasonable sum of the income on WASH services through various means like contributions in cash/kind for capital expenditures, connection fees, and tariff payment or investments in improving their individual WASH services. So much investment is regularly lost because the WASH structures are of poor quality and the systems fail shortly after commissioning (AGUASAN 2012).

Sustainable WASH services require sound investment plan to cater for routine maintenance and operation of the systems. The major issue is that no attention is given to the life – cycle cost analysis, looking at capital maintenance, direct and indirect support costs. WASH service providers and stakeholders are required to have some sense of financial knowledge of which limited knowledge can affect implementation. The approaches to sustainable WASH financing establish good practices with current innovative mechanisms or techniques. Improving sustainable financing for WASH systems is crucial to increase the revenues mobilisation or decrease operation costs which are helping in creating user perception on satisfaction services (AGUASAN 2012).

2.2.4 *Wash Technology*

Choose of WASH technology is important to sustainable implementation for creating new business opportunities, to attract investments and to generate employment. The use of technology is not sufficient for improving WASH implementation. Technology is a central component to define sustainable WASH. A technology can be unsustainable if it is manufactured away, and the local users, obtain replaceable spear parts. In some cases, the simple technologies used for low service level are more vulnerable than the complex systems used for service provision. The latter typically have better and more sophisticated management systems, greater access to finance and technical supports, and often better construction quality. WASH technologies are considered appropriate for many communities when they are; cost-effective, affordability and easily maintenance, socially acceptable, users friendly, sustainable, accepted and supported within the national institutional environment and environmentally friendly seen in plate 4 (Baumann et al. 2010).

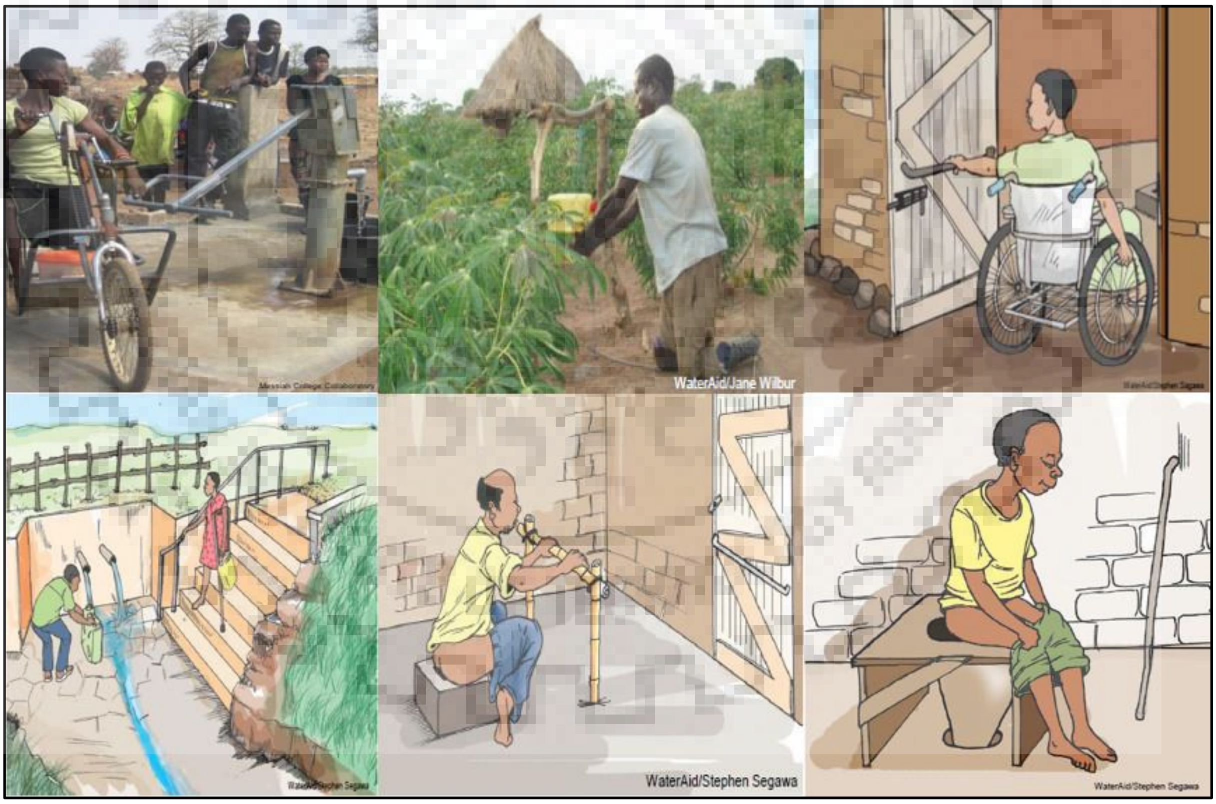


Plate 4: WASH technologies that are environmentally friendly (www.google.com)

WASH technologies are reliable when they deliver WASH services in an acceptable and maintained formed by the community for quality levels of service. During the course of implementation, the WASH sectors need to think about the cultural, behavioral, and social factors in choosing of technologies for communities that can be accepted and maintained. Any technology selected could be operated and maintained by Community making it economically viable and reliable. The provision of low cost technologies that offer social impacts, implementation, operation and maintenance, can promote WASH technology in a sustainably (Kimera, Okurut, and Bamutaze 2016).

2.3 WATER, SANITATION AND HEALTH

Providing WASH in communities, with associated sustained behavior patterns or changes, is crucial for improving the human health and environmental sanitation. These services remain functional for good public and environmental health, the WASH packages should be prioritized in the national budget. The evidence on public health consequences relating to poor quality water and unimproved sanitation is prevalent in Freetown. There are many diseases relating to poor quality water and sanitary infrastructures causing diarrhea disease spread which killing an estimated amount of nearly 1,000 or more under five children globally (Howard et al. 2016).

Managing the quality of water with the provision of good sanitation and health care services can reduce diarrheal in Freetown. Reliable and sustainable WASH services can prevent diseases outbreak in an area, owning to that fact that constant interruption in services even for a shorter duration can cause health alarm (Environmental Protection Agency 2016). WASH related diseases from contaminated sewage enter into water bodies by the discharge of untreated sewage or human excreta. The sewage is extremely contaminated with a high quantity of human or animal excreta causing serious health risks. Sewage sludge solids, biological and mineral components. Consequently, environmental pollutants in water effluents accumulate in to sediments and stay longer as suspended matter there by affecting its quality (Dickin et al. 2016).

Water bodies are invariably contaminated from contaminated sewage, stormwater, solid waste and other pollutants. The human excreta discharge to water bodies either through runoff water, sewage or solid waste extremely affect its quality. The excreta from human or animal waste can affect both the public and environmental health. The pollutants from runoff, sewage and other environmental generated wastes run into ocean, rivers and lakes, groundwater aquifer and irrigation canal. Human exposure to related diseases occurs through aquatic habitats, recreation, water supply, crop and agricultural chemicals. From contaminated waters, crops are irrigated and fertilisers are applied through which human get infected with water related diseases. Contaminated water bodies are used for recreational purposes which exposes human to water-borne diseases. Also, contaminated water from rivers, lakes and groundwater sources are the most regularly for users. Disease outbreaks from unsafe, untreated surface water; untreated groundwater sources; improper treatment procedures; leakages in the network; and many others, have adverse or negative consequences on the public health seen in figure 14.

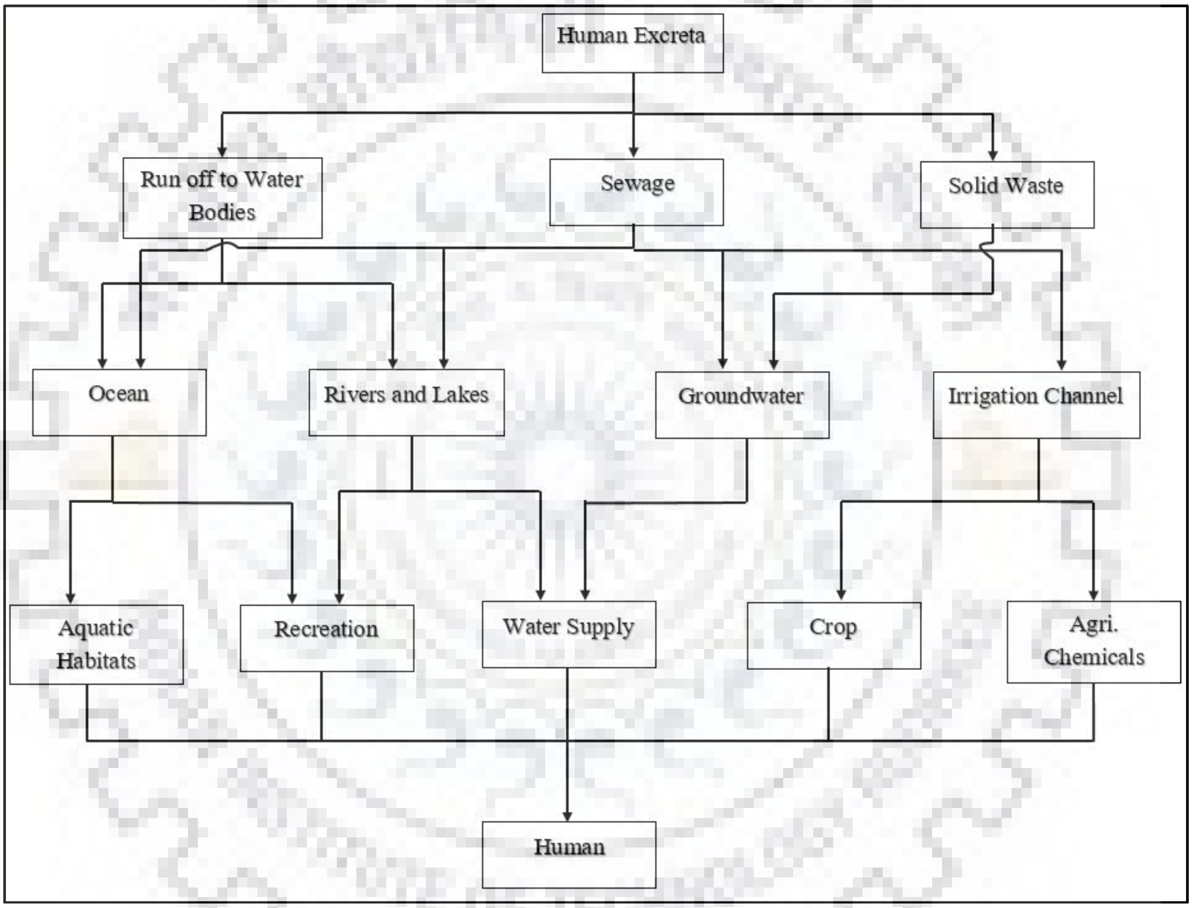


Figure 13: Mode of WASH related disease transmissions to human

Untreated wastewater may often contain high contaminants from municipal, agricultural, industrial, and domestic (community) sources. The availability of human excreta-related pathogens from different organisms and chemicals from improper agricultural practices cause risks to the public health particularly the farming communities and associate including users of contaminated products (Dickin et al. 2016). The use of wastewater for increased food production, improved nutrition and livelihoods and the likelihood of preventing disease spread from wastewater becomes a critical issue. Untreated wastewater carries micro-organisms like bacteria, viral and protozoan and its reuse in food production cause diseases like salmonellosis, shigellosis, cholera, giardiasis, amoebiasis, hepatitis A, viral enteritis and other diarrheal related diseases (Dickin et al. 2016). A disease that is associated with the exposure to wastewater can cause anaemia (ascariasis) and physical impairment affecting cognitive development (Mara 2017). Aquatic habitats feeding on this pollutant can transfer the diseases to human by eating them

Frequent exposure to untreated waste water by agricultural workers can cause dermatitis, rashes, arsenic, cadmium, lead poisoning and mercury. The continuous exposure trigger inhalation of irrigated soil and occupational ingestion with chronic health defects. Cadmium accumulation, particularly in the kidneys can cause the kidney to fail and osteoporosis, leading to death (Mara 2017).

2.4 ENVIRONMENTAL HEALTH

The environmental factor is classed as traditional and modern hazards (figure 15 below) which are haven risks to human health in general. Traditional hazards are related to poverty and under developed societies and vulnerable groups. The poor who suffer getting access to WASH services is normally affected by indoor air pollution, malaria and poor waste disposal of more risks to human health and the environment. Modern hazards are related to urban air pollution, problems arising from agro industrial chemicals, solid waste and waste water. Environmental health factors are challenging to the public health and environmental sanitation when poorly managed. These factors are connected with poor quality water, unimproved sanitation, water pollution, effluent discharge from industrial and agriculture to water bodies, food contamination through pathogens, indoor air pollution from coal and biomass fuel, air pollution from motor vehicles, thermal power and industry, poor waste disposal and pesticides and chemical runoff (Trtanj et al. 2016).

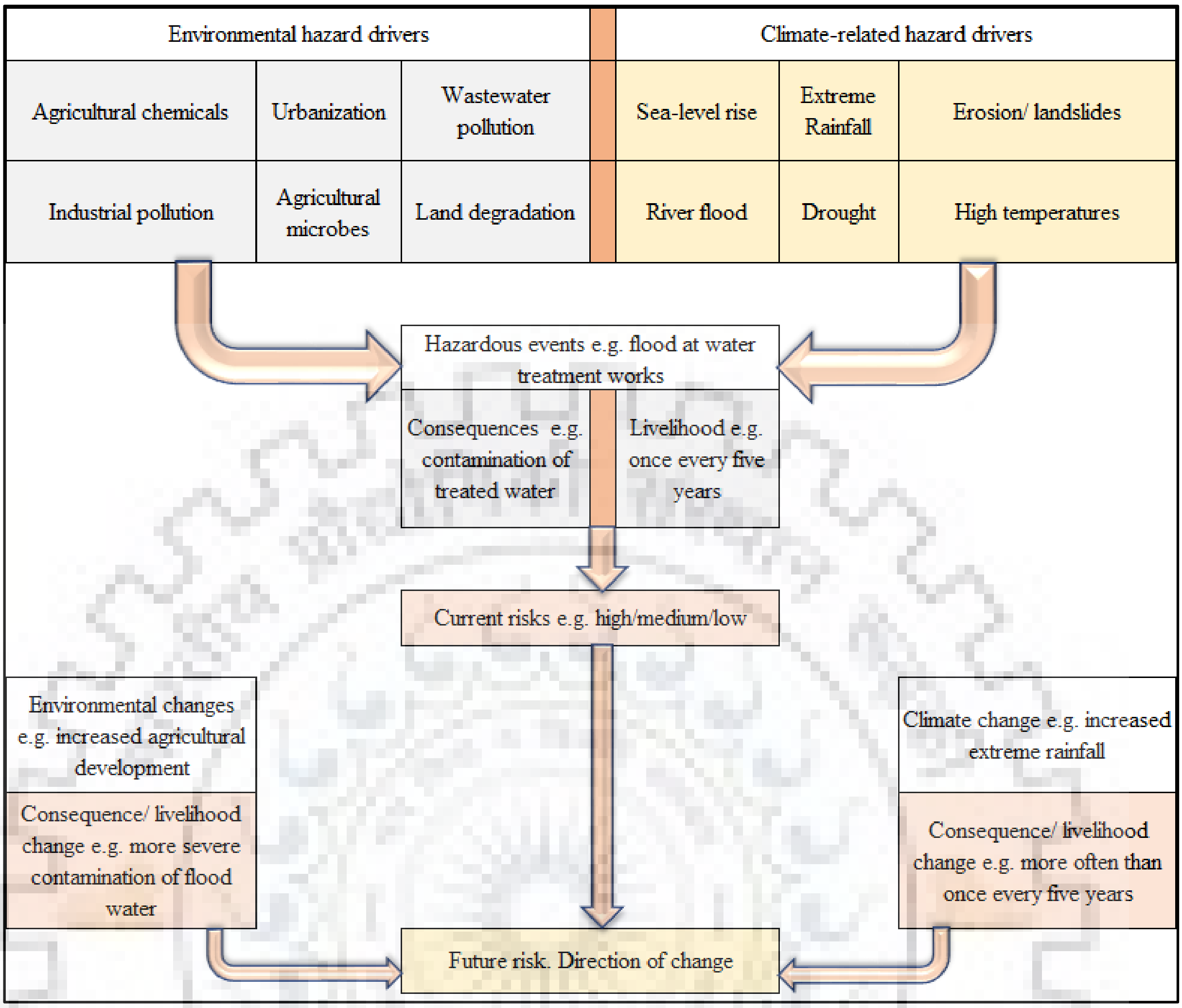


Figure 14: Environmental and Climate related hazards (WHO 2016 (109))

Environmental health issues are crucial to sanitary conditions in any societal setting and poor management can hinder the health of the environment and its members. In protecting sanitation is a concern for urban decision-makers and planners so that waste components can be recycled and reused thereby creating market and job for many. Good idea of keeping cities and other communities clean and free from health challenges. Agricultural practices impact the environmental sustainability of food production become the focus. The agricultural activities have greater impacts on health, animals, food security and the environment (Mie et al. 2017).

2.5 CLIMATIC IMPACTS ON WATER AND SANITATION

Variability in climate has got international focus in the recent century. Processes of climate changes have been confirmed changes that are unavoidable, meaning has to leave with them. Climatic variability impacts like droughts, floods, and less predictability of rainfall and stream or surface water flows or runoff become visible. There are visible changes in water surface levels, affecting quality WASH services. In the events of heavy rainfall, much attention is not given to water storage which can likely smoothen climate variability for rainfall and river flows. Changing climate has already resulted in changes in water flows and water availability in the world. With climate variability, much focus on investment in water storage techniques is taken the centre stage for community WASH management. Insufficient water storage capacity from rain water can hamper economic development, water security and creating vulnerability to the impacts of climatic variation (Rahman and Rahman 2015, Howard et al. 2016).

Climate variability has little effect on groundwater source and can serve as an alternative option in cases of unpredictable rainfall. Though groundwater source has of recent increasing demand leading to salt intrusion more especially around the coaster zone of Freetown. In coastal Freetown, groundwater source is affected by saline intrusion as sea levels rise, the situation becomes even worse. Sanity in ground water source around coaster Freetown is not only due to over abstraction but as well pollution from agrochemicals. In mountain areas of Freetown, shallow wells in fractured rock or small aquifers coupled with spring source are the only reliable water source. When there are changes in rainfall patterns or length seasons, place more pressure on the water sources affecting WASH services in communities (Charles et al. 2010).

Climatic variability has limited on sanitation components and is extremely small as compared with water sources. The simple on-site sanitation infrastructure may be positive, as groundwater pollution risks can reduce base on the distance between the bottom of the pits and groundwater rise. On the contrary, when there are a decline water and rise in flood allows sewerage and septic systems to interface with water sources. In cases where the rainfall intensity becomes high, sanitation components become seriously affected by climate variability. On-site sanitation primarily relates to flood with serious consequences by spreading disease in society. The on-site sanitation is vulnerable to flood, causing excreta to spread in the environment and water pollution. Climate change creates WASH scarcity, from variations in precipitation, the rise in temperature, the rise in demand, and reduced water quality through pollution. In an event of serious climate change impacts, rising population, economic expansion, and urbanization subject WASH to great pressures (Howard et al. 2016).

When WASH components are not properly designed to be resilience in cases of climatic variability then the services can be disrupted. Extreme flooding or droughts can adversely impact the WASH components causing severe risks to the health and environment. Both biological pollutants that are from micro-organisms and chemical pollutants from nitrates, phosphates, organic matters, and oil enter water bodies through flood events. Climate variability is likely to be severe in the world when human activities continue to temper with the environment. The Vision 2030 indicates changes anticipation in the climate for long term affecting the drinking-water and sanitation. Climate variability requires WASH systems optimization to ensure quality service delivery. A resilience technology that can resist the variation in climate around the world. What should be done differently to ensure WASH services meet the required needs as the climate keep changing (Oates et al. 2014).

2.6 ISSUES AND CHALLENGES OF WASH INTERVENTIONS

The global WASH crisis is from poverty, politics and inequality but not in the physical availability of components. This can be because of poor resources management, corruption, poor institutional frameworks, bureaucratic procedures within institutional setups, inadequate capacity of officials and limited investments and lack creativity in the WASH sector. WASH institution anywhere without adequate investment in WASH cannot be sustained (Johnston, Teague, and Graham 2015).

Many communities are yet to have access to adequate WASH infrastructures. About 1.7 million death is reported for under-five children yearly due to poor WASH services (Butt 2014). WASH services have several challenges which are; private sector partnership, inadequate data, unrealistic WASH plans, weak policy, weak implementation strategies, poor instructional framework and performance, inadequate capacity and limited financial including equipment and capacity development.

Access to WASH services is a global challenge affecting nearly 800 million people. About one third of the population living in Africa, have piped water in the homes. Millions rely on poor quality water sources, facing great economic and health consequences. 2.4 million, reported a death, annually the developing countries mainly from diarrhea disease from which 1.8 million are children between the ages of 1 – 5 years. WASH services for urban settlement is hampered by multiple factors like insecure and uncertain land tenure systems, limited infrastructures, and population rise subjecting them to poverty (Adams and Zulu 2015).

Cholera, caused by bacteria is a diarrheal disease, transmitted through poor quality water. In cases of earthquakes or natural disasters, WASH components are normally contaminated with bacteria causing cholera. The WHO, estimates of about 3 - 5 million deaths are reported yearly because of cholera disease with 100,000–120,000 official deaths (Taylor et al. 2015). Adequate WASH caters for good health and environment, quality education, dignity and equality. Poor and vulnerable communities have low WASH coverage. When the WASH services are improved, the population will benefit poverty reduction, and socioeconomic growth (Hutton and Chase 2016).

2.7 CONCLUSIONS

Sustainable services are hindered due to limited funding, weak policies, poor institutional framework, and low technical capacity of WASH professionals, limited awareness, and limited support and follow up actions, lack the necessary management skills, and low political will. These are seriously affecting WASH services. Poor WASH conditions are related to life expectancy, health risks, low educational standard and low economic growth and productivity. Adequate WASH services can reduce cases of the diarrheal disease, raise the life expectancy rate, improve education and enhance the economy and productivity. Well-structured policies, good institutions, better management style, more investment and better allocation and quality construction services can enhance sustainable WASH services. Improved WASH services in Africa and Asia, minimised poverty thereby promoting a healthier life.

CHAPTER – 3

METHODOLOGY

3.1 GENERAL

The Methodology adopted for analysis involves Sustainability Index Tool (SIT), multivariate analysis (Cronbach Coefficient Alpha and Principal Components Analysis – PCA and WASH performance criteria) and the HDI dimensions. The entire process consists of sustainability index tool development, data and weights generation using SPSS tool, determine the HDI and validation.

3.2 SUSTAINABILITY INDEX TOOL

SIT, measure the progress achieved in WASH services through a set of indicator questions to determine the index on sustainable services. The indicator questions where developed, considering institutions, management styles, financing, and technical. The tool was developed globally, necessary to customize indicators and the associated questions specific to the WASH interventions.

There are series of indicator questions developed to determine the progress at the institutions, management, financial and technical aspect. The indicator questions targeted stakeholders, institutional levels, relevant legislator bodies, decision-makers, service providers (e.g. WASH committee, school or utility) and community members. At the household levels, information was collected through household surveys on communities WASH interventions. Indicator questions for each intervention in 2017 and linking economic, social and environmental aspect to institutional, management, financial and technical indicators seen in figure 16 & 17. These questionnaires are available in Annex 1. The names and contacts of experts and response seen in Annex 2. The questionnaire was developed on “google form platform” and distributed electronically, responses were generated through the same electronics means. The answers from the indicator questions measure indicator scores and aggregated to show sustainability scores by a factor.

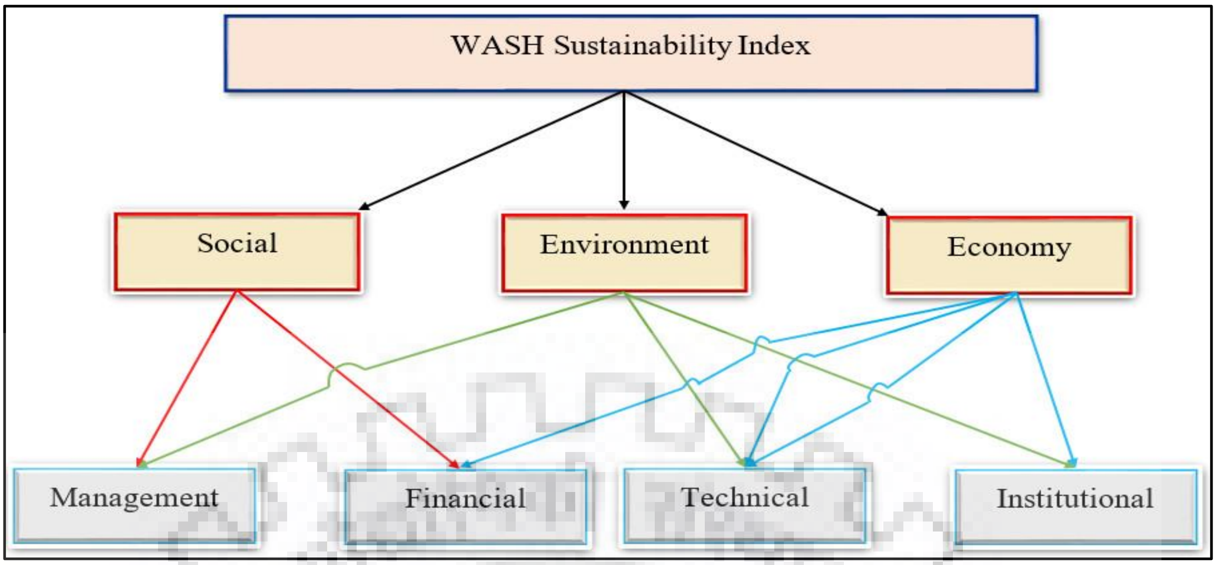


Figure 15: SDGs dimensions on WASH

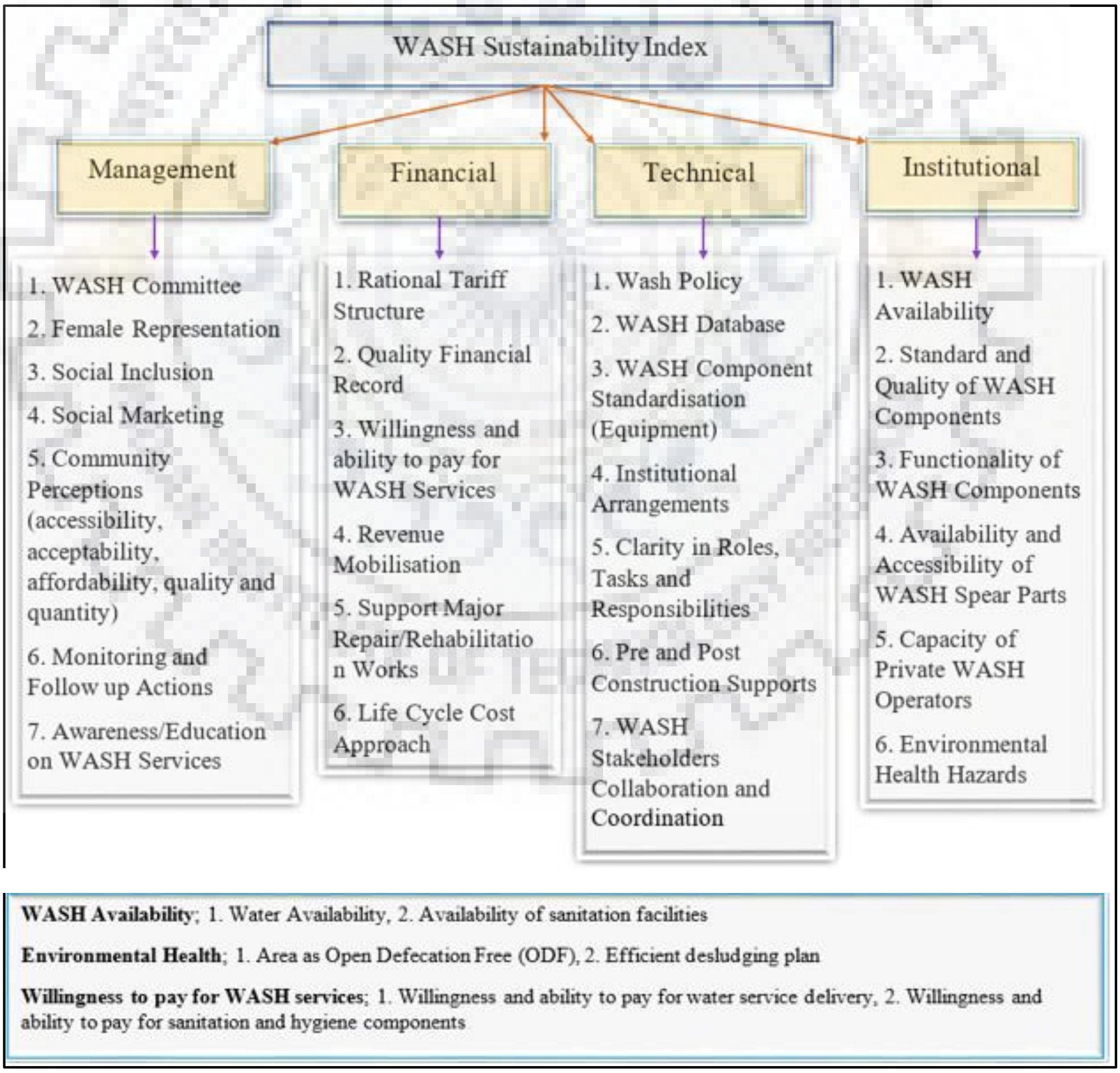


Figure 16: Indicator questions

3.2.1 Service Provider Level

This level looks at the individual or named organization responsible for managing and operating specific service either at individual household (latrines or water treatment), community entity, private operator or services in institutions. Investigation at this level assesses the physical infrastructure like functioning borehole or latrine.

3.2.2 Community Level

Considered conditions, capacities, and roles, spare parts, and other needed goods and services. Community leaders or organisations normally play the central role and assesses the performance of non-governmental organizations, local private sector, or public bodies or education.

3.2.3 National Level

Considered the policies connected to WASH, institutions, and functions. Critical issues that impact the sustainable service nationwide like monitoring, financing flows (including subsidies), technical standards, and good coordination and collaboration. Here, the assessment looks at the ministries responsible for WASH services and finance including legislations.

3.3 MULTIVARIATE ANALYSIS

Multivariate analysis analyses numbers of composite indicators. The selected arbitrarily give a little indication of the interrelationships among indicators. This can generate indices that are confusing and misleading for decision-makers and the general populace. The indicator questions need careful analyses before getting the composite indicator. Data set are accessed by considering their suitability, methodology in generating weight and aggregating composite indicator. The decision from the indicators based on expert opinion for analysis. The data generated can be checked whether the dimensions of the phenomenon are statistically well-balanced in with the principal component analysis. Cronbach Coefficient Alpha measure the internal consistency considering items. The multivariate analysis techniques provide an insight into a data set and the composite indicator (Guide 2008). For the purposes of this study, the PCA and Cronbach Alpha are considered for data analyses.

3.3.1 Cronbach Coefficient Alpha

Cronbach Coefficient Alpha (Cronbach, 1951), commonly used to determine the internal consistency of survey items (reliability test). The manner, data set of individual indicators measure a single unidimensional object. Cronbach's Alpha is defined as in equation 1:

$$\alpha_c = \left(\frac{Q}{Q-1}\right)\frac{\sum_{i \neq j} \operatorname{cov}(x_i, x_j)}{\operatorname{var}(x_o)} = \left(\frac{Q}{Q-1}\right)\left(1 - \frac{\sum_j \operatorname{var}(x_j)}{\operatorname{var}(x_o)}\right) \quad c = 1 \ldots. M : i, j = 1 \ldots. Q \quad \textbf{(1)}$$

where

M number of items considered,

Q number of individual indicators available,

$$xo = \sum_{Q=1}^{Q} (xj) \qquad \text{the sum of all individual indicators}$$

C-alpha measures the total variability of individual indicators base on the correlation coefficient of indicators. The individual indicators can increase with covariance in each pair. When it is realised that there no correlation exists, individual indicators become independent and C-alpha becomes zero. When item indicators become perfectly correlated, C-alpha becomes one. C-alpha is considered as a non-statistical test, but otherwise a coefficient of reliability. Correlation is high, showing the items are measuring the same the correct survey intent. Similarly, a high reliability, indicates items are correctly measuring the survey intent. According to Nunnally (1978), a suggested value of 0.7 is accepted as the reliability threshold.

The acceptable range fall between 0.75 or 0.80 as a cut-off value but others consider 0.6 as the cut-off value. In a case, the variances of items vary widely and can be standardised to a standard deviation of 1 before calculating the coefficient alpha (c-alpha). C-alpha varies when the deletion of each individual indicator is done at a time which can show the existence of clusters of individual indicators. With the increase in the reliability coefficient after deleting an individual indicator, it is extended that items are not correlated highly with other individual indicators (Guide 2008). Alternatively, reliability test for items is done using the software known as SPSS package by IBM, to measure the internal consistency of items. The steps in achieving reliability test with SPSS are given below.

Step 1. Lunch the application programme and import the required data into the SPSS software. On the task bar, go to "analyse" tool and click, "Scale" seen in figure 18.

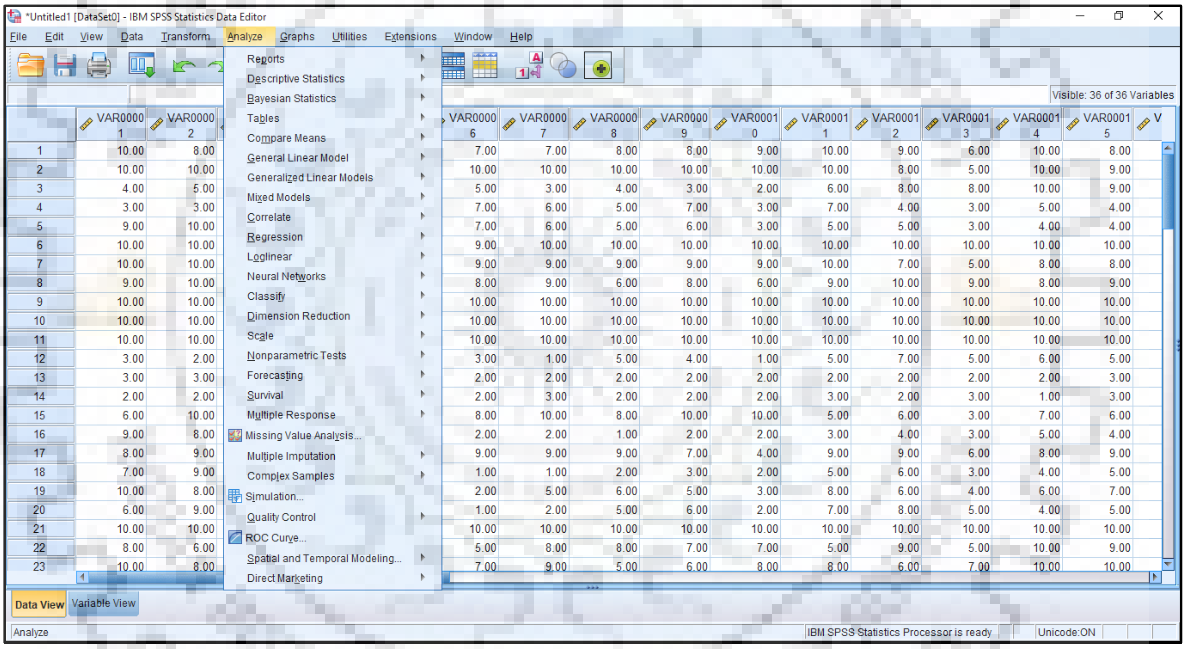


Figure 17: Click "analyse" and "scale"

Step 2. Among the programme, click on "scale" and then "reliability" seen in figure 19.

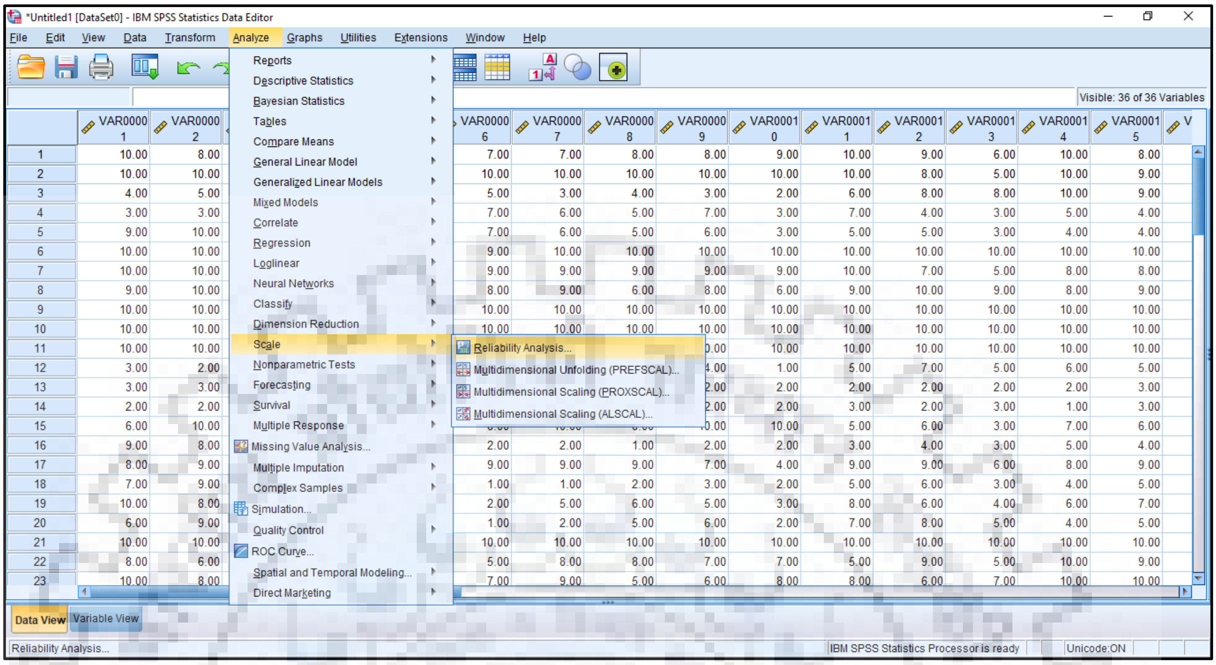


Figure 18: Click "scale" and "reliability analysis"

Step 3. Move your data to the items box, click statistics to tick your output result. Click on the model and select "Alpha" and click "ok" seen in figure 20.

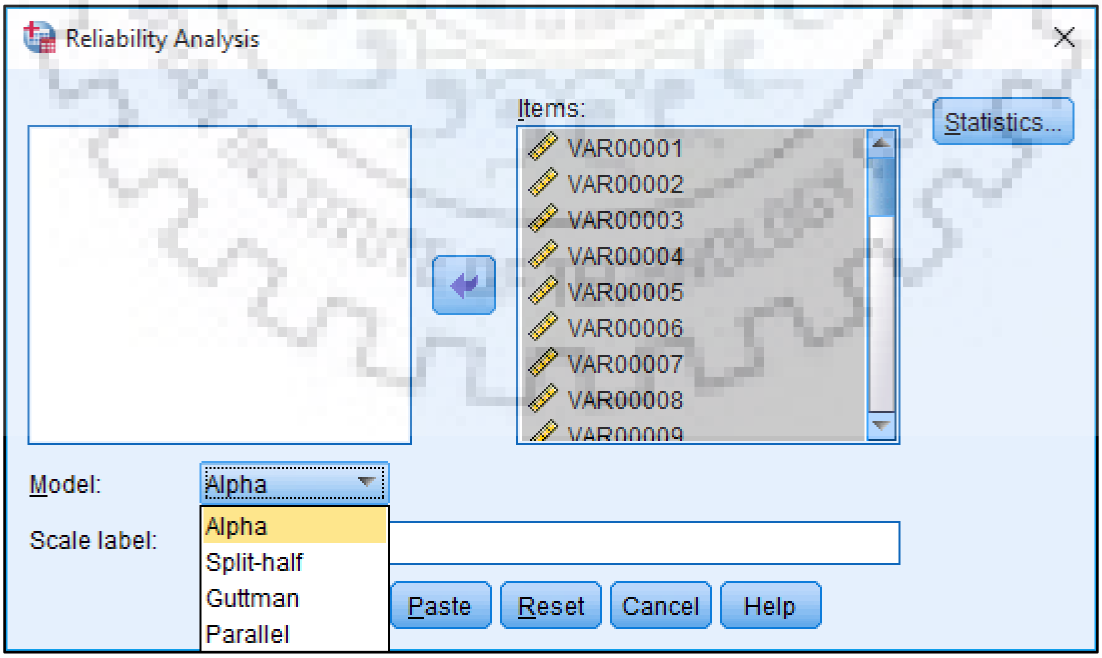


Figure 19: Transfer items and click on "alpha" and "ok"

Step 4. Click on the “ok” and the result can be generated with Cronbach Alpha and the entire result generated seen in figure 21.

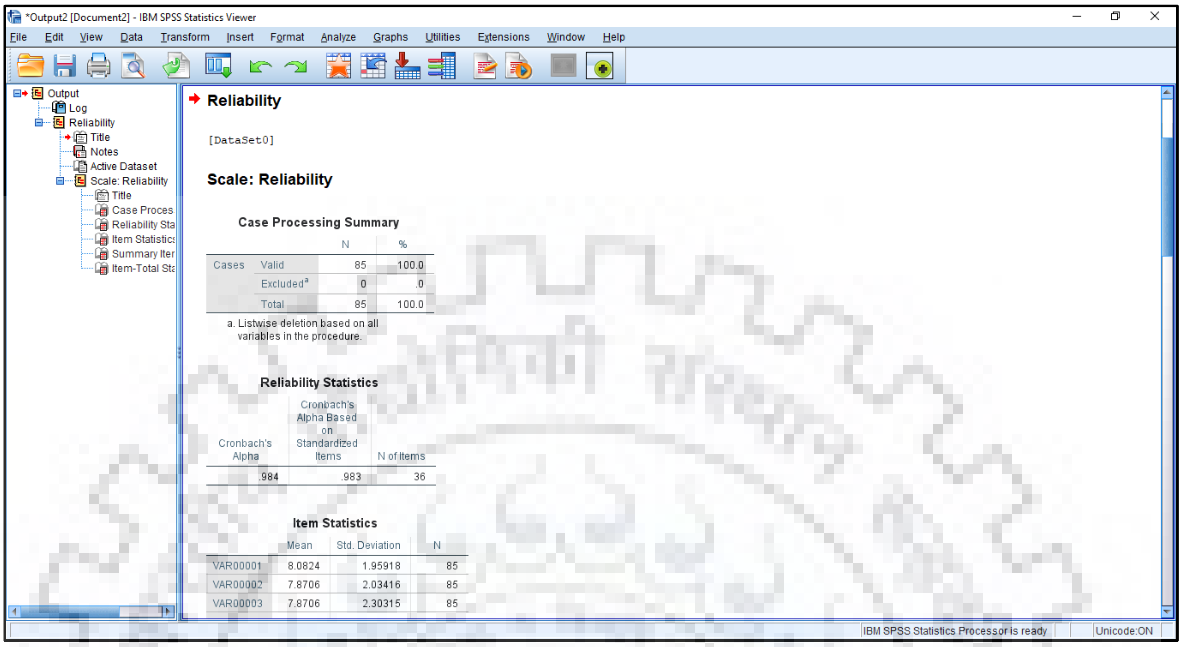


Figure 20: Click “ok” to generate the reliability test result

3.3.2 Principal Components Analysis

PCA identify the different variables change with their association. With PCA, the correlated variables are transformed uncorrelated variables through the correlation matrix. In PCA, the variance observed data can linearly combine with the original data. Consider Q variables, Q x, x... x in which data’s variation accounted for small variables (principal components, or linear relations) that is Q Z, Z... Z, that are uncorrelated. Select the case where P<Q for principal components with a “high” amount of cumulative variance of the original data.

$$Z_1 = a_{11}x_1 + a_{12}x_2 + \ldots + a_{1Q}x_Q$$

$$Z_2 = a_{21}x_1 + a_{22}x_2 + \ldots + a_{2Q}x_Q \qquad (2)$$

$$Z_1 = a_{Q1}x_1 + a_{Q2}x_2 + \ldots + a_{QQ}x_Q$$

When there exists no correlation, the PCA becomes the common property showing that the PCA is measuring different “statistical dimensions” of items. PCA technique cannot always reduce the size of variables to a small transformed variable. Again, when original variables are uncorrelated, then the analysis is of no value. When the original variables are highly correlated positively or negatively, a significant reduction can be obtained. Take the weights a_{ij} (as factor loadings) and applied to the variables x_j, equation (3) to give the principal components Z_i. This condition is only satisfied when; (1) they are uncorrelated; (2) the maximum proportion of the variance accounts is set at x s, the second maximum remaining variance until the last remaining variance not accounted for by the preceding components equation 3.

$$a^2_{i1} + a^2_{i2} + \ldots + a^2_{iQ} = 1,\ i = 1, 2\ldots Q \qquad (3)$$

Where a_{ij} are the factor loadings, for x_1, $x_2 \ldots x_Q$ variables (indicators), and Q the number of variables. Eigenvalues λ_j, j=1… Q got from PCA from item covariance matrix CM.

$$CM = \begin{bmatrix} cm_{11}\ cm_{12}\ \ldots cm_{1Q} \\ cm_{21}\ cm_{22}\ \ldots cm_{2Q} \\ \ldots \\ cm_{Q1}\ cm_{Q2}\ \ldots cm_{QQ} \end{bmatrix}$$

Where the diagonal element cm_{ii} is the variance of x_i and cm_{ij} and covariance of variables x_i and x_j. The matrix shows an eigenvalues CM and is the characteristic equation of $|CM - \lambda I| = 0$, where I, the identity matrix of the order as CM and λ eigenvalues vector. The condition is possible only if Q is small. Eigenvalues are negligible and negative eigenvalues are a hardly possible matrix. It is advisable to standardise the variable – x s – to have zero so that no one variable can have an undue influence on the PCA. In that case, co-variance matrix CM can take the form of the correlation matrix. The individual indicators in a collinear form become the composite indicator capturing more information common to the individual indicators. It can be established that the sum of the variances of the principal components equal to the sum of the variances of the original variables seen in equation 5.

$$\lambda_1 + \lambda_2 \ldots + \lambda_Q = Cm_{11} + Cm_{22} + \ldots.. + Cm_{QQ} \qquad (5)$$

When no correlation existing in the variables then PCA technique cannot be used. In finding weight from the PCA associated with the eigenvalues most be larger than one, can contribute individually to the overall variance by more than 10% and contribute cumulatively to the overall variance by nothing less than 60%. The varimax rotation cab is to minimise the number of individual indicators with high factor loading. Rotation changes the factor loadings including the interpretation of the factors. This can leave the analytical unchanged. The PCA can generate the weight of variables by using the software called SPSS as illustrated in the following steps.

Step 1. Lunching the software and import the selected data to be analysed on the work space of the SPSS software. Arrange items with indications by title head under variable view. On the task bar, look for the analyse tool and click. List of the programme can come from a drop down menu. Look for "Dimension Reduction" and click. The window where you can fine "Factor" opens. Click on the "factor" tool seen in figure 22.

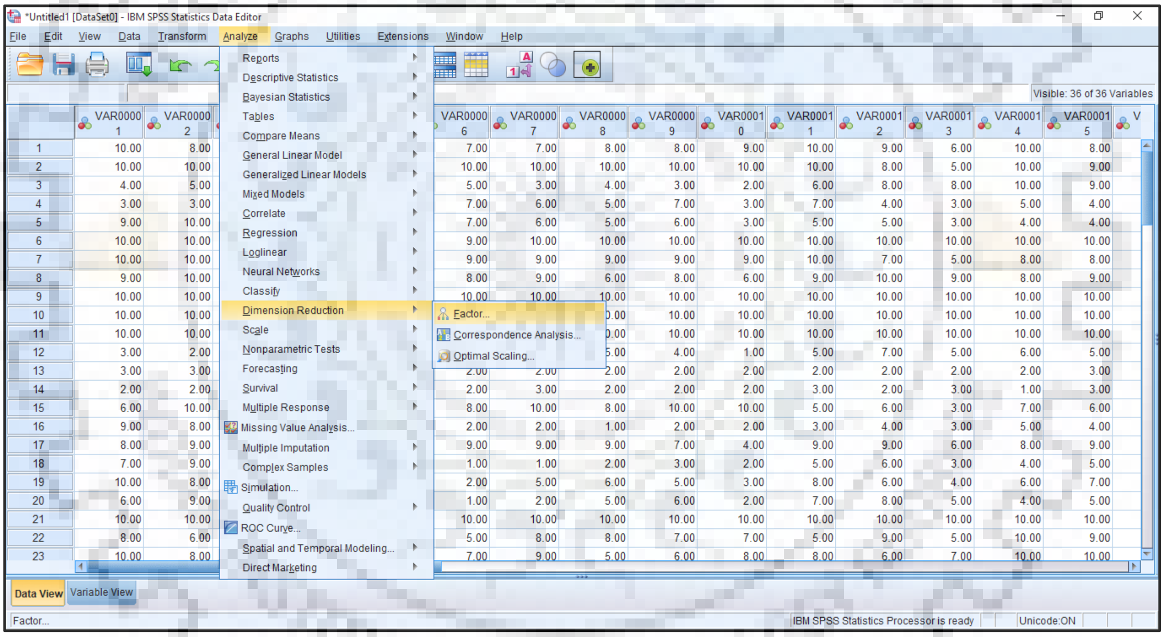
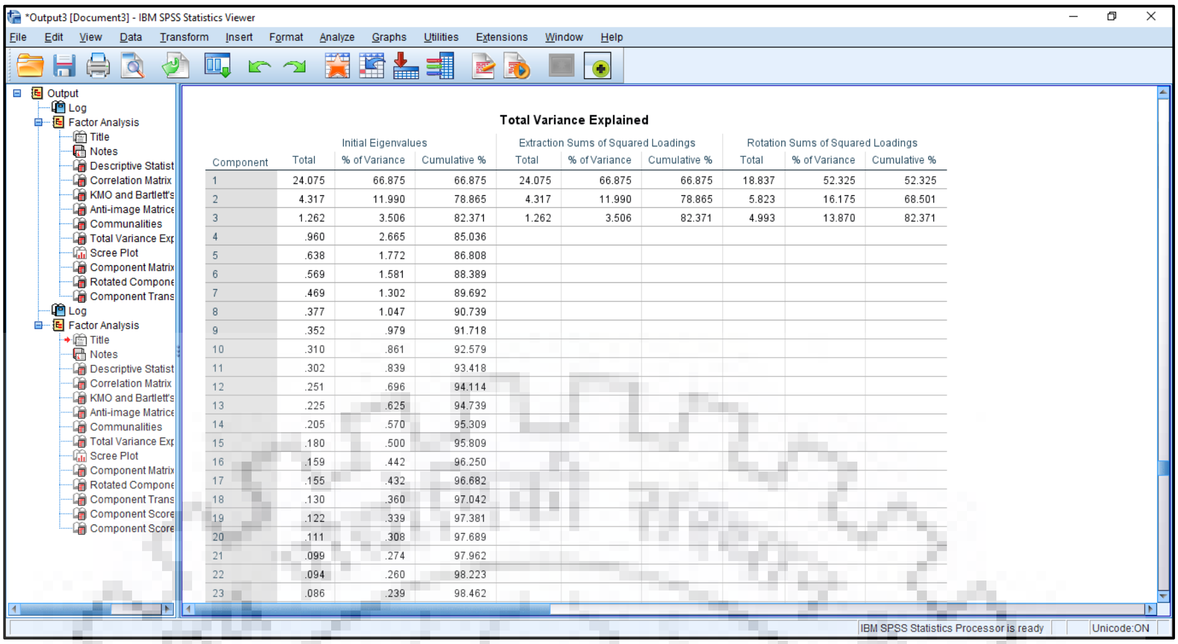


Figure 21: Click on "dimension reduction" tool and "factor" tool

Step 2. Click on the "Factor" tool and a small dialogue box prop name "Factor Analysis". Move all data under the variables column and setup the description, extraction, rotation, scores and options icons. After doing all settings as per your requirement, then click the "ok" to generate eigenvalues, rotated values as seen in figure 23 & 24.

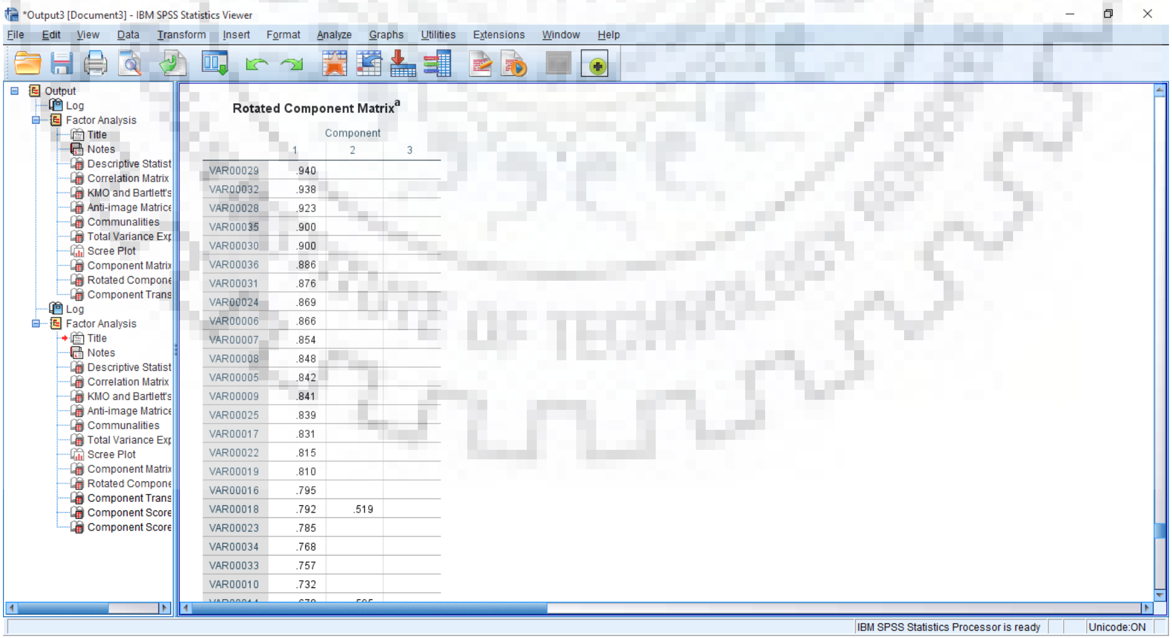


Total Variance Explained

Component	Initial Eigenvalues Total	% of Variance	Cumulative %	Extraction Sums of Squared Loadings Total	% of Variance	Cumulative %	Rotation Sums of Squared Loadings Total	% of Variance	Cumulative %
1	24.075	66.875	66.875	24.075	66.875	66.875	18.837	52.325	52.325
2	4.317	11.990	78.865	4.317	11.990	78.865	5.823	16.175	68.501
3	1.262	3.506	82.371	1.262	3.506	82.371	4.993	13.870	82.371
4	.960	2.665	85.036						
5	.638	1.772	86.808						
6	.569	1.581	88.389						
7	.469	1.302	89.692						
8	.377	1.047	90.739						
9	.352	.979	91.718						
10	.310	.861	92.579						
11	.302	.839	93.418						
12	.251	.696	94.114						
13	.225	.625	94.739						
14	.205	.570	95.309						
15	.180	.500	95.809						
16	.159	.442	96.250						
17	.155	.432	96.682						
18	.130	.360	97.042						
19	.122	.339	97.381						
20	.111	.308	97.689						
21	.099	.274	97.962						
22	.094	.260	98.223						
23	.086	.239	98.462						

Figure 22: Click on “ok” to generate results

The three intermediate composites of the rotated variance percent give assign weight to each one of them equal to the proportion of the explained variance in the data set: (0.552 = 14.861/(14.861+6.569+5.497)), 0.244 for the second, 0.204 for the third and the sum will be equal to 1.



Rotated Component Matrix[a]

	Component 1	2	3
VAR00029	.940		
VAR00032	.938		
VAR00028	.923		
VAR00035	.900		
VAR00030	.900		
VAR00036	.886		
VAR00031	.876		
VAR00024	.869		
VAR00006	.866		
VAR00007	.854		
VAR00008	.848		
VAR00005	.842		
VAR00009	.841		
VAR00025	.839		
VAR00017	.831		
VAR00022	.815		
VAR00019	.810		
VAR00016	.795		
VAR00018	.792	.519	
VAR00023	.785		
VAR00034	.768		
VAR00033	.757		
VAR00010	.732		

Figure 23: Rotated components matrix

3.4 WASH PERFORMANCE CRITERIA

WASH developing and managing required making meaningful decisions. When the WASH sector has the ability to make well-meaning, scientific, social or political criteria ensuring success in WASH interventions. A set of tools which are quantitative are used to measure the performance criteria for reliability, resilience and vulnerability are considered for this study though qualitative judgement. In this regard, the reliability, resilience, and vulnerability of WASH conditions in Freetown can be estimated with equations below:

$$\text{Reliability} = \frac{\text{Number of Satisfactory values}}{\text{Total number of values}} \tag{6}$$

$$\text{Resilience} = \frac{\text{Number of times a satisfractory value follows an unsatisfactory value}}{\text{Number of unsatisfactory value}} \tag{7}$$

$$\text{Vulnerability} = \text{Expected extent given unsatisfactory} * \text{Expected duration is given unsatisfactory values} \tag{8}$$

$$\text{Expected extent given unsatisfactory values} = \frac{\text{Cumulative extent of failure}}{\text{Number of individual failure events}} \tag{9}$$

$$\text{Expected duration given unsatisfactory values} = \frac{\text{Total number of failure periods}}{\text{Number of continuous series of failure events}} \tag{10}$$

The concept of reliability describes the probability or frequency of meeting the water demand at desired time and place with required pressure. In other words, the system reliability is considered, as the ratio of satisfactory periods to the total number of simulation periods considering system resilience as significant operational benefits to improve WASH under uncertain climatic impacts and population expansion (Zhang et al. 2017). The emerging realisation to build resilience is a significant element that enhances WASH sustainability in the world. Resilience considers the ability of any system to continue service despite experiencing disturbances from variability in climate and population expansion, etc. It shows how quickly a system recovers after disturbances or failures. System resilience goes with performance under disturbances of climatic impacts and population expansion. A system can be unstable because the pressure rise due to population densities but can persist severe shocks (Hashimoto, Stedinger, and Loucks 1982). The concept of resilience may be used to measure the duration (time) and severity (vulnerability) of failure event either natural or artificial (Cubillo and Martínez-Codina 2017). The severity of WASH systems, making the systems unsustainable and non-reliable account for the system vulnerability. The WASH systems with its ability to resist inherent variable stresses indicate lesser vulnerability (Foti et al. 2010). The vulnerability is the magnitude of a failure when it occurs. When the probability of failure is small, the resulting consequences are considered (Hashimoto, Stedinger, and Loucks 1982).

3.5 HUMAN DEVELOPMENT INDEX DIMENSIONS

The HDI considering three dimensions: the long and healthy life measured by life expectancy index, knowledge measured adult literacy rate and combined primary, secondary and tertiary enrolment ratio and a decent standard of living measured the GDP per capita. HDI in 2012 for Serra Leone was low and out of 187 countries, it came 177. Human development empowers the population and prioritises the improvement in basic human capacity. HDI goes beyond economic growth, increase in income, productivity and capital accumulation but socio-economic growth and poverty gap. Countries that are haven high income levels do not succeed to reduce social problems like alcohol, homelessness, drug abuse, HIV and domestic violence. Countries can achieve high levels HDI because they wisely use all the resources to develop basic human capabilities (Ruslan 2017). HDI dimensions are seen in figure 25.

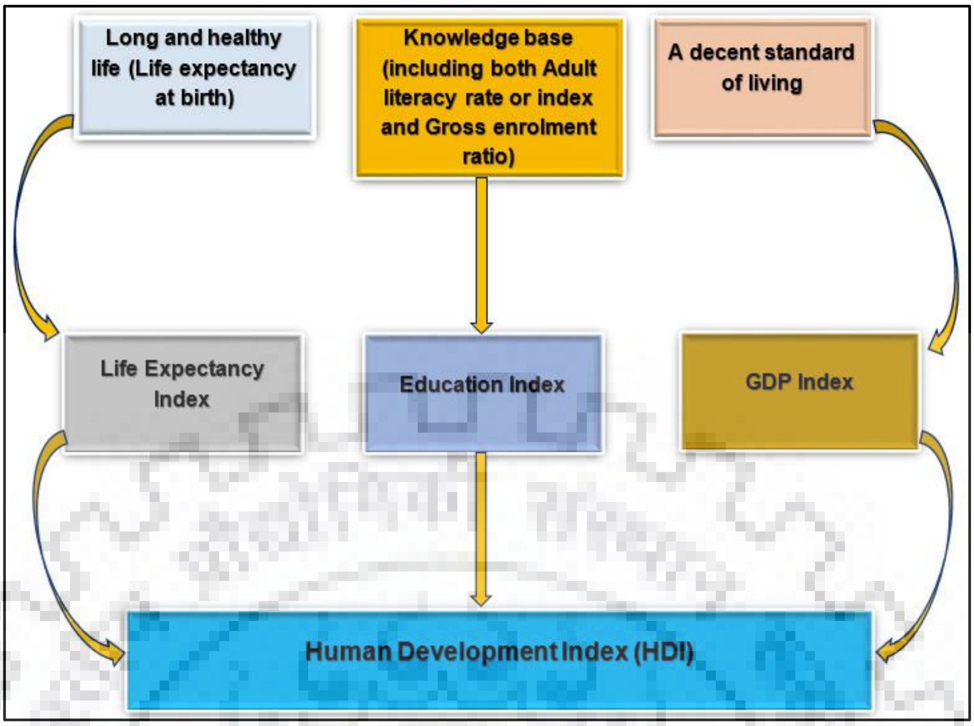


Figure 24: HDI dimensions

HDI considers the geometric mean of normalized indices for the dimensions seen in figure 25 above.

$$HDI = \sqrt[3]{I_{health} \times I_{education} \times I_{income}} \quad (11)$$

3.6 CONCLUSIONS

Employing different methods to measure the sustainability index of the WASH with indicator questions. The indicator questions response were tested for the internal consistency using the SPSS. The SPSS test the reliability of data collected by a method known as Cronbach's Alpha method. The weight attributed to the indicators was measured with the help of mean weight and weight based on PCA. Generated weights, used in calculating the sustainability of WASH in Freetown. WASH performance criteria could be calculated empirical formulas to measure reliability, resilience and vulnerability. The HDI calculation used mathematical formulas to measure the HDI dimensions like life expectancy index, education index and income index.

CHAPTER – 4

RESULTS AND DISCUSSIONS

4.1 GENERAL

The methods as highlighted previously, generate the required results. Results got from SPSS technique give the reliability of data collected. The weight given to indicators are generated through the mothed of PCA and mean weight. The human development, reliability resilience and vulnerability results were calculated with mathematical principles.

4.2 RESULTS AND DISCUSSIONS

Achieving sustainability WASH services, continuing to be crucial for communities and service providers. The government has invested so much money on WASH services for years but yet millions have limited access and coverage (Schreier and Cohen 2013). The interventions provided to communities are not properly managed because of limited and unreliable financing and the infrastructures are not adequately maintained causing them to breakdown within the short time. In this regard, the study undertook to gather data on completed WASH projects in Freetown. Indicator questions were developed using "google form" platform (Annex 1) and information was gathered from WASH experts. Internal consistency test carryout on the data to see how reliable information collected are using Cronbach Coefficient Alpha method through SPSS. The ranges for comparing the reliability test result is given in table 1.

Table 1: Range of Cronbach Alpha internal consistency check

Cronbach's alpha	Internal Consistency
$a \geq 0.9$	Excellent
$0.7 \leq a < 0.9$	Good
$0.6 \leq a < 0.7$	Acceptable
$0.5 \leq a < 0.6$	Poor
$a < 0.5$	Unacceptable

The case processing summary for reliability test is given in table 2 below.

Table 2: Reliability processing summary

Case Processing Summary			
		N	**%**
Cases	Valid	85	100.0
	Excluded	0	0.0
	Total	85	100.0

a. List-wise deletion based on all variables in the procedure.

The Reliability Statistics of the indicator questions seen in table 3.

Table 3: Reliability Statistics

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.984	0.983	36

The Reliability scale for the main indicators (Institutional, Management, Financial and Technical) as in table 4.

Table 4: Reliability Scale for Main Indicators

	Indicator	No. of items	Cronbach's Alpha	Cronbach's Alpha if Item Deleted
Sustainability Index	I	4	0.985	0.985
	M			0.985
	F			0.985
	T			0.985

The Reliability scale for Sub-Indicator (Institutional) given in table 5.

Table 5: Reliability Scale for Sub-Indicator (Institutional)

Indicator	Attribute/Sub-Indicator	No. of items	Cronbach's Alpha	Cronbach's Alpha if Item Deleted
Institutional	SI1	7	0.984	0.983
	SI2			0.984
	SI3			0.983
	SI4			0.983
	SI5			0.984
	SI6			0.984
	SI7			0.984

The Reliability scale for Sub-Indicator (Management), as in table 6 below.

Table 6: Reliability for Sub-Indicator (Management)

Indicator	Attribute/Sub-Indicator	No. of items	Cronbach's Alpha	Cronbach's Alpha if Item Deleted
Management	SM1	6	0.984	0.984
	SM2			0.984
	SM3			0.984
	SM4			0.984
	SM5			0.983
	SM6			0.983

The Reliability scale for Sub-Indicator (Financial) as in table 7.

Table 7: Reliability of Sub-Indicator (Financial)

Indicator	Attribute/Sub-Indicator	No. of items	Cronbach's Alpha	Cronbach's Alpha if Item Deleted
Financial	SF1	8	0.983	0.983
	SF2			0.983
	SF3			0.984
	SF4			0.984
	SF5			0.983
	SF6			0.983
	SF7			0.983
	SF8			0.983

Table 8: Reliability Scale for Sub-Indicator (Technical)

Indicator	Attribute/Sub-Indicator	No. of items	Cronbach's Alpha	Cronbach's Alpha if Item Deleted
Technical	ST1	11	0.984	0.984
	ST2			0.984
	ST3			0.983
	ST4			0.983
	ST5			0.983
	ST6			0.983
	ST7			0.983
	ST8			0.984
	ST9			0.984
	ST10			0.983
	ST11			0.983

When the value for c-alpha is high it means the items in the test survey instrument are highly correlated. The α is high (0.983) for the items in the survey instrument indicating a higher correlation. The α value is sensitive to the number of test items in a survey instrument. When the survey items are large, can result in a larger α, and a smaller number of survey items mean smaller α value. Where the alpha value is low, means the questions are not enough on the test. Putting more relevant survey items or indicator questions to the test can increase alpha value above. Where there is an imperfect relationship between the indicator questions can also cause low values. The reliability or internal consistency of the data using Cronbach’s Alpha, has shown that the test items are acceptable as c-alpha for all the test items tend to 1.

The weight of the indicator questions and the internal consistency test or reliability of the survey items were calculated. The survey which had been undertaken received responses from 85 WASH experts. The expert's view is acceptable base on the high c-alpha value and the information provided for further analysis. The mean weight of the survey items is given in table 9 below.

Table 9: Mean weight for main indicators and sub-indicators of survey items

Main Indicator	Mean Weight	Sub-Indicator	Mean Weight	Sub-Indicator	Mean Weight	Sub- Indicator	Mean Weight
I	8.08	SI1	4.42	SM4	2.47	ST1	6.72
M	7.87	SI2	3.65	SM5	2.86	ST2	5.66
F	7.87	SI3	4.18	SM6	3.06	ST3	4.28
T	8.74	SI4	3.86	SF1	2.69	ST4	3.76
		SI5	3.82	SF2	2.91	ST5	4.60
		SI6	4.93	SF3	2.25	ST6	4.01
		SI7	6.24	SF4	2.44	ST7	3.13
		SM1	6.04	SF5	2.80	ST8	4.64
		SM2	4.81	SF6	2.47	ST9	3.96
		SM3	5.55	SF7	2.77	ST10	3.91
				SF8	2.92	ST11	3.72

The mean weight for the indicator questions considering the indicators is given in table 10 to 13.

Table 10: Mean weight for Institutional and attributes

Indicator	Mean Weight	Sub-Indicator	Mean Weight
Institutional	0.246	WASH Policy	0.142
		WASH Database	0.117
		WASH Equipment standardization	0.134
		Institutional performance	0.125
		Clarity in roles, tasks and responsibilities	0.123
		Financial support and subsidies	0.159
		WASH Collaboration and coordination	0.200
		Total	1.000

Table 11: Mean weight for management and attributes

Indicator	Mean Weight	Sub-Indicator	Mean Weight
Management	0.242	WASH Committee	0.202
		Gender Equity	0.161
		Social inclusion	0.187
		Social marketing	0.180
		Community perceptions (accessibility, acceptability, affordability, quality and quantity)	0.145
		Monitoring and follow up actions	0.125
		Total	1.000

Table 12: Mean weight for financial and attributes

Indicator	Mean Weight	Sub-Indicator	Mean Weight
Financial	0.241	Rational Tariff Structure	0.115
		Quality financial record	0.120
		Willingness and ability to pay for water service delivery	0.162
		Willingness and ability to pay for sanitation and hygiene components	0.159
		Good System of collecting and managing funds	0.125
		Reduction in non-revenue water for pipe born source	0.099
		Financial capacity for major repairs	0.104
		Life cycle cost	0.116
		Total	1.000

Table 13: Mean weight for technical and attributes

Indicator	Mean Weight	Sub-Indicator	Mean Weight
Technical	0.268	Water availability	0.138
		Availability of sanitary facilities	0.116
		Water quality standard	0.089
		Quality of WASH facilities construction	0.078
		Functionality of water facilities	0.095
		Functionality (quality and maintenance of latrines)	0.083
		Readily available and accessible spare parts	0.065
		Capacity of the private WASH operators for routine repairs	0.095
		Area as Open Defecation Free (ODF)	0.082
		Very good hygiene practices	0.081
		Efficient desludging plan	0.078
		Total	1.000

The values of table 14 are subject to modification as this is taken from the International H_2O (USIAD and Rotary International) showing ranges Sustainability Index on WASH interventions.

Table 14: Sustainability Index Levels

<50%	Low
75%≥51%	Average
90%≥76%	Satisfactory
>90%	Good

Sustainability Index scores for WASH services considering each intervention can be calculated by aggregating information from experts on the survey items. The answers to indicator questions were scored on the survey item from household levels, community levels and national levels to determine the overall indicator scores on WASH services in Freetown. These indicators were aggregated (averaged) by their factor (institutional, management, financial and technical), to yield the factor scores on WASH sustainability in Freetown. The responses from expert's opinion during the survey are given in annex 3. Equation 12 calculated the WASH sustainability index as given below.

$$WSI = \sum_{n=1}^{n} (Wi\ Si) \tag{12}$$

Where:

WSI is WASH Sustainability Index based on functionality, water points under construction, partially damaged and broken down water points, W_i is the weighing factor equal to the ratio of the variance of each factor to total cumulative variance coefficients in the equation, and Si is scored value of each indicator.

The WASH Sustainability Index in Freetown, using mean weight method is given in table 15.

Table 15: Sustainability Index using Mean Weighted

Indicator	Mean Weight	Attribute	Average Scores	Sustainability Index (Wi*Si)	WSI
I	0.2490	SI1	44	0.1096	0.111
		SI2	36	0.0896	
		SI3	42	0.1046	
		SI4	39	0.0971	
		SI5	38	0.0946	
		SI6	49	0.1220	
		SI7	62	0.1544	
M	0.2420	SM1	60	0.1452	0.138
		SM2	48	0.1162	
		SM3	56	0.1355	
		SM4	54	0.1307	
		SM5	43	0.1041	
		SM6	37	0.0895	
F	0.2410	SF1	38	0.0916	0.099
		SF2	39	0.0940	
		SF3	53	0.1277	
		SF4	52	0.1253	
		SF5	41	0.0988	
		SF6	32	0.0771	
		SF7	34	0.0819	
		SF8	37	0.0892	
T	0.2687	ST1	67	0.1800	0.119
		ST2	57	0.1532	
		ST3	43	0.1155	
		ST4	38	0.1021	
		ST5	46	0.1236	
		ST6	40	0.1075	
		ST7	31	0.0833	
		ST8	46	0.1236	
		ST9	40	0.1075	
		ST10	39	0.1048	
		ST11	37	0.0992	
Overall Sustainability Index					**0.467**

The overall WASH Sustainability Index = 0.111+0.138+0.099+0.119 = **0.467 = 46.7%**

The WASH Sustainability Index in Freetown, using the weights based on PCA method as in table 16.

Table 16: WASH Sustainability Index using PCA

Component 1 (P1)	Average Scale value	Rotated Component Matrix ≥ 0.50	Component Weight	WSI
ST4	0.40	0.882	0.552	0.221
SI2		0.873		
ST7		0.852		
SI5		0.849		
SI4		0.831		
ST3		0.828		
SI1		0.800		
SI3		0.798		
ST10		0.788		
ST5		0.776		
SF7		0.775		
SM6		0.769		
ST11		0.764		
SM5		0.759		
SF8		0.747		
SF2		0.744		
ST9		0.738		
ST6		0.733		
SF6		0.729		
SF1		0.726		
SF5		0.709		
SM3		0.610		
Component 2 (P2)	**Average Scale value**	**Rotated Component Matrix ≥ 0.50**	**Component Weight**	**WSI**
SI6	0.540	0.560	0.244	0.132
ST2		0.799		
SF4		0.788		
ST1		0.744		
SF3		0.733		
ST8		0.676		
Component 3 (P3)	**Average Scale value**	**Rotated Component Matrix ≥ 0.50**	**Component Weight**	**WSI**
SM1	0.560	0.789	0.204	0.114
SM2		0.777		
SM4		0.654		
SI7		0.601		

The Overall PCA – WSI = 0.221+0.132+0.114 = **0.467** = **46.7%**

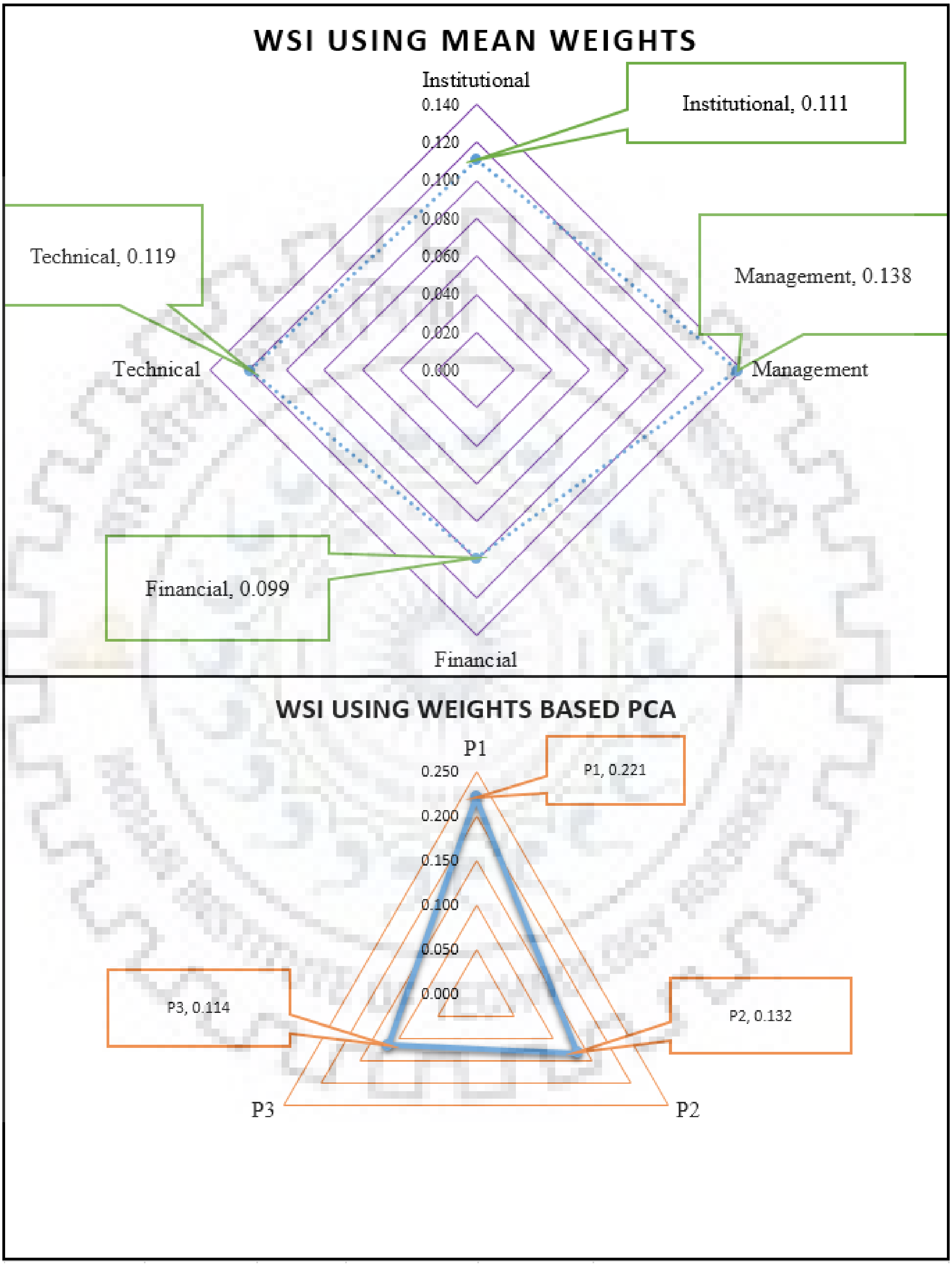


Figure 25: WSI for mean weighted and PCA

The WASH Sustainability Index of Freetown, according to the International H_2O (USIAD and Rotary International), shows that the WASH Sustainability Index is low (0.467 or 46.7%) which is less than 50%. The WASH coverage is low and achieving the target in 2030 seemed impossible. The low WASH index, impact the health, education, socio-economic, lifestyle and income generation.

The performance has been measured, considering reliability, resilience and vulnerability of WASH systems as in figure 27.

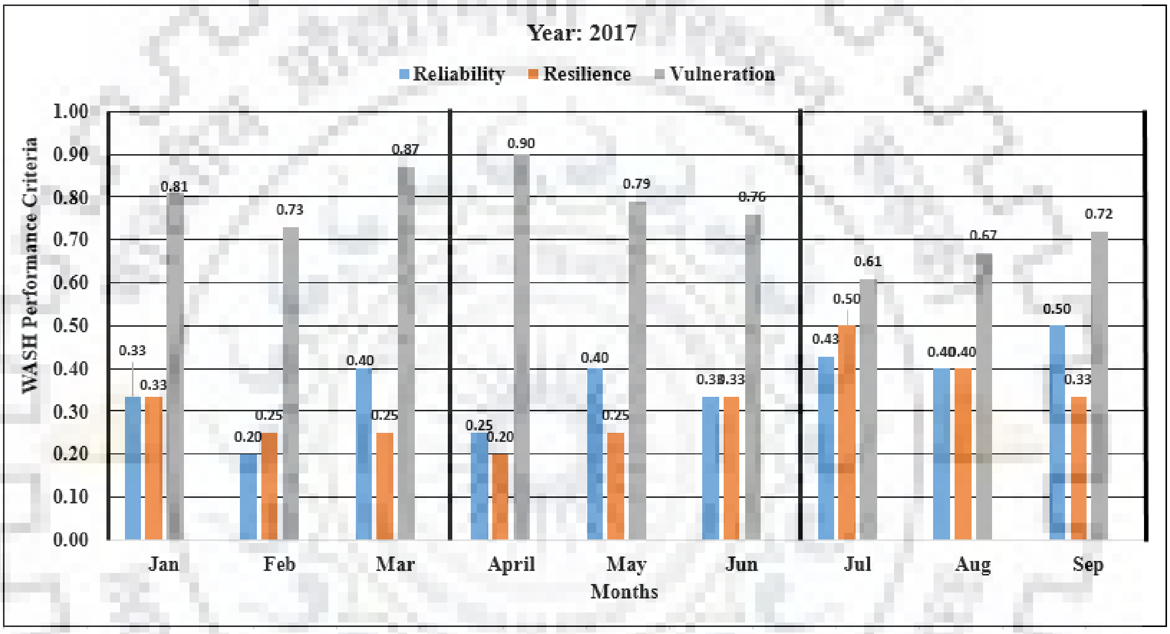


Figure 26: WASH performance criteria

The WASH performance in Freetown was at high risks, January to September 2017. The reliability and resilience of the WASH systems where at an all-time low within the selected periods. The systems show high vulnerability in the selected period, making service delivery and access a huge challenge. A development is a sustainable base on the criteria, social, economic and environmental aspects. WASH services are low, impact health, education, growth and life expectancy. The WASH systems are made resilience and reliable in the face of climate variability. When the system fails to withstand the effect of climate variability, the health is at risks and communities exposed to WASH related disease.

WASH conditions in Freetown is unsatisfactory and have got an impact on the HDI. The HDI dimensions, life expectancy, education index and income index have been measured from 1980 to 2017 as in table 17.

Table 17: HDI and WSI

Sustainable Human Development Index (HDI) and WASH Sustainability Index (WSI)							
Year	Life Expectancy Index	Mean Year of Schooling Index	Expected Year of Schooling	Education Index	Gross National Index	HDI	WSI
1980	0.355	0.063	0.375	0.157	0.694	0.338	0.413
1985	0.352	0.081	0.375	0.178	0.659	0.346	0.415
1990	0.288	0.100	0.306	0.179	0.648	0.322	0.410
1995	0.265	0.125	0.294	0.196	0.594	0.314	0.403
2000	0.305	0.150	0.294	0.215	0.453	0.309	0.402
2006	0.377	0.188	0.456	0.299	0.339	0.337	0.423
2007	0.392	0.194	0.456	0.304	0.351	0.347	0.427
2008	0.406	0.194	0.456	0.304	0.344	0.349	0.431
2009	0.420	0.200	0.456	0.309	0.343	0.354	0.437
2010	0.422	0.206	0.456	0.314	0.478	0.398	0.420
2011	0.428	0.206	0.456	0.314	0.478	0.400	0.427
2012	0.432	0.206	0.456	0.314	0.486	0.404	0.434
2013	0.468	0.250	0.563	0.383	0.480	0.442	0.425
2014	0.475	0.250	0.563	0.383	0.486	0.446	0.439
2015	0.483	0.250	0.563	0.383	0.470	0.443	0.430
2016	0.481	0.250	0.563	0.383	0.488	0.448	0.453
2017	0.486	0.250	0.529	0.372	0.512	0.452	0.467

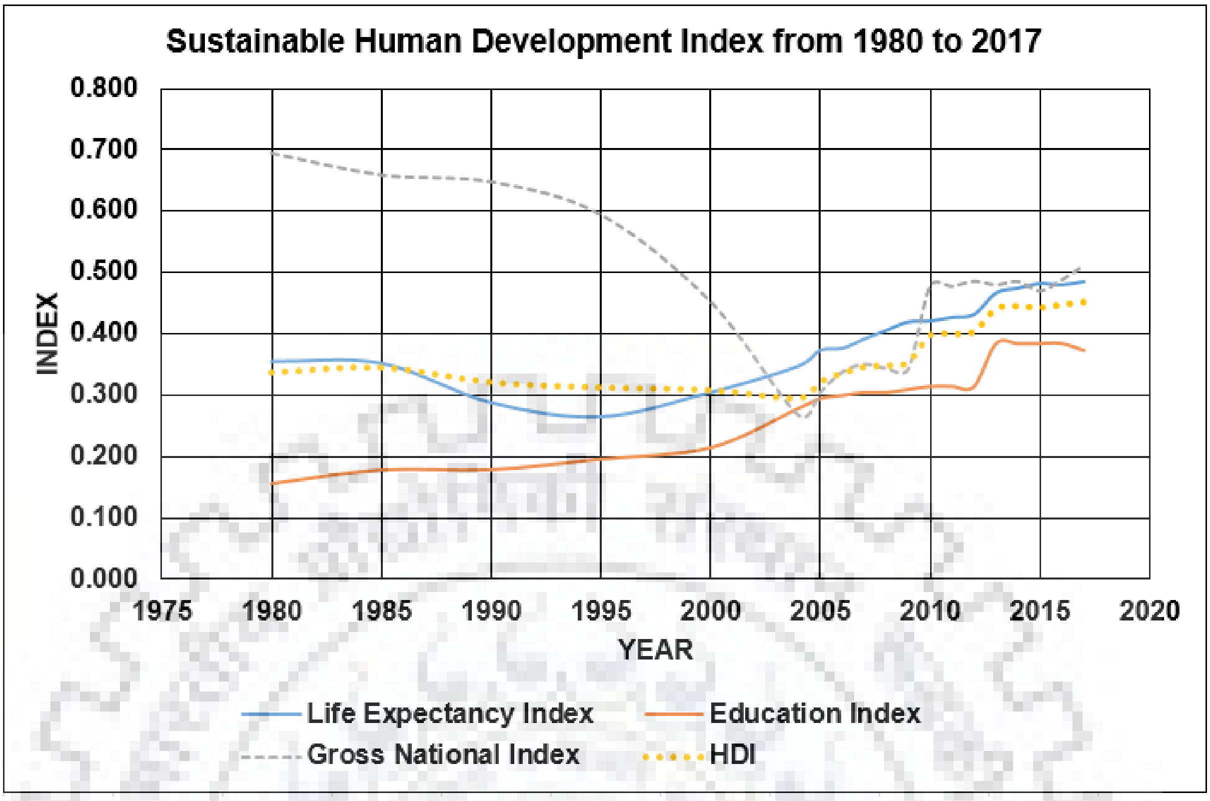


Figure 27: HDI

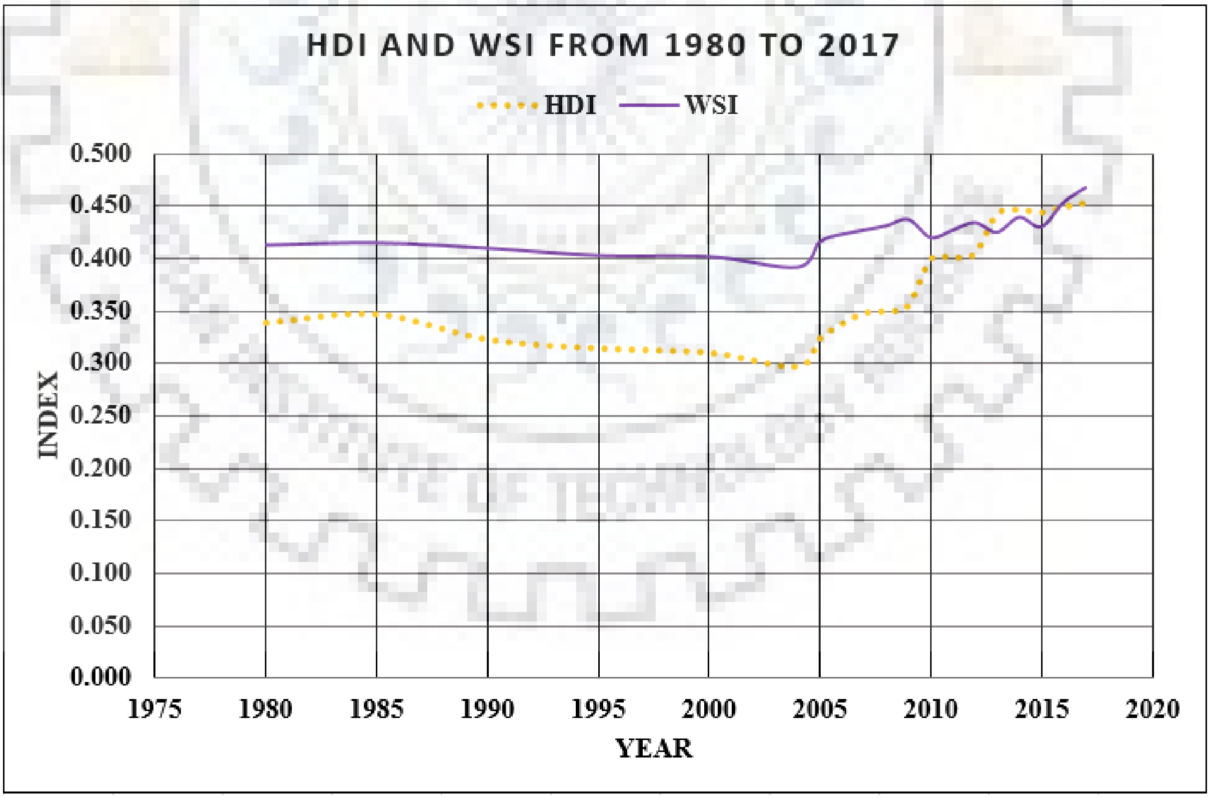


Figure 28: WSI

The HDI has been measured to be low from 1980 to 2017. Sustainability Development Index increase from 1980, drop lower in 1990 because of the civil war and continue right through the war to 2004. From 2004, the HDI steadily rise up to 2017. After the war, the socio-economic status started improving, businesses started gaining ground, schools reopened, the health care improve and income generation started. HDI is influenced by the income gap in society. When the war was concluded, wealth was accumulated and lost for others making them very poor. Since then the gap keeps widening and closing influencing the HDI. As the WASH conditions go worst, HDI becomes affected. Quality WASH services, provide good health, education, and decent life. When the WASH services are poor, HDI will be affected and the life expectance reduces with low educational achievement and low GDP. WASH services promote sustainable development and HDI for countries in the world.

4.3 CONCLUSIONS

The index on WASH services is poor or low from the measured calculations. The index is measured low because of poor institutions, management, investment and technology. The result shows the risks of diarrheal or WASH related diseases, which can claim more lives in especially the under-five children. WASH systems reliability and resilience are unsatisfactory, making the vulnerable of the systems higher. When these WASH components are vulnerable, then the health, economy, environment, income status and education are at risks. Freetown has unsatisfactory WASH index exposing its population to the risks of diarrheal and other WASH related diseases. The WASH sustainability index can cause the HDI to be low. From the result estimated, HDI is low for the study area due to poor WASH conditions.

CHAPTER – 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL

The results estimated on WASH sustainability index, have generated the following conclusions and recommendations. The concluding statement and recommendations can help service providers, institutions and community leaders to device a better way of implementing WASH services to communities globally.

5.2 CONCLUSIONS

The monitoring of WASH activities in areas around Freetown that are underserved by service providers have the physical structures and how many people can access services. The approaches cannot take the actual WASH service delivered to the people staying in an underserved community. WASH services in the city, lack the required design standard causing low service levels, far short of the estimated. In an effect to solve the challenge, monitoring mechanism should be enforced to improve the levels of service with little attention on the physical components. Reliable WASH services do not only consider functioning hardware but the software package which can enhance successful implementation.

The software aspect for any WASH interventions does not consider the physical infrastructures but the supportive policies, levels of decentralization, political economy, population density and topography and legislation. WASH services in Freetown are low because of limited financing, inadequate services and capital maintenance. Revenue mobilisation for WASH is low due to low tariff structure hindering the operational cost and extension of service to others. Institutional or policy vacuum provides the highest sustainability risks, shortening the life of WASH services and reducing coverage to communities. Inadequate WASH policy or institutional frameworks negatively impact the functionality of components. Similarly, there is complete lack of willingness and capacity of institutions in providing a sustainable follow up supports.

5.2 RECOMMENDATIONS

The specific and detailed recommendations for improving WASH services in Freetown. This study has highlighted trends and issues relating to policy development, planning and collaboration. The following recommendations might be useful to funding agencies, service providers, international development partners, and government, which can likely contribute to sustainable WASH interventions.

1. More rigorous and evidenced based monitoring of services delivery in Freetown. The monitoring findings encourage engagement at stakeholder levels and as well promote changes in policy and institutional framework which can enhance health care and reduce under-five death rates.
2. Addressing capacity building constraints for short term projects particularly at local levels. Improving discrete interventions, such as training local government staff on project management, administrative and contract management or promote private sector capacity, can provide better sustainable WASH services.
3. Having a good understanding of Life-cycle costs analysis can improve WASH financing, provide sustainable support and strengthen revenue mobilisation.
4. Encouraging better collaboration and coordination relevant authorities in the WASH sector, as a way of providing better returns on investments.
5. Raising awareness to address certain policy or capacity constraints relating to WASH sustainability, can be valid for any intervention in Freetown.

1. Adams, Ellis Adjei, and Leo Charles Zulu. 2015. "Participants or Customers in Water Governance? Community-Public Partnerships for Peri-Urban Water Supply." *Geoforum* 65: 112–24. http://dx.doi.org/10.1016/j.geoforum.2015.07.017.
2. AfDB. 2015. "Water Supply and Sanitation in Africa: Findings, Lessons and Good Practices to Improve Delivery." (June).
3. AGUASAN. 2012. "Financial Sustainability of WASH Services: 28th AGUASAN Workshop Briefing Note." *About mindset change and an eye for the future, 18-22 June 2012*: 1–7.
4. Aguasan, About. 2017. "Circular Economy – Transforming Waste into Resources." : 1–6.
5. Andersson, Kim, Sarah Dickin, and Arno Rosemarin. 2016. "Towards 'Sustainable' Sanitation: Challenges and Opportunities in Urban Areas." *Sustainability* 8(12): 1289. http://www.mdpi.com/2071-1050/8/12/1289.
6. Babovic, Marija, and Danilo Vukovic. 2014. "Social Accountability in Cambodia." (August).
7. Baumann, Eric, Agnes Montangero, Sally Sutton, and Karl Erpf. 2010. "WASH Technology Information Packages." *Unicef*. http://www.unicef.org/supply/index_54301.html.
8. Bizikova, Livia, and Laszlo Pinter. 2017. "Indicator Preferences in National Reporting of Progress Toward the Sustainable Development Goals." : 7.
9. Butt, Nisa. 2014. "Evaluating Water, Sanitation and Hygiene (WASH) Affecting School Children Performance in Lahore and Islamabad, Pakistan."
10. Caruso, Bethany A et al. 2013. "WASH in Schools Empowers Girls' Education in Freetown, Sierra Leone: An Assessment of Menstrual Hygiene Management in Schools." : 40. www.unicef.org/wash/schools%5Cnhttps://www.unicef.org/wash/schools/files/Sierra_Leone_MHM_Booklet_DM_15_Nov_1020_single-Sierra_Leone.pdf.
11. Charles, Katrina et al. 2010. "The Resilience of Water Supply and Sanitation in the Face of Climate Change: Technology Projection Study." : 81.
12. Chaves, Henrique M L. "WSI Integrating Basin Hydrology, Environment, Life, & Policy : The Watershed Sustainability Index."

13. Cortés, Ana Elizabeth et al. 2012. "Application of the Watershed Sustainability Index to the Elqui River Basin, North-Central Chile." *Obras y Proyectos* 12: 57–69.
14. Cubillo, Francisco, and Ángela Martínez-Codina. 2017. "A Metric Approach to Measure Resilience in Water Supply Systems." *Journal of Applied Water Engineering and Research* 9676(November): 1–12. https://www.tandfonline.com/doi/full/10.1080/23249676.2017.1355758.
15. Dickin, Sarah K, Corinne J Schuster-wallace, Manzoor Qadir, and Katherine Pizzacalla. 2016. "Health Risks and Pathways of Wastewater Exposure." (7): 900–909.
16. Ellert, Richard et al. 2013. "Orientation Framework: Water, Sanitation and Hygiene." : 47–53.
17. Emas, Rachel. 2015. "The Concept of Sustainable Development : Definition and Defining Principles." *Brief for GSDR*: 1–3.
18. Environmental Protection Agency. 2016. "Environmental Challenges and Emerging Issues for Ireland Environmental Challenges for Ireland." *State of the Environment Report 2016*.
19. Fewtrell, L, and J M Colford. 2005. "Water, Sanitation and Hygiene in Developing Countries: Interventions and Diarrhoea - a Review." *Water Science and Technology* 52(8): 133–42.
20. Foti, Romano et al. 2010. "Vulnerability of U. S. Water Supply to Shortage." *U.S. Department of Agriculture*.
21. Framework, Regulatory. 2016. "Análise Das Práticas E Do Quadro Regulatório Review of Regulatory Framework Manual de Governança E Substância Regulatórias Manual of Regulatory Governance and Substance." (July).
22. Fulazzaky, Mohamad. 2014. "Challenges of Integrated Water Resources Management in Indonesia." *Water* 6(7): 2000–2020. http://www.mdpi.com/2073-4441/6/7/2000/.
23. Gender Tool Box. 2015. "Women, Water, Sanitation and Hygiene." (March): 1–4.
24. Guide, User. 2008. *Handbook on Constructing Composite Indicators: Methodology and User Guide*. http://www.oecd-ilibrary.org/economics/handbook-on-constructing-composite-indicators-methodology-and-user-guide_9789264043466-en.
25. Hashimoto, Tsuyoshi, Jery R. Stedinger, and Daniel P. Loucks. 1982. "Reliability, Resiliency, and Vulnerability Criteria for Water Resource System Performance Evaluation." *Water Resources Research* 18(1): 14–20.
26. Howard, Guy, Roger Calow, Alan Macdonald, and Jamie Bartram. 2016. "Climate Change and Water and Sanitation: Likely Impacts and Emerging Trends for Action."

Annual Review of Environment and Resources 41(1): 253–76. http://www.annualreviews.org/doi/10.1146/annurev-environ-110615-085856.

27. Hutton, Guy, and Claire Chase. 2016. "The Knowledge Base for Achieving the Sustainable Development Goal Targets on Water Supply, Sanitation and Hygiene." *International Journal of Environmental Research and Public Health* 13(6): 1–35.
28. Johnston, E. Anna, Jordan Teague, and Jay P. Graham. 2015. "Challenges and Opportunities Associated with Neglected Tropical Disease and Water, Sanitation and Hygiene Intersectoral Integration Programs Global Health." *BMC Public Health* 15(1): 1–14.
29. Kimera, Authors Paul, Kenan Okurut, and Asha Bamutaze. 2016. "Technology Applicability Framework : Cases from Uganda for WASH Technology Validation and Uptake." : 1–8.
30. Mack, James W. 2012. "Accounting for Material-Specific Inflation Rates in Life-Cycle Cost Analysis for Pavement Type Selection." *Transportation Research Record* (2304): 86–96.
31. Mara, Duncan. 2017. "The Elimination of Open Defecation and Its Adverse Health Effects: A Moral Imperative for Governments and Development Professionals." *Journal of Water Sanitation and Hygiene for Development* 7(1): 1–12. http://washdev.iwaponline.com/lookup/doi/10.2166/washdev.2017.027.
32. Marshall, L., and J. Kaminsky. 2016. "When Behavior Change Fails: Evidence for Building WASH Strategies on Existing Motivations." *Journal of Water, Sanitation and Hygiene for Development* 6(2): 287–97.
33. Mie, Axel et al. 2017. "Human Health Implications of Organic Food and Organic Agriculture: A Comprehensive Review." *Environmental Health: A Global Access Science Source* 16(1): 1–22.
34. Mills, Joanna Esteves et al. 2016. "The Impact of Water, Sanitation and Hygiene on Key Health and Social Outcomes: Review of Evidence." (June).
35. Milman, Anita, and Anne Short. 2008. "Incorporating Resilience into Sustainability Indicators: An Example for the Urban Water Sector." *Global Environmental Change* 18(4): 758–67.
36. Nedjoh, John. 2016. "A Case for Governance and Institutional Re-Alignment for Small Towns Piped Water Services in Africa." *39th WEDC International Conference* (2014): 7 pp. http://wedc.lboro.ac.uk/resources/conference/39/Nedjoh-2489.pdf.
37. Oates, Naomi et al. 2014. "Adaptation to Climate Change in Water, Sanitation and

Hygiene: Assessing Risks and Appraising Options in Africa.” (January): 98. http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8858.pdf.

38. ONU. 2017. “The Sustainable Development Goals Report.” *United Nations*: 1–56. https://unstats.un.org/sdgs/files/report/2017/TheSustainableDevelopmentGoalsReport2017.pdf.
39. Osumanu, Ki, L Abdul-Rahim, and Jacob Songsore. 2010. Water and Sanitation *Urban Water and Sanitation in Ghana: How Local Action Is Making a Difference*.
40. Partners in Population and Development. 2013. “Intergrating WASH Interventions Across Sectors to Improve Health Outcomes.”
41. Prüss-Ustün, Annette et al. 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.
42. Rahman, Sowmen, and Mohammed Ataur Rahman. 2015. “Climate Extremes and Challenges to Infrastructure Development in Coastal Cities in Bangladesh.” *Weather and Climate Extremes* 7: 96–108. http://dx.doi.org/10.1016/j.wace.2014.07.004.
43. Rana, Sujata et al. 2011. “Water, Sanitation and Hygiene (WASH) Behaviour Change Communication (BCC) Strategy for the Urban Sub-Sector.” : 70.
44. Ruslan, Dede. 2017. “Analysis of Factors Affecting the Human Development Index in North Sumatra Province.” 19(10): 27–36.
45. Schreier, Pamela, and Ilana Cohen. 2013. “Sustainability Index of WASH Activities Dominican Republic Country Report.”
46. Schwemlein, Stefanie, Ryan Cronk, and Jamie Bartram. 2016. “Indicators for Monitoring Water, Sanitation, and Hygiene: A Systematic Review of Indicator Selection Methods.” *International Journal of Environmental Research and Public Health* 13(3).
47. Shrestha, Rabin Lal, Ramisetty Murali, and Govind Bahadur Shrestha. 2015. “Sustainable and Equitable Financing of Sanitation Services.” : 11. http://www.freshwateraction.net/sites/freshwateraction.net/files/Sanitation Financing SACOSAN VI.pdf.
48. Statics Sierra Leone. 2016. “Sierra Leone 2015 Population and Housing Census.” (March): 1–16. https://www.statistics.sl/wp-content/uploads/2016/06/2015-Census-Provisional-Result.pdf.

49. Taylor, Dawn L., Tanya M. Kahawita, Sandy Cairncross, and Jeroen H.J. Ensink. 2015. "The Impact of Water, Sanitation and Hygiene Interventions to Control Cholera: A Systematic Review." *PLoS ONE* 10(8): 1–19.
50. The Government OF, Republic Of, Sierra Leone, and Ministry O F Energy. 2010. "Ministry of Energy and Water Resources." (July).
51. Thomson, Patrick, and Johanna Koehler. 2016. "Performance-Oriented Monitoring for the Water SDG – Challenges, Tensions and Opportunities." *Aquatic Procedia* 6(0): 87–95.
52. Trtanj, Juli et al. 2016. "The Impacts of Climate Change on Human Health in the United States." *U.S. Global Change Research Program* 6: 157–88. http://dx.doi.org/10.7930/J03F4MH4.
53. UNICEF. 2016a. "Equity in Public Financing of Water, Sanitation and Hygiene (WASH) INDONESIA." (June). https://www.unicef.org/eapro/UNICEF_WASH_Financing_Indonesia.pdf.
54. UNICEF. 2016b. "Strategy for Water, Sanitation and Hygiene." : 75. https://www.unicef.org/wash/files/UNICEF_Strategy_for_WASH_2016-2030.pdf.
55. UNICEF. 2017. "Water, Sanitation and Hygiene: UNICEF in South Sudan." : 1–4. https://www.unicef.org/southsudan/WASH.pdf.
56. Vaughan, Scott. 2016. "Sustainable Development Goals (IISD Perspectives on the 2030 Agenda for Sustainable Development)." : 35.
57. The National water and Sanitation Policy. 2010. "GOVERNMENT OF THE REPUBLIC OF SIERRA LEONE MINISTRY OF ENERGY AND WATER RESOURCES Table of Contents." (July).
58. Zhang, Chi, Bo Xu, Yu Li, and Guangtao Fu. 2017. "Exploring the Relationships among Reliability, Resilience, and Vulnerability of Water Supply Using Many-Objective Analysis." *Journal of water resources planning and management* 143(8): 4017044. http://ascelibrary.org/doi/pdf/10.1061/(ASCE)WR.1943-5452.0000787.

Annex 1: Indicator questions as below.

Indian Institute of Technology, Department of Water Resources Development and Management, Roorkee.

A research is being carried out for understanding the Sustainability of Water, Sanitation and Hygiene (WASH) Intervention in Western Sierra Leone". The quantitative framework, termed as the Sustainability Index, focuses on four sub-indicators, i.e., Institutional, Management, Financial, and Technical. These sub-indicators have many attributes. In order to assess the sustainability, it is desired to get the opinion of the experts like you and to collect data at different levels like that at household, community, local-municipal/ district and/ or regional/ national level.

It will be strongly appreciated if by any chance you spare few minutes to offer your opinion on the sustainability indicators and the attributes as mentioned in this questionnaire. Your opinion will be duly acknowledged. For any question/ clarification, you are welcome to contact me on ingamara20131@gmail.com

* Required

1. Title *

Choose

2. Name *

Your answer

3. Organization(optional)

Your answer

4. Designation/Role(optional)

Your answer

5. Contact number(optional)

Your answer

Section I

In your opinion, how important/weightage (on a scale of 1 to 10) are the sustainability indicators, i.e., Institutional(I), Management(M), Financial(F) and Technical(T) (1=minimum and 10=maximum).

6. Institutional *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

7. Management *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

8. Financial *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

9. Technical *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

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Section II

In your opinion, how important/weightage (on a scale of 1-10) are the Institutional sub-indicators (1=minimum and 10=maximum)

10.Water Sanitation and Hygiene Policy (WASH) *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

11. Database on WASH *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

12. Technical/equipment standardization of WASH components *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

13. Institutional performance *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

14. Clarity in roles, tasks and responsibilities *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

15. Financial support and subsidies *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

16. Collaboration and coordination among WASH partners *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

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Section III

In your opinion, how important/weightage (on a scale of 1-10) are the Management sub-indicators (1=minimum and 10=maximum)

17. WASH Committee *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

18. Female representation on WASH Committee *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maxi

19. Social inclusion (Community Participation) *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

20. Social marketing (training and information on WASH and household level behavior change) *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

21. Community perceptions (accessibility, acceptability, affordability, quality and quantity) *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

22. Monitoring and follow up actions (hygiene promotion and household water treatment) *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

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Section IV

In your opinion, how important/weightage (on a scale of 1-10) are the Financial sub-indicators (1=minimum and 10=maximum)

23. Rational Tariff Structure *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

24. Quality financial record *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

25. Willingness and ability to pay for water service delivery *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

26. Willingness and ability to pay for sanitation and hygiene components *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

27. Good System of collecting and managing funds *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

28. Reduction in non-revenue water for pipe born source *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

29. Financial capacity for major repairs *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

30. Life cycle cost plan (including Operation and Maintenance cost). *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

BACK NEXT

Section V

In your opinion, how important/weightage (on a scale of 1-10) are the Technical sub-indicators (1=minimum and 10=maximum)

31. Water availability *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

32. Availability of sanitary facilities *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

33. Water quality standard *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

34. Quality of WASH facilities construction *

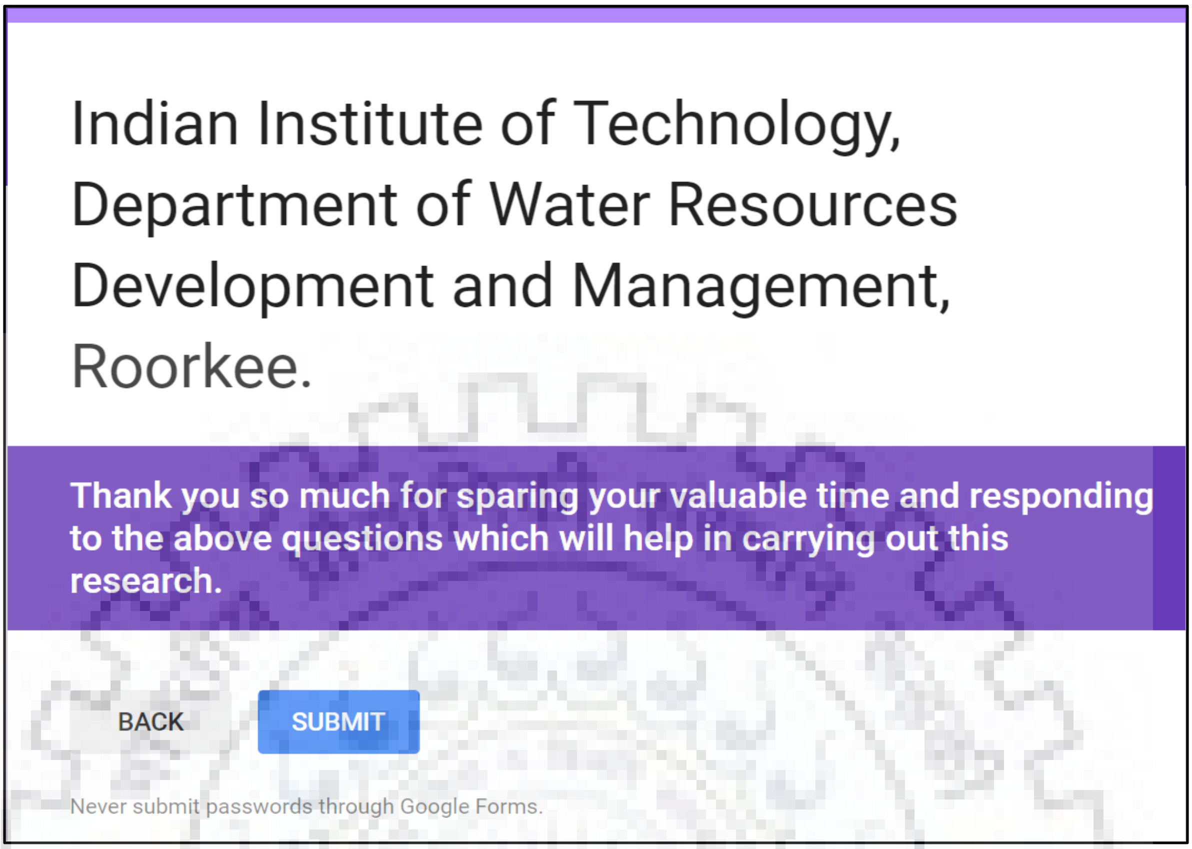
	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

35. Functionality of water facilities *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum

36. Functionality (quality and maintenance of latrines) *

	1	2	3	4	5	6	7	8	9	10	
Minimum	○	○	○	○	○	○	○	○	○	○	Maximum


Indian Institute of Technology, Department of Water Resources Development and Management, Roorkee.

Thank you so much for sparing your valuable time and responding to the above questions which will help in carrying out this research.

BACK

SUBMIT

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Annex 2: Names and Contacts of Respondents

1	Timestamp	1. Title	2. Name	3. Organization(optional)	4. Designation/Role(optional)	5. Contact number(optional)
2	6/22/2017 9:17:45	Mr.	Ibrahim C. Bah	Guma Valley Water Company	Planning and Development Manager/Head of Projects	76936107
3	6/22/2017 9:33:18	Mr.	Williamson A Taylor	Ministry of Water Resources	Water Mapping Officer	+23278070765
4	6/22/2017 9:46:49	Mr.	Morrison Benjamin Gboyor	Ministry of Energy- Sierra Leone	Deputy Permanent Secretary	+232-76624880/+232-30291056
5	6/22/2017 9:47:55	Mr.	Edward O. Toby	Ministry of Water Resources	Laboratory Technicain	+23279-317-532
6	6/22/2017 9:47:57	Mr.	Ishmail Kamara	Ministry of Water Resources	Water Analyst	
7	6/22/2017 9:55:44	Mr.	Umaru D.Rogers	Ministry of Water Resources,Water Directorate	District WASH Engineer	+23276579949
8	6/22/2017 11:02:25	Mr.	Maruff Barrie	NATCOM		Senior Engineer Standards
9	6/22/2017 13:43:28	Mr.	Mohamed Bah	Ministry of Water Resources, Water Directorate	Programme Officer Monitoring and Evaluation	+23276823288
10	6/23/2017 2:12:31	Ms.	Florence Lansana			
11	6/23/2017 2:17:53	Ms.	Matu Golia			
12	6/23/2017 2:21:15	Mr.	Edward Kongor			
13	6/23/2017 3:39:36	Ms.	Rose Lansana			
14	6/23/2017 4:05:45	Ms.	Michael Jusu			
15	6/23/2017 4:08:02	Mr.	Michael Ablanga Jusu			
16	6/23/2017 11:31:10	Mr.	Sulaiman Gassama	Port Loko District Council	Procurement Officer	+23278359355
17	6/24/2017 2:04:10	Ms.	Isata Kargbo	Save the children	WASH Officer	+23288987295
18	6/24/2017 9:36:07	Mr.	Morie Bayoh Kobba	Ministry of Water Resources	District WASH Engineer	+23278270247
19	6/24/2017 12:48:49	Mrs.	Joseph Golia	Care Intérnational	WASH Coordinator	+23278652563
20	6/24/2017 12:54:37	Mrs.	Isha Jalloh	CaWec	WASH Supervisor	+23277093576
21	6/24/2017 13:05:25	Ms.	Aminata Ansu lasie	Plan International	Natural Leader in WASH	+23277265275
22	6/24/2017 15:55:00	Mr.	Patrick Amara Ngaojia	Ministry of Water Resources	WASH Mapping Officer	+232-78-252-993/77-722-677
23	6/24/2017 17:06:01	Mr.	Joseph Bengeh	university student		+232-76-26-88-70
24	6/24/2017 21:35:38	Mr.	Francis Amara Makieu	Power Of Salvation Ministry	Executive Chairman	+23299297953
25	6/27/2017 10:24:51	Mr.	Peter I. Vandy	EDSA	Area Engineer	+23276242466

1	Timestamp	1. Title	2. Name	3. Organization(optional)	4. Designation/Role(optional)	5. Contact number(optional)
26	6/27/2017 11:06:48	Mr.	Ing. Patrick. C.I.Cole	Ministry of Water Resources	Senior Civil Engineer	+232 76 332988
27	6/27/2017 14:55:27	Mrs.	Johnson	sierra Leone Postal Services	Assistant Accountant	
28	6/28/2017 13:13:00	Mr.	Sallieu Bundu	Ministry of Water Resources (Sierra Leone)	Assistant Executive Engineer	+23279538350
29	6/29/2017 14:28:50	Mr.	Alusine Milton Turay			+23278800696
30	6/29/2017 16:35:14	Mr.	Foday Bassie Kamara	Sierra Leone TeleCommunications	Software Engineer	+23225373104
31	6/29/2017 17:09:18	Mr.	Sylvester Dangima	Local Government	Information, Education and Communication Officer	+232-78-289-652
32	7/6/2017 15:10:32	Mr.	Ade Tuboku-Metzger		Civil Engineer	
33	7/9/2017 14:10:18	Mr.	Saramadie Thorlu-Bangura	Ministry of Water Resources	WASH Engineer	+232 76960047
34	7/10/2017 19:27:03	Mr.	Mohamed Mattia	GrACED	project manager	23276391767
35	7/13/2017 16:15:01	Mr.	James Gbonda	Techsult & Company Limited	Highway Engineer	+23279541194
36	7/14/2017 13:00:40	Mr.	Emmanuel Fanday Bayoh	Sierra Leone Water Company SALWACO	Production/Distribution Engineer	+23276441551
37	7/16/2017 3:19:51	Ms.	Jean Kamara	ACF	WASH Officer	+23288213668
38	7/16/2017 3:25:45	Mrs.	Rosaline Kamara	Port-Loko District Council	WASH Desk Officer	+23288244600
39	7/16/2017 3:30:41	Mrs.	Veronica Koroma	Save the Children	Outreach Officer	+23276963374
40	7/16/2017 3:34:40	Ms.	Theresa Makieu	UNDP	WASH Outreach Officer	+23277928385
41	7/16/2017 3:38:26	Mr.	Paul Kamara	Oxfam	+23277478733	
42	7/24/2017 2:12:19	Mr.	Ibrahim Kamara	UNICEF-Sierra Leone	WASH Field Officer	
43	7/24/2017 2:15:28	Mr.	Peter Makieu	UNICEF	Social Mobilizer	
44	7/24/2017 2:21:21	Mrs.	Bintu Jalloh	Kailahun District Council	WASH Officer	+23276791276
45	7/24/2017 2:25:20	Ms.	Martha Kordovoh	Goal	Field Officer	
46	7/24/2017 2:28:59	Dr.	Paul Thomas	Fourah Bay College	Lecture-Hydrogeology	
47	7/24/2017 2:33:38	Prof.	Badamasi Savage	Fourah Bay College	Lecture-Hydrology	
48	7/24/2017 2:36:34	Dr.	Oba Davies	Fourah Bay College	Senior Lecturer-Goetechnical	
49	7/24/2017 2:39:40	Dr.	Ben Johnson	Njala University College	Lecturer	
50	7/24/2017 2:42:20	Mr.	Pierre Cole	Guma	Area Engineer	
51	7/24/2017 2:44:32	Ms.	Agnes John			
52	7/25/2017 12:41:34	Mr.	Abdul Karim Conteh	Ministry of Labour and Social Security	Assistant Director Occupational Safety and Health	+23278110975
53	7/28/2017 16:35:16	Mr.	Lansana Yorpoi	WaterAid		
54	7/29/2017 3:15:11	Mrs.	Hannah Makieu	Kenema District Council	WASH Desk Officer	
55	7/29/2017 3:21:32	Mr.	Fodie J. Kamara	Ministry of Health and Sanitation	Medical Doctor	+23277349188
56	7/29/2017 3:28:37	Mr.	Amadu Wurie	Ministry of Health and Sanitation	WASH Focal Person-Freetown	+23276640029
57	7/29/2017 12:09:24	Mr.	Amara Kamara	Ministry of Health and Sanitation	Sanitary Officer	
58	7/29/2017 12:13:59	Mrs.	Metonia Wright	Plan-Sierra Leone	WASH Field Officer	
59	7/29/2017 12:20:02	Ms.	Augusta Kamara	UNICEF	WASH Desk Officer	
60	7/29/2017 12:29:19	Dr.	Sulla Kamara	Sanitation Directorate	Director	
61	7/29/2017 12:32:42	Mr.	Francis Koroma	Ministry of Health and Sanitation	Sanitary Engineer	
62	7/30/2017 8:29:42	Mr.	Lamin K.S. Souma	Ministry of Water Resources	Director, water directorate	+23276331090
63	7/30/2017 8:32:57	Mr.	Augustine Tucker	Ministry of Water Resources	Deputy Director	
64	7/30/2017 8:35:47	Mr.	Alhaji Sesay	Ministry of Water Resources	Water mapping officer	
65	7/30/2017 8:41:20	Mrs.	Musu Kabia	Plan International	WASH Technician	
66	7/30/2017 8:44:41	Mrs.	Patricia Lansana	Goal-SL	WASH Officer	
67	7/31/2017 3:05:21	Mrs.	Fengo Gedemeh	Local Council Western Rural	Deputy Chief Administrator	+23276655049
68	7/31/2017 3:08:41	Ms.	Fatmata Kamara	Sierra Leone Red Cross	Field Officer WASH	
69	7/31/2017 3:13:16	Mrs.	Agnes Koroma	WaterAid	Technician	
70	7/31/2017 3:20:58	Ms.	Winnifred Lansana	CaWec	WASH Field Officer	
71	7/31/2017 3:26:52	Mr.	Mohamed Sesay	Slva	Field Officer	
72	7/31/2017 3:44:54	Mr.	Mohamed Gandy	CaWac	Technician	
73	7/31/2017 3:52:10	Ms.	Aminata Musa	Living Water International	WASH Officer	
74	7/31/2017 4:12:36	Mr.	Danial Komba	Ministry of Water Resources	WASH Technician	
75	7/31/2017 4:17:54	Mr.	Francis Karama	Ministry of Health and Sanitation	Sanitary Officer	
76	7/31/2017 4:24:52	Mr.	Ansumana Swarray	SALWACO	Program Officer	
77	8/2/2017 12:35:47	Mr.	Brima Kamara	SLVA	WASH Field Officer	
78	8/2/2017 13:49:37	Mrs.	Memunatu Kamara	Ministry of Health and sanitation	Sanitary Engineer	
79	8/2/2017 15:17:15	Mr.	James Faya	Ministry of Water Resources	WASH Engineer	
80	8/4/2017 9:11:03	Mrs.	Anie Wurie	Ministry of Health and Sanitation	Sanitary Officer	
81	8/4/2017 9:27:49	Mr.	Amadu Wurie	Safe the Children	WASH field Officer	
82	8/4/2017 9:38:37	Mr.	Idrissa Bockarie	Ministry of Education	Permanent Secretary	
83	8/4/2017 10:14:47	Mr.	Iddrissa Kalie	Pikin to Pikin	WASH Desk-Officer	
84	8/4/2017 10:22:52	Mrs.	Fatmata Sandy	Hopeless Children	Outreach Officer	
85	8/4/2017 11:06:06	Mr.	Alpha mansaray	Port-Loko District Council	Technicial	
86	8/4/2017 11:56:27	Mr.	Almamy Turay	Ministry of Water Resources	WASH Engineer	

Annex 3: Responses from indicator questions

1	6. Institutional	7. Management	8. Financial	9. Technical	10.Water Sanitation and Hygiene Policy (WASH)	11. Database on WASH	12. Technical/equipment standardization of WASH components	13. Institutional performance	14. Clarity in roles, tasks and responsibilities	15. Financial support and subsidies
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1	16. Collaboration and coordination among WASH partners	17. WASH Committee	18. Female representation on WASH Committee	19. Social inclusion (Community Participation)	20. Social marketing (training and information on WASH and household level behavior change)	21. Community perceptions (accessibility, acceptability, affordability, quality and quantity)	22. Monitoring and follow up actions (hygiene promotion and household water treatment)	23. Rational Tariff Structure
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1	24. Quality financial record	25. Willingness and ability to pay for water service delivery	26. Willingness and ability to pay for sanitation and hygiene components	27. Good System of collecting and managing funds	28. Reduction in non-revenue water for pipe born source	29. Financial capacity for major repairs	30. Life cycle cost plan (including Operation and Maintenance cost).	31. Water availability	32. Availability of sanitary facilities
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83	5	6	7	6	4	3	3	8	6
84	1	5	4	2	1	3	4	9	6
85	3	7	5	3	1	2	3	7	6
86	6	7	9	6	5	6	5	8	7

1	33. Water quality standard	34. Quality of WASH facilities construction	35. Functionality of water facilities	36. Functionality (quality and maintenance of latrines)	37. Readily available and accessible spare parts	38. Capacity of the private WASH operators for routine repairs	39. Area as Open Defecation Free (ODF)	40. Very good hygiene practices	41. Efficient desludging plan
2	9	10	9	9	8	8	9	8	10
3	10	10	10	10	10	5	9	9	10
4	3	4	4	3	2	3	4	2	2
5	4	4	6	4	5	4	7	5	4
6	4	4	6	4	5	4	7	5	4
7	10	10	10	5	10	7	5	10	10
8	9	10	10	10	9	9	3	10	8
9	2	4	3	2	2	2	1	1	1
10	10	10	10	10	10	10	10	10	10
11	10	10	10	10	10	10	10	10	10
12	10	10	10	10	10	10	10	10	10
13	3	4	3	3	3	4	4	3	3
14	2	4	2	2	2	1	2	3	2
15	2	2	2	2	3	3	2	3	3
16	5	5	6	5	3	7	10	3	5
17	2	1	2	1	2	2	3	2	1
18	8	8	10	9	8	8	7	9	8
19	3	2	2	1	1	2	5	2	1
20	4	1	3	2	1	2	2	3	4
21	2	1	2	3	1	2	4	2	3
22	10	10	10	10	10	10	10	10	10
23	10	10	7	8	7	5	7	10	8
24	10	10	10	10	8	7	7	10	8
25	10	10	10	10	8	8	1	10	10
26	3	5	4	3	2	1	7	5	3
27	3	4	4	4	3	4	4	4	3
28	9	8	8	7	5	6	7	6	6
29	6	3	3	1	2	3	1	3	3
30	5	6	4	3	4	4	4	4	5
31	8	7	6	3	3	4	3	5	5
32	10	10	10	10	10	8	9	10	9
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34	6	7	7	7	6	6	4	6	3
35	10	9	9	9	8	8	8	10	7
36	4	3	4	3	3	3	4	3	2
37	3	1	2	1	1	2	2	2	1
38	2	2	2	1	1	3	2	1	1
39	3	2	3	2	1	4	2	1	1
40	2	1	2	2	1	4	3	2	2
41	3	2	4	3	1	5	2	3	1
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46	4	2	4	3	1	5	3	2	1
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48	2	1	2	3	1	5	2	1	2
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50	2	1	2	2	1	4	3	2	4
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65	2	1	3	4	2	6	3	3	3
66	3	2	3	2	1	3	2	3	1
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68	3	2	4	3	2	4	2	3	2
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70	3	2	5	4	1	4	2	3	3
71	3	2	3	2	1	5	4	2	3
72	3	2	3	2	1	5	2	3	1
73	3	2	3	3	2	4	3	2	3
74	3	2	3	2	1	4	3	2	2
75	2	1	3	2	2	4	3	4	3
76	4	2	4	3	1	5	3	3	2
77	3	2	4	5	1	5	3	2	3
78	3	2	5	4	1	4	3	4	3
79	2	1	5	4	2	5	3	5	3
80	5	3	7	6	4	5	3	4	3
81	5	4	6	5	3	5	4	2	4
82	2	4	6	5	1	5	4	2	3
83	4	2	4	3	2	5	3	2	1
84	3	3	4	3	1	3	2	4	5
85	2	1	4	3	1	4	3	2	1
86	6	5	4	5	4	5	6	3	7

S/N	I	M	F	T	SI1	SI2	SI3	SI4	SI5	SI6	SI7	SM1	SM2	SM3	SM4	SM5	SM6	SF1
1	10	8	7	9	6	7	7	8	8	9	10	9	6	10	8	10	8	6
2	10	10	10	10	10	10	10	10	10	10	10	8	5	10	9	9	10	7
3	4	5	3	4	6	5	3	4	3	2	6	8	8	10	9	5	4	8
4	3	3	2	3	4	7	6	5	7	3	7	4	3	5	4	3	2	4
5	9	10	7	9	6	7	6	5	6	3	5	5	3	4	4	3	2	4
6	10	10	10	10	10	9	10	10	10	10	10	10	10	10	10	10	10	8
7	10	10	10	10	9	9	9	9	9	9	10	7	5	8	8	9	8	9
8	9	10	8	10	8	8	9	6	8	6	9	10	9	8	9	10	10	8
9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
11	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
12	3	2	1	3	1	3	1	5	4	1	5	7	5	6	5	5	6	4
13	3	3	2	2	1	2	2	2	2	2	2	2	2	2	3	3	2	1
14	2	2	2	3	2	2	3	2	2	2	3	2	3	1	3	2	3	1
15	6	10	10	8	10	8	10	8	10	10	5	6	3	7	6	6	6	6
16	9	8	9	10	4	2	2	1	2	2	3	4	3	5	4	3	1	2
17	8	9	7	9	8	9	9	9	7	4	9	9	6	8	9	8	7	8
18	7	9	8	9	3	1	1	2	3	2	5	6	3	4	5	6	2	2
19	10	8	7	9	3	2	5	6	5	3	8	6	4	6	7	4	2	2
20	6	9	6	10	3	1	2	5	6	2	7	8	5	4	5	3	2	2
21	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	9	10
22	8	6	10	10	10	5	8	8	7	7	5	9	5	10	9	10	10	6
23	10	8	10	10	10	7	9	5	6	8	8	6	7	10	10	10	10	8
24	8	7	9	10	10	6	10	8	10	10	8	8	5	7	10	10	9	10
25	5	3	2	5	7	3	3	3	8	3	5	3	3	4	4	5	3	2
26	4	3	2	4	4	5	5	3	4	4	5	4	3	6	3	4	3	4
27	9	9	8	9	7	8	8	9	6	6	8	8	7	6	4	5	4	3
28	4	3	3	2	3	4	2	4	3	4	2	3	2	4	2	3	2	3
27	5	5	4	3	6	5	6	8	8	5	9	6	8	7	7	4	4	5
30	6	7	7	8	6	7	5	6	4	4	5	3	2	4	2	5	4	4
31	7	8	8	9	10	8	9	8	9	10	10	7	5	8	10	10	10	7
32	6	4	6	8	9	7	6	5	4	6	4	3	6	7	3	5	6	8
33	5	6	8	8	7	7	7	7	6	7	7	7	8	8	8	8	8	7
34	8	9	10	10	9	8	10	9	9	10	9	8	7	10	10	9	10	9
35	6	5	5	5	6	7	5	4	5	5	6	6	5	5	6	4	4	4
36	8	9	7	10	1	2	1	1	1	3	3	4	3	3	4	5	1	1
37	9	8	8	9	3	1	1	2	1	2	6	3	4	5	4	5	1	1
38	10	8	7	9	2	1	1	1	1	3	6	6	4	4	5	4	1	1
39	8	10	7	9	2	1	1	1	2	4	7	5	6	6	6	5	1	2
40	8	8	7	9	3	1	2	1	1	5	8	6	6	6	6	2	1	2
41	9	10	9	9	1	1	1	2	1	3	3	4	4	3	2	1	2	1
42	7	9	8	10	2	1	1	1	1	3	6	2	3	4	5	2	1	1
43	10	9	9	10	2	1	1	1	1	2	3	4	3	5	6	2	1	1
44	8	7	9	10	1	1	1	1	2	3	5	5	4	4	6	2	1	2
45	9	8	10	10	2	1	1	2	2	3	6	2	3	6	5	1	2	3
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47	10	9	10	8	1	1	1	1	2	3	6	2	3	5	4	2	1	1
48	9	8	9	10	1	1	2	1	1	3	4	5	4	6	6	3	2	2
49	10	9	10	10	1	1	2	1	1	2	4	3	2	3	3	2	2	1
50	8	9	10	10	2	1	3	1	1	4	5	3	2	4	4	2	2	1
51	7	6	5	6	6	5	5	5	6	5	7	7	6	7	6	6	6	7
52	8	9	9	10	1	1	2	1	2	3	4	5	3	3	3	2	1	2
53	9	10	10	9	2	1	2	3	1	3	5	4	5	3	2	1	1	2
54	9	8	10	10	2	1	3	1	2	4	4	4	3	4	4	2	2	2
55	8	9	8	10	2	2	3	2	1	4	5	5	4	3	2	1	2	2
56	9	10	8	10	2	1	1	2	2	3	4	5	3	4	3	2	1	2
57	10	8	9	9	2	1	3	1	2	4	5	5	4	3	2	1	2	2
58	8	7	9	10	2	1	4	3	2	6	3	4	3	4	3	2	1	1
59	10	8	9	10	3	2	4	3	3	6	5	5	4	4	3	2	1	1
60	10	8	8	10	2	3	1	2	1	4	4	5	4	3	4	2	1	2
61	9	7	9	10	2	1	3	2	1	5	2	6	5	4	7	2	3	4
62	9	10	8	9	2	1	1	2	1	4	5	5	4	3	3	2	2	2
63	9	8	10	10	3	2	4	1	3	5	6	6	4	3	2	1	1	3
64	9	8	7	9	3	1	2	2	1	5	5	6	4	6	8	3	2	2
65	9	7	10	9	3	2	4	2	3	4	6	8	5	5	6	3	2	3
66	9	8	7	10	3	2	4	2	1	4	7	7	6	6	5	2	2	2
67	8	10	9	8	3	2	4	2	3	5	6	7	4	5	4	3	1	2
68	9	8	7	9	4	3	2	1	2	5	6	8	4	3	4	2	1	2
69	8	9	8	10	2	3	3	1	1	6	7	6	4	3	4	2	2	1
70	10	8	8	9	3	2	4	1	1	6	7	7	4	5	5	3	2	3
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72	9	8	9	10	3	2	3	1	3	6	7	7	5	4	5	3	2	3
73	9	8	10	9	3	2	3	1	2	4	8	7	4	5	3	2	2	3
74	8	9	9	8	4	3	4	2	1	6	7	7	5	4	5	3	4	4
75	9	8	8	10	4	2	3	1	2	4	8	5	4	3	5	2	1	4
76	10	9	10	10	3	2	4	2	3	5	7	8	7	6	4	3	1	2
77	10	9	10	9	3	1	4	2	3	5	9	9	6	4	5	2	3	2
78	9	8	9	10	4	2	3	5	2	6	7	7	6	5	4	3	3	3
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80	6	8	7	9	4	3	2	5	4	2	5	7	6	5	3	3	4	4
81	9	7	10	10	5	3	2	4	1	6	7	8	5	7	8	4	5	4
82	8	7	8	10	4	1	2	4	3	6	7	5	4	5	3	4	3	3
83	8	10	9	10	6	3	3	4	2	5	6	7	5	6	8	4	2	3
84	8	9	7	10	6	4	2	4	1	4	6	8	4	6	7	4	2	4
85	8	7	8	10	4	3	5	7	4	6	9	8	5	7	4	6	6	5
Average	8.105	7.872	7.86	8.744	4.442	3.686	4.209	3.907	3.872	4.977	6.279	6.07	4.826	5.605	5.407	4.349	3.721	3.814
	STATISTICAL ANALYSIS																	
Range	8	8	9	8	9	9	9	9	9	9	8	8	8	9	8	9	9	9
Mean	8.082	7.871	7.871	8.741	4.424	3.647	4.177	3.859	3.824	4.929	6.235	6.035	4.812	5.553	5.377	4.282	3.671	3.788
Variance	3.838	4.138	5.305	4.504	8.652	8.612	8.766	8.837	9.147	5.995	4.706	4.654	3.940	5.179	6.095	8.181	9.343	7.217
Std. Dev	1.959	2.034	2.303	2.122	2.941	2.935	2.961	2.973	3.024	2.449	2.169	2.157	1.985	2.276	2.469	2.860	3.057	2.686
Coef. Of Variation	0.242	0.258	0.293	0.243	0.665	0.805	0.709	0.770	0.791	0.497	0.348	0.357	0.413	0.410	0.459	0.668	0.833	0.709
Std.error	0.213	0.221	0.250	0.230	0.319	0.318	0.321	0.322	0.328	0.266	0.235	0.234	0.215	0.247	0.268	0.310	0.332	0.291
Skewness	-1.305	-1.367	-1.437	-2.070	0.805	0.924	0.867	0.828	0.934	0.866	0.098	-0.032	1.090	0.659	0.599	1.024	1.130	1.039
Excess kurtosis	1.138	1.402	1.527	3.224	-0.634	-0.546	-0.515	-0.624	-0.493	-0.061	-0.692	-0.697	0.901	-0.359	-0.791	-0.235	-0.136	-0.064

SF2	SF3	SF4	SF5	SF6	SF7	SF8	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11
8	9	9	10	9	7	10	10	8	9	10	9	9	8	8	9	8	10
8	7	7	7	7	10	10	10	10	10	10	10	10	10	5	9	9	10
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2	5	3	3	2	3	3	3	2	4	4	6	4	5	4	7	5	4
10	10	10	10	5	5	10	10	10	10	10	10	5	10	7	5	10	10
9	5	7	9	7	8	9	10	10	9	10	10	10	9	9	3	10	8
9	7	6	6	7	5	6	4	4	2	4	3	2	2	2	1	1	1
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10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
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1	4	6	2	2	1	1	5	6	2	1	2	1	2	2	3	2	1
9	10	8	9	6	9	10	10	9	8	8	10	9	8	8	7	9	8
1	2	1	3	2	1	2	7	6	3	2	2	1	1	2	5	2	1
3	6	4	3	1	3	2	7	5	4	1	3	2	1	2	2	3	4
1	3	4	2	1	3	2	7	5	2	1	2	3	1	2	4	2	3
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4	2	2	3	2	2	3	4	2	6	3	3	1	2	3	1	3	3
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1	2	2	1	1	1	1	6	3	3	1	2	1	1	2	2	2	1
2	3	2	1	1	1	1	7	4	2	2	2	1	1	3	2	1	1
1	2	1	2	1	1	1	7	4	3	2	3	2	1	4	2	1	1
1	4	3	2	1	1	1	8	4	2	1	2	2	1	4	3	2	2
2	4	3	2	2	1	2	8	5	3	2	4	3	1	5	2	3	1
2	3	2	1	1	1	1	5	4	3	2	2	1	2	3	2	2	1
2	4	5	2	1	1	1	4	3	2	1	3	2	1	4	3	2	1
2	3	4	2	2	1	2	5	3	2	1	2	2	1	4	2	1	2
1	3	2	1	1	2	2	4	3	2	1	2	3	2	3	2	3	2
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1	5	4	2	1	2	1	5	4	3	1	3	2	1	5	2	3	3
1	4	4	2	1	1	1	6	5	2	1	2	2	1	4	3	2	4
2	3	3	1	2	1	3	8	7	2	1	3	2	2	4	2	1	2
6	6	6	6	6	5	6	5	6	6	6	5	5	5	4	4	3	3
1	4	5	2	1	1	2	7	6	3	2	2	1	1	2	3	1	1
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3	4	5	2	3	1	2	5	4	2	1	3	4	2	4	4	3	2
3	4	3	3	1	2	1	5	6	2	2	4	3	1	4	4	3	2
3	5	4	3	2	1	1	5	6	2	1	3	4	1	3	2	2	3
3	6	7	3	1	2	3	6	5	2	1	4	3	1	4	2	3	4
2	5	6	3	2	1	2	6	5	2	3	3	2	2	5	3	2	1
2	6	5	3	1	2	3	7	5	2	2	3	2	1	4	3	4	5
3	5	4	2	1	2	1	6	5	3	2	3	3	1	5	3	2	1
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3	6	6	3	2	2	2	5	5	2	1	2	3	1	4	2	2	1
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4	6	7	3	2	3	2	8	6	2	1	3	4	2	6	3	3	3
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3	6	5	2	3	3	2	6	5	3	2	3	2	1	5	2	3	1
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1	6	8	4	2	4	2	7	6	3	2	5	4	1	4	3	4	3
2	6	8	4	3	4	3	7	5	2	1	5	4	2	5	3	5	3
5	6	7	3	4	3	5	8	7	5	3	7	6	4	5	3	4	3
2	6	5	3	5	3	3	9	7	5	4	6	5	3	5	4	2	4
3	6	7	4	2	3	4	6	5	2	4	6	5	1	5	4	2	3
5	6	7	6	4	3	3	8	6	4	2	4	3	2	5	3	2	1
1	5	4	2	1	3	4	9	6	3	3	4	3	1	3	2	4	5
3	7	5	3	1	2	3	7	6	2	1	4	3	1	4	3	2	1
6	7	9	6	5	6	5	8	7	6	5	4	5	4	5	6	3	7
3.965	5.36	5.267	4.151	3.279	3.453	3.814	6.756	5.686	4.337	3.837	4.651	4.07	3.186	4.674	4.023	3.953	3.791
9	9	9	9	9	9	9	9	8	8	9	8	9	9	9	9	9	9
3.918	5.318	5.224	4.082	3.212	3.412	3.741	6.718	5.659	4.282	3.765	4.600	4.012	3.129	4.635	3.965	3.906	3.718
8.457	5.077	5.961	7.862	6.098	7.650	8.528	4.491	4.775	7.848	10.063	6.957	7.464	8.947	4.235	5.749	8.039	7.848
2.908	2.253	2.442	2.804	2.469	2.766	2.920	2.119	2.185	2.801	3.172	2.638	2.732	2.991	2.058	2.398	2.835	2.801
0.742	0.424	0.467	0.687	0.769	0.811	0.781	0.315	0.386	0.654	0.843	0.573	0.681	0.956	0.444	0.605	0.726	0.754
0.315	0.244	0.265	0.304	0.268	0.300	0.317	0.230	0.237	0.304	0.344	0.286	0.296	0.324	0.223	0.260	0.308	0.304
0.994	0.629	0.362	1.125	1.363	1.243	1.211	-0.126	0.632	1.187	1.082	1.081	1.214	1.353	1.027	1.311	1.308	1.169
-0.382	-0.037	-0.518	-0.012	1.094	0.511	0.174	-0.343	-0.053	-0.096	-0.320	-0.128	0.311	0.394	0.861	0.773	0.416	0.242