University of Gezira

Challenges and Opportunities of Water Safety Planning Implementation in Nyala, South Darfur State, Sudan (2017)

Mohammed Ishag Altaib Gomma

October/2018
Challenges and Opportunities of Water Safety Planning Implementation in Nyala, South Darfur State, Sudan (2017)

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Water Management
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Date: October/2018
Challenges and Opportunities of Water Safety Planning Implementation in *Nyala*, South Darfur State, Sudan (2017)

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Date of Examination: 22\(^{th}\) October/2018
DEDICATION

I dedicate this research project to Water Irrigation and Management Institution generally and teaching council specifically which is considered as my strong pillar to extract my knowledge and understand the directions. They have been the source of my strength throughout this program and on his wings only have I soared. I also dedicate this work to my small family whom was always the source of inspiration and wisdom has encouraged me all the way.
ACKNOWLEDGMENT

I would first like to thank my main supervisor Dain of Water Management and Irrigation Institution Dr. Eltigani Elnour Bashier, who provided me will all tools, essentially knowledge and advise to achieve the goal without his encouragement I might have the feeling of loneliness and isolated. He consistently allowed this research to be my own work, but steered me in the right the direction whenever he thought I needed it.

I would also like to thank the experts who were involved in collection and analyzed the survey for this research project: Without their passionate participation and input, the validation survey could not have been successfully conducted.

Finally I would like to extend my thanks to my family which always encourage me throughout almost three years, also my colleagues whom committed to enroll in this project and contribute to provide scientific solutions of water resource in Darfur.
Challenges and Opportunities of Water Safety Planning
Implementation in Nyala, South Darfur state, Sudan (2017)

Mohammed Ishag Altaib Juma

Abstract

The quality of water that is consumed is well-recognized as an important transmission route for infectious diarrheal and other diseases. Although the majority of the health burden is carried by children in developing countries, this research is investigating the challenges and opportunities of water safety planning in Nyala, South Darfur state. The research aims at investigating the problems of water supply system along the supply chain, understand households and community behaviour, practices and responsibilities to ensure Water Safety Planning (WSP) and to determine the role of water services providers in WSP implementation. The methods used to collect the required data were designed questionnaire and focus group discussion with Water and Environmental Sanitation project and the State Ministry of Health in Nyala town and other International Non-Governmental Organization (INGOs) as service providers. Statistical frequencies and percentages were used to analyse the collected data. The main findings were lacking sustainability approach of water supply and poor water quality control mechanisms to fit with the water safety planning. It has been found that water was stored (84%) in metallic elevated tanks, community members (81%) didn't clean their water containers and dirty Jerry cans (water handling containers) increases the exposure of drinking water contaminants due to existence of bacteria colonies and algae. The result of sanitary inspection showed 49% of distribution point did not have fencing for protection, the pipelines were not disinfected on regular basis, and community participation was poor as 68% of the community were not participated in the water projects. In water quality, water tanks and hand pumps were safe for human consumption while 60% of the water distribution points already contaminated also 50% of the boreholes were contaminated. Engagement of water users in water supply issues and in decision making will help into improvement and sustainable water supply. Also there is need to establish water master plan to include SDG targets so to achieve universal and equitable access to safe and affordable drinking water for all by 2030.
التحديات والفرص لتنفيذ خط سلامة المياه في نيالا، ولاية جنوب دارفور السودان (2017)

محمد اسحق الطيب جمعه

مستخلص الدراسة

ان نوعية المياه المستهلكة معرفة بشكل جيد كطريق انتقال مسبب للإصابة بالإسمال والأمراض المعدية الأخرى. على الرغم من أن غالبية العوامل الصحية التي تتحملها الأطفال في البلدان النامية، هذا البحث يكشف التحديات والفرص لتنفيذ دراسة خطة سلامة المياه في نيالا، ولاية جنوب دارفور. هذا البحث يهدف إلى دراسة مشاكل نظام إمداديات المياه على طول سلسلة الإمداد، وفهم السلوكيات والمسئوليات المجتمعية لضمان تخطيط سلامة المياه وتحديد دور مقدمي خدمات المياه في تنفيذ برنامج سلامة المياه. الطرق التي استخدمت في جمع البيانات هي استبيان المستفيدين (النازحين والمجتمعات المشتركة) ومجموعة نقاشات مركزة استهدفت فيها شركاء مشروع المياه، الإصلاح البيئي، وزوداء الصحة في ولاية جنوب دارفور وغيرها من المنظمات الدولية غير الحكومية كمقدم للخدمات. أوضحت النتائج تدهور عدد مراعاة الاستدامة في التخطيط السليم للمحافظة على جودة المياه. 84% من المياه مخزنة في خزائن حديدية عميقة وفي ارتفاعات مقبولة مقارنة بالمواصفات السودانية و81% من افراد المجتمع لا ينظفون أواني نقل وحفظ المياه بطريقة طبيعية وقد تساهم في تلوث مياه الشرب نسبة لنمو البكتيريا والطحالب. أظهرت نتائج الفحص الصحي أن 49% من نقاط التوزيع المياه لم يكن لديها سياج لحماية الإنسان والحيوان، وأخرى لا تحتوي على أبواب، وخط الأدايب نفسه لا يتم تطهيره بصورة منتظمة. كما أظهرت الدراسة 68% من المجتمع لا يشاركون في مشايع المياه واصلاح البيئة بصورة مطلوبة. من خلال بيانات نوعية المياه، اتضح ان مياه الطلعات آمنة للاستهلاك الشربي ولكنها تتعرض للتلوث من عوامل خارجية. ولكن 60% من نقاط توزيع المياه ملوثة وغير امنة وكذلك ظهرت التلوث في 50% من مياه الآبار. يجب إشراك مستخدمي المياه في قضايا إمدادات المياه وصنع القرار والمساعدة في تحسين إمدادات المياه المستدامة. كما يجب وضع خطة رئيسية للمياه يمكن من خلالها تحقيق ما يريده لها اهداف التنمية المستدامة الخاصة بمياه الشرب الأمنة وبأسعار معقولة للجميع بحلول 2030.
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# ACRONYMS AND ABBREVIATIONS

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<tr>
<td>WPS:</td>
<td>Water Safety Planning</td>
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<tr>
<td>INGOs:</td>
<td>International None Governmental Organizations</td>
</tr>
<tr>
<td>SDG:</td>
<td>Sustainable Development Goals</td>
</tr>
<tr>
<td>IDP:</td>
<td>Internally Displaced People.</td>
</tr>
<tr>
<td>WHO:</td>
<td>World Health Organization.</td>
</tr>
<tr>
<td>WASH:</td>
<td>Water and Sanitation, Hygiene</td>
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<td>OCHA:</td>
<td>Office for the Coordination of Humanitarian Affairs</td>
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<td>WES:</td>
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<td>HTH:</td>
<td>High Test Hypochlorite</td>
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CHAPTER ONE
INTRODUCTION

1.1 Introduction
Domestic water supplies are one of the fundamental requirements for human life. Without water, life cannot be sustained beyond a few days and the lack of access to adequate water supplies leads to the spread of disease. Children bear the greatest health burden associated with poor water and sanitation. Diarrheal diseases attributed to poor water supply, sanitation and hygiene account for 1.73 million deaths each year and contribute over 54 million disability Adjusted Life Years, a total equivalent to 3.7% of the global burden of disease (Harvell, et all, 1999).

The importance of water quality continues to be emphasized by its role in epidemics and contribution to endemic disease from pathogens (Payment, P. and Hunter, P.R., 2001). This affects both developed and developing countries, although the majority of the health burden is carried by children in developing countries (Prüss, A., Kay, D., Fewtrell, L,2002). Disease may also result from consumption of water containing toxic levels of chemicals. The health burden is most significant for two chemicals: arsenic and fluoride. Arsenic contamination of drinking water sources is being found in increasing numbers of water supplies world-wide. Fluoride is also a significant global problem and (Howard, G., Bartram, J., Water, S. and World Health Organization, 2003.) suggest that over 60 million people are affected by Fluorosis in India and China and suggest the total global population affected as being 70 million.

Since water is such an important component to our physiology, it would make sense that the quality of the water should be just as important as the quantity. Drinking water should always be clean and free of contaminants to ensure proper health and wellness. Water supply along the supply chain must be of high quality. Therefore, the World Health Organization recommends the adoption of the Water Safety Plan (WSP) approach as the most effective way of ensuring the safety of drinking water. This study was designed to look into WSP in Darfur region, Nyala, Otash camp.
1.2 Objectives

The Main Objective study: The overall objective is to sort the Challenges and Opportunities of Water safety planning implementation in water supply system.

1.3 The Specific Objective

1. To investigate the problems of water supply system along the supply chain in Otsah camp - Nyala.
2. To understand households and community behavior, practices and responsibilities to ensure WSP.
3. To determine the role of water services providers in WSP implementation.
CHAPTER TWO
LITERATURE REVIEW

2.1 Importance of Water

Water makes up more than two thirds of the weight of the human body, and without it, we would
die in a few days. The human brain is made up of 95% water; blood is 82% and lungs 90%.
A mere 2% drop in our body's water supply can trigger signs of dehydration: fuzzy short-term
memory, trouble with basic math, and difficulty focusing on smaller print, such as a computer
screen. (Are you having trouble reading this? Drink up!) Mild dehydration is also one of the
most common causes of daytime fatigue. An estimated seventy-five percent of Americans have
mild, chronic dehydration. Pretty scary statistic for developed country shoed water is readily
available through the tap or bottle. Water is important for the mechanics of the human body. The
body cannot work without it, just as a car cannot run without gas and oil. In fact, all the cell and
organ functions made up in our entire anatomy and physiology depend on water for their
functioning.

Water serves as a lubricant Water forms the base for saliva Water forms the fluids that surround
the joints. Water regulates the body temperature, as the cooling and heating is distributed through
perspiration. Water helps to alleviate constipation by moving food through the intestinal tract and
thereby eliminating waste -the best detox agent. Regulates metabolism In addition to the daily
maintenance of our bodies, water also plays a key role in the prevention of disease. Drinking
eight glasses of water daily can decrease the risk of colon cancer by 45%, bladder cancer by 50%
and it can potentially even reduce the risk of breast cancer. And those are just a few examples!
As you follow other links on our website, you can read more in depth about how water can aid in
the prevention and cure of many types of diseases, ailments and disorders that affect the many
systems of our bodies.

Our bodies are made up of 55-70% water, but it does not replenish itself, so drinking water helps
maintain that healthy balance. But even still, many will walk around dehydrated, most of the
time unknowingly. That is because thirst is a poor indicator of dehydration. By the time someone
gets thirsty, it is too late! Or, if one is thirsty, they may go for a beverage that does not actually
replenish the body. A cold soda may feel nice going down, but beverages with caffeine are not meant to hydrate. Water is the best remedy for dehydration. If mild dehydration sets in, it can decrease one's energy level and mental functioning and increase stress in the body. Severe dehydration can have far more damaging effects. There are three important rules when it comes to drinking water:

- Drink twice as much as it takes to quench your thirst. Drink frequently throughout the day to prevent dehydration. Drink at least eight glasses daily, or one cup for every 20 pounds of body weight. For example, a 150-pound person who does not exercise or work in hot climates needs 7.5 cups. While some fruit juices and green tea may account for some fluid intake, you can count out beverages such as coffee or alcohol. They have a mild diuretic effect, which promotes urination and therefore water loss, which ultimately defeats the purpose.

Another important factor is the amount of water necessary for our body to function at its peak performance. Bearing in mind again that your body is about 75 percent water it is easy to understand that water must be your body's most essential daily ingredient. Your body loses each day about 2-3 litters of water through elimination, urination, perspiration and respiration. However, this may increase during illness, high performance, exercise, pregnancy and nursing. The beverages most people choose to consume are often counterproductive in promoting hydration. Coffee, tea, alcohol, soft and sugary drinks are all diuretics and will cause not only the loss of water are dissolved in, but they will draw water the bodies reserves. In normal conditions, your body needs to replace the fluids it has lost throughout the day. Most of fluids should be replaced by drinking pure water. The rest you should get from fruit, vegetables and their juices. Attention must be given that the elderly and children are meeting their daily requirements. Dry mouth is not the only indication of dehydration; in fact, it is the last sign. You need to acquire the habit to drink water even when you think you do not need it and eventually your true thirst mechanisms will be reawaken. Signs to look for that identify with dehydration are constipation, headaches, indigestion, weight gain, fluid retention, dark and pungent urine, and their associated pathologies colitis, kidney stones, bladder and urinary tract infections to name only a few.
- Water is involved in all bodily functions: digestion, assimilation, elimination, respiration, maintaining temperature (homeostasis) integrity and the strength of all bodily structures. Today, the water is polluted with hundreds of toxins and impurities. Authorities only test for a small number of them. Your body, being primarily water, requires sufficient daily water replacement in order to function efficiently. Water treatments, that are aimed to render our drinking water bacteriologically safe, have been proven ineffective and the presence of certain pathogenic bacteria like giardia and cryptosporidium recently found in Sydney water is just one of the many examples. Viewing the effects of individual chemicals, inorganic minerals and their by-products, you can see a link to today's major diseases. If you drink devitalized, impure water, how can you expect vitality and health? Dehydration, due to the offensive taste of the water and the introduction of commercial sugar loaded beverages, has become another contributing factor to dis-ease.

- Mineral water may be wonderful to bathe in; however, the presence of inorganic minerals makes it undesirable, pure water may become the medicine of the future. 'Oxygen enriched and free of radioactive and chemical compounds' may read on the label of our bottle water in the next millennium.

2.2 Quantities of Water Required for Cooking

Water is essential as a medium for preparing food. One study noted that the volume of cooking water available may be an important determinant for diarrhea incidence in children over 3 years of age, although this was less important than water quality for the under 3 years age group (Howard, Bartram, Water, and World Health Organization, 2003.).

Defining the requirements for water for cooking is difficult, as this depends on the diet and the role of water in food preparation. However, most of the community cultures have a staple foodstuff, which is usually some form of carbohydrate-rich vegetable or cereal. A minimum requirement for water supplies would therefore also include sufficient water to be able to prepare an adequate quantity of the staple food for the average family to provide nutritional benefit. It is difficult to be precise about volumes required to prepare staples as this depending on the staple itself. However, an example can be provided for rice, which probably represents the most widely used staple food worldwide. Recommendations for nutrition usually deal with the intake of nutrients rather than specific food stuffs. Most
food pyramids give a suggest an intake for cereals of 6 to 11 servings per day, or 600 – 1100 grams per day (Graeme Clugston, personal communication). To prepare the rice using the adsorption method, 1.6 liters is required for 600g per capita per day. More water may be required to ensure that other foodstuffs can be cooked, although defining minimum quantities is difficult as this depends on the nature of the food being prepared. For instance, Gleick (1996) suggests that on average 10 litres per capita per day is required for food preparation, whilst Thompson et al, (2001) show that in East Africa only 4.2 litres per capita per day were used for both drinking and cooking for households with a piped connection and even less (3.8 litres per capita per day) for households without a connection. Taking into account drinking needs, this suggests that between 1.5 and 2 litres per capita per day is used for cooking. if the quantity of water required for cooking rice is taken as representing the needs for staple preparation and assuming further water is required for preparation of other food, the evidence suggests that in most cases approximately 2 litres per capita per day should be available from domestic supplies to support food preparation. By adding the volume required for food preparation to the volumes identified in table 2, a figure for total consumption (i.e. Drinking water plus water for foodstuffs preparation) of 7.5 liters per capita per day can be calculated as the basic minimum of water required, taking into account the needs of lactating women.

2.3 Water Quantity Requirements for Hygiene
The need for domestic water supplies for basic health protection exceeds the minimum required for consumption (drinking and cooking). Additional volumes are required for maintaining food and personal hygiene through hand and food washing, bathing and laundry. Poor hygiene may in part be caused by a lack of sufficient quantity of domestic water supply (Cairncross and Feachem, 1993). The relative influence of consumption of contaminated water, poor hygiene and lack of sanitation on diarrheal disease in particular has been the topic of significant discussion. This has mirrored a broader debate within the health sector worldwide regarding the need for quantifiable evidence in reducing health burdens. The desire for evidence-based health interventions is driven by the need to maximize benefits from limited resources (a critical factor both for governments and their populations). It is also driven by the desire to ensure that
populations benefit from the interventions that deliver the greatest improvement in their health. Human alteration of the nitrogen cycle has resulted in steadily accumulating nitrate in our water resources. The U.S. maximum contaminant level and World Health Organization guidelines for nitrate in drinking water were promulgated to protect infants from developing methemoglobinemia, an acute condition. Some scientists have recently suggested that the regulatory limit for nitrate is overly conservative; however, they have not thoroughly considered chronic health outcomes. In August 2004, a symposium on drinking-water nitrate and health was held at the International Society for Environmental Epidemiology meeting to evaluate nitrate exposures and associated health effects in relation to the current regulatory limit. The contribution of drinking-water nitrate toward endogenous formation of N-nitroso compounds was evaluated with a focus toward identifying subpopulations with increased rates of nitrosation. Adverse health effects may be the result of a complex interaction of the amount of nitrate ingested, the concomitant ingestion of nitrosation cofactors and precursors, and specific medical conditions that increase nitrosation. Workshop participants concluded that more experimental studies are needed and that a particularly fruitful approach may be to conduct epidemiologic studies among susceptible subgroups with increased endogenous nitrosation. The few epidemiologic studies that have evaluated intake of nitrosation precursors and/or nitrosation inhibitors have observed elevated risks for colon cancer and neural tube defects associated with drinking-water nitrate concentrations below the regulatory limit. The role of drinking-water nitrate exposure as a risk factor for specific cancers, reproductive outcomes, and other chronic health affects must be studied more thoroughly before changes to the regulatory level for nitrate in drinking water can be considered. (Ward et al., 2005).

2.4 Water Source in Sudan
The Darfur conflict is strongly linked to increasing pressures on the readily available natural resources, particularly lack of adequate water supply to meet the immediate demand of population. It has been estimated in this study that current water supply in Darfur region represents only about 14% of the required domestic and livestock demand. Available records on conflict in Darfur indicate that out of 49 recorded conflicts that took place during the past six decades, more than 75% of them were triggered due to high competition over water and pasture especially during low rainfall seasons, therefore, any plans to achieve peace
and stability in the region, would require an integrated water management strategy that ensures the provision of sustainable water supply to meet livelihood needs of the people of Darfur. Failure to adopt the integrated approach could lead to more water supply problems, which may lead to more conflicts in the future.

The main objective of this study was to conduct a preliminary assessment of the water resources of Darfur and suggest directions for strategic water resources management. While addressing this issue, there were many key problems and bottlenecks pertaining to Darfur water resources that were important to look at, in order to ensure the sustainability of the recommended management strategy. Examples of these problems are absence of monitoring and water resources information base, lack of comprehensive guiding policy document and water strategy linked to a plan of action, poor governance and legislative framework, inadequate capacity development, lack of coordination among water sub-sectors and inadequate stakeholders participation (Abdu, Gama.- Water Resources Management in Darfur- 2016).

2.5 The Main Water Resources Potential

2.5.1 Rainfall
The climate in Darfur varies from extremely arid in the north to semi-tropic climate in the southern part. Accordingly, rainfall varies from less than 50 mm in the northern part of the region to more than 1000 mm in the higher altitude savannah regions of South and West Darfur. Typical to arid zone characteristics, rainfall data analysis in Darfur shows that it is highly seasonal and highly variable in space and time with annual coefficient of variation ranging from 30% in central Darfur to more than 40% in the northern desert.

Analysis also shows annual rainfall decreasing trend and a marked shift in rainfall isohyets towards the south, Furthermore North Darfur rainfall records show increased frequency of droughts over the past 40 years. Sixteen out of 20 driest years on record in North Darfur have occurred since 1972, it appears from the above features that the climate in Darfur is influenced by global climate change. This matter, however, needs further research to determine the effect of global climate dynamics on Darfur climate and suggests action plans to overcome the related challenges.
2.5.2 Wadi Water Resources
The hydrological system in Darfur depends mostly on rainfall on Jabil Mara and the surrounding hills of central Darfur draining radially through nine large Wadi systems. Due to lack of monitoring, Wadi flow data in Darfur is generally poor, except for very few Wadies such as Wadi Nyala. For the purpose of this study, techniques for flow estimation in ungauged catchments have been employed, with catchment characteristics for different Wades; being derived from satellite data and average rainfall over a gauged catchment. The total average Wadi flow has been estimated as 1159 MCM/y distributed among the three Darfur states as 100 MCM/y, 159 MCM/y and 900 MCM/y for North Darfur, South Darfur and West Darfur respectively. Though this resource is of reasonable magnitude, it is concentrated during the rainy season from June to October and therefore it requires careful management including recharging potentials within the underlying formation.

2.5.3 Groundwater Resources
Darfur has three basic hydrogeological units, the deep sedimentary basins of the Nubian Sandstone and Um Raba aquifers, the Wadi Alluvial aquifers and the fractured aquifers of the Basement Complex. Detailed information on the vertical extents, saturated thicknesses, the hydrogeological characteristics, recharge sources and recharge mechanisms, water balance components and exchange of flow between surface and groundwater or between aquifers themselves in the different basins are not available. Considerable work is needed to fill in these information gaps. However, for the purpose of this study, a rapid assessment has been carried out using the available limited data and the results are presented in Table 2 which shows the Darfur groundwater storage potential, annual recharge and current abstraction rates. As can be seen, the current groundwater abstraction represents less than 2% of the annual recharge. Therefore, there is still large renewable and storage potential for groundwater development in all Darfur States. It should be emphasized that groundwater monitoring systems should be put in place before embarking on large scale development.

2.6 Water Supply Vulnerability
The future adequacy of freshwater resources is difficult to assess, owing to a complex and rapidly changing geography of water supply and use. Numerical experiments combining climate model outputs, water budgets, and socioeconomic information along digitized river networks
demonstrate that (i) a large proportion of the world's population is currently experiencing water stress and (ii) rising water demands greatly outweigh greenhouse warming in defining the state of global water systems to 2025. Consideration of direct human impacts on global water supply remains a poorly articulated but potentially important facet of the larger global change question (Vörösmarty, et al 2000).

2.7 Water Supply Demands
Water is a naturally circulating resource that is constantly recharged. Therefore, even though the stocks of water in natural and artificial reservoirs are helpful to increase the available water resources for human society, the flow of water should be the main focus in water resources assessments. The climate system puts an upper limit on the circulation rate of available Renewable Freshwater Resources (RFWR). Although current global withdrawals are well below the upper limit, more than two billion people live in highly water-stressed areas because of the uneven distribution of RFWR in time and space. Climate change is expected to accelerate water cycles and thereby increase the available RFWR. This would slow down the increase of people living under water stress; however, changes in seasonal patterns and increasing probability of extreme events may offset this effect. Reducing current vulnerability will be the first step to prepare for such anticipated changes.

2.8 Population Increase
The renewable of water resources is finite and vulnerable overexploitation especially after clear increasing in population. In 2015 the world population reached 7.3 billion, implying that the world has added approximately one billion people in the span of the last twelve years. Sixty per cent of the global population lives in Asia (4.4 billion), 16 per cent in Africa (1.2 billion), 10 per cent in Europe (738 million), 9 per cent in Latin America and the Caribbean (634 million), and the remaining 5 per cent in Northern America (358 million) and Oceania (39 million). China (1.4 billion) and India (1.3 billion) remain the two largest countries of the world, both with more than 1 billion people, representing 19 and 18 per cent of the world’s population, respectively.
More than half of global population growth between now and 2050 is expected to occur in Africa. Africa has the highest rate of population growth among major areas, growing at a pace of 2.55 per cent annually in 2010-2015. Consequently, of the additional 2.4 billion people projected to be added to the global population between 2015 and 2050, 1.3 billion will be added in Africa. The concentration of population growth in the poorest countries will make it harder for those governments to eradicate poverty and inequality, combat hunger and malnutrition, expand education enrolment and health systems, and putting high pressure on provision of water supply service in Africa.

Sudan in 2015 42,433 which will predicted to be 63,530 million which will increase the water supply demand putting more pressure in limited sources that will reflect in as water deficit.

### 2.9 Climatic Changes

Human and natural activities affect virtually all sections of the water cycle, often with additive effects. Over time, human activities such as forest clearing, afforestation, agriculture, etc., have disturbing influences on the water cycle including evapotranspiration, flow regimes, groundwater table and sea level. Also, human activities influence cloud formation via the emission of aerosols and their gaseous precursors, Principal threats to water resources for humans include water pollution (the contamination of surface water and groundwater reservoirs with chemicals and microorganisms); water scarcity (the change of run-off regimes and the change – mostly lowering – of the groundwater table). Climate change has been defined by the
Intergovernmental Panel on Climate Change, IPCC (Smithson, P. A., 2002. IPCC, 2001), as statistically significant variations in climate that persist for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature. Climate, water resources, biophysical and socioeconomic systems are interconnected in complex ways, so a change in any one of these induces a change in. Anthropogenic climate change adds a major pressure to nations that are already confronting the issue of sustainable water resource use, such as in Africa. Observational records and climate projections provide abundant evidence that water resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems (Batiste, al, 2008). Numerous internal and external feedback paths occur between anthropogenic impairment of the water cycle and the environmental resources of the atmosphere, soils and the biosphere.

2.10 Water Quality
The general water quality considered one of the issues creating health problem in Nyala rural and urban, the bacterial contaminations in drinking water in Nyala city, South Darfur, Sudan with special reference to the internally displaced people camps (IDPs). Two hundred and forty water samples from different sites and sources including bore holes, hand pumps, dug wells, water points, water reservoir and household storage containers were collected in 2009. The most probable number method was used to detect and count the total coliform, faecal coliform and faecal enterococci. Results revealed that the three indicators bacteria were abundant in all sources except water points. Percentages of the three indicators bacteria count above the permissible limits for drinking water in all samples were 46.4% total coliform, 45.2% faecal coliform and 25.4% faecal enterococci whereas the highest count of the indicators bacteria observed was 1,600 U/100 ml water. Enteric bacteria isolated were Escherichia coli (22.5%), Enterococcus faecalis (20.42%), Klebsiella (15.00%), Citrobacter (2.1%) and Enterobacter (3.33%). The highest contamination of water sources was observed in household storage containers (20%) followed by boreholes (11.25%), reservoirs (6.24%), hand pumps (5.42%) and dug wells (2.49%). Contamination varied from season to season with the highest level in autumn (18.33%) followed by winter (13.75%) and summer (13.32%), respectively. All sources of water in IDP camps except water points were contaminated. Data suggested the importance of greater
attention for household contamination, environmental sanitation control and the raise of awareness about water contamination (Abdelrahman, and Eltahir, 2011).

2.11 Source of Drinking Water Contamination
In many parts of the developing world, drinking water is collected from unsafe surface sources outside the home and is then held in household storage vessels. Drinking water may be contaminated at the source or during storage; strategies to reduce waterborne disease transmission must safeguard against both events. We describe a two-component prevention strategy, which allows an individual to disinfect drinking water immediately after collection (point-of-use disinfection) and then to store the water in narrow-mouthed, closed vessels designed to prevent recontamination (safe storage). New disinfectant generators and better storage vessel designs make this strategy practical and inexpensive. This approach empowers households and communities that lack potable water to protect themselves against a variety of waterborne pathogens and has the potential to decrease the incidence of waterborne diarrheal disease. (Mintz, E.D., Reiff, F.M. and Tauxe, R.V., 1995. Safe water treatment and storage in the home: a practical new strategy to prevent waterborne disease. Jama, 273(12), pp.948-953).

2.12 Water Safety Planning
2.12.1 Definitions, Concept and Principles
Unsafe drinking water, poor sanitation and lack of hygiene continue to be significant causes of disease in both developing and developed nations, resulting in millions of deaths each year, mainly among children under five (Prüss-Üstün et al 2008). Much of this disease burden is preventable. It is estimated that almost one-tenth of the global disease burden could be avoided by improving water, sanitation and hygiene. Poor drinking-water quality is a significant contributing factor to this burden and outbreaks have shown that the conventional approach of monitoring end product water is not sufficient to guarantee safe drinking water. Notification comes too late, test results are not timely enough to prevent consumption of unsafe water and sufficient information is not provided to identify the source of contamination (when, why and where it occurred). Recognizing these limitations, the World Health Organization recommends the adoption of the Water Safety Plan (WSP) approach as the most effective way of ensuring the safety of drinking-water.(Water Safety Plan guideline – WHO)
The Water Safety Planning (WSP) approach emphasizes preventive risk management. It requires that risks to drinking-water safety are identified, prioritized and managed to protect drinking-water quality before problems occur. This approach draws on the methodology of sanitary inspection, which offers quick results and clearly identifies action points for improvements. Water safety planning also requires regular monitoring of control measures and periodic confirmation of water quality (verification/compliance monitoring). The WSP itself documents the process and practice of providing safe water at the community level. It is vital to remember that the WSP document in itself is not the end; rather, it is a beginning.

Water Safety planning is process of ensuring water quality in all level of its paths (from the catchment to the mouth of the beneficiaries. The WSP approach, community members identify and prioritize health risks and, where necessary, take steps, over time, to improve the safety of the water supply using available resources. WSPs are applicable for a range of scales and levels, and in different contexts. A WSP can be developed for all existing schemes, from point sources to piped systems, as well as for new supplies. In new schemes, it should be straightforward for the supporting agency to incorporate the WSP approach into initial community mobilization and project implementation. The development and implementation of WSPs in small community water supplies are associated with many positive impacts. Implementing a WSP will improve day-to-day risk management and operation of the water supply and will ultimately lead to consistently safer water. It provides a catalyst to develop essential skills and capacities of community members. The WSP process encourages a team-based approach, improving cooperation and engagement with stakeholders and technical experts. (WHO manual for Water Safety Planning for small communities)

**2.12.2 Steps and Process of Water Safety Planning**

Steps and process of WSP been illustrated by several practical examples of what has been effective for some WSP implementers. The examples highlighted that flexibility should be applied in developing and implementing WSPs to take account of local conditions and circumstances. It is up to each community to determine how best to achieve each task and establish a “living” WSP (Bartram J et al). While each task in developing the WSP is an integral part of the whole planning process, each task on its own helps improve the management of a small community water supply and may be undertaken or updated at any time.
2.12.3 Task1: Engage the Community and Assemble a Water Safety Plan Team
The community as a whole can be engaged in a number of ways. It is generally more efficient and effective to identify suitable members of the community to represent the community’s interests as part of a WSP team. Other methods of engagement include, for example, public meetings, participatory techniques (e.g. participatory rural appraisal, mapping, transect walk, pocket chart; see Glossary) and subgroup (corner) meetings by service areas or interest groups (women, the poor, farmers). A visit to a nearby community that has successfully applied a WSP is a good way to trigger interest in the approach. If you already have an established community group in charge of managing the community water supply – for example, a water association, a water user group or an operation and management committee – you do not need to create a new team solely for the WSP: you can incorporate the WSP tasks into the roles and responsibilities of the existing group. This will help you to integrate the WSP into existing management structures.

WSP team list. One person should be chosen as the WSP team leader who drives the water safety planning process with authority and motivation. You may need external support for some aspects: do not hesitate to ask, for example, your local health office, water supply office or NGOs for help. Local water, sanitation and hygiene experts also have a strong interest in the safety of your water supply and can support you. It is important that your WSP team meets regularly. As the WSP is about the day-to-day operation and management of your supply, you should ensure regular communication about what you have been doing, any challenges you are facing and what you need to do next. You will typically have more meetings at the beginning of the WSP implementation process, but do not forget to continue meeting once you have gone through the WSP tasks for the first time. A WSP is never finished but is a continuous process.

2.12.4 Task1 Assemble a Water Safety Planning Team
A WSP covers all steps of the water supply system from the area where the source water originates all the way through to the point of water consumption. You should describe this whole system as the basis for your next WSP tasks. You will see that a thorough and accurate system description will be of great help as you carry out WSP tasks 3 and 5 ahead. In day-to-day operations, you will regularly see the installations for water abstraction (including wellheads and spring boxes) and treatment (if in place), central storage reservoirs and public taps. To complete the WSP system description, however, you will also need to visit the drainage area from which your water comes and to look at the storage and handling practices for drinking-water in homes.
Contamination may be introduced to the drinking-water supply system in both these areas and they therefore need to be considered.

Do you have several water sources, several water abstraction points or several water storage reservoirs? Make sure that your system description includes all of them and that you do not overlook any part of your water supply system. To complete this WSP task you should draw an overview map of your entire supply system, Map of water supply system. You should also describe your system in more detail. Description of water supply. Please note that this is not a task you can complete sitting at a table. The WSP team needs to walk along all parts of the water supply and visit, for example, all water abstraction facilities and collection points, treatment and storage facilities and public taps, in order to describe the system accurately.

In case you need to explain something about your system to somebody who has not seen it, or if you want to re-check something after the site visit, it is helpful to take pictures if you have a camera or mobile phone available. If there is any information you do not have, it is worth asking for external support. Your local health office or water supply office may have information on the quality of your water, for example. The WSP team should be responsible for developing, implementing and maintaining the WSP. The team is also needed to help the community to understand and accept the WSP approach. When choosing WSP team members, it is best to consult community leaders, such as elders, elected officials or other persons who know the community well. Ideally, team members will have varying backgrounds.

2.12.5 WSP Task 3. Identify and Assess Hazards, Hazardous Events, Risks and Existing Control Measures
This task is at the heart of the WSP. To complete it, you need to ask yourself the following questions for each step of your water supply system.

- What can go wrong?
- How and why might it go wrong?
- At what times and where might it go wrong?
- Is anything being done to prevent it from going wrong?

For this WSP task, the first job of the WSP team is to identify what dangers (so-called “hazards”) might threaten the safety of your water supply, and how and at what supply steps these hazards might be introduced (so-called “hazardous events”).
Hazards include harmful pathogenic microorganisms (for example, from human or animal faeces), chemicals (for example, from agriculture or manufacturing), physical constituents (for example, turbidity, which is caused by very fine particles suspended in water) or simply a lack of water. Examples of hazardous events include heavy rainfall, snow-melt, pipe breaks, malfunction of a disinfection unit or power cuts. Often a hazardous event is a combination of several events and unfavorable conditions: for example, heavy rainfall causing surface runoff, which collects animal faeces from the ground and then enters a damaged wellhead.

Different kinds of hazardous events can introduce hazards at every step of your water supply. For instance, the same hazard (for example, pathogenic microorganisms derived from faeces) may be introduced to the water supply by defecating animals at the water collection point, by faecal contamination from a latrine, or by consumers who handle water in their homes with dirty hands. Depending on how often the hazardous event could happen and how severe the consequences of the hazard could be, the risk to public health will be greater or smaller. In a WSP, you should always consider hazards and hazardous events in pairs and assess the risk for each pair (see the table on the next page). To complete this assessment you will need to have detailed discussions within the WSP team about which risks you consider more important than others. The relative importance of individual risks is different for every water supply system and for every community. Always remember that the focus of a WSP is the protection of community members’ health. Other issues may also be important to your community but should not be the basis of your WSP risk assessment. “Control measures” are barriers preventing contamination. Fencing off animals from your well, having a screen at your reservoir air vents preventing ingress of insects and disinfecting the water are examples of control measures that prevent water from becoming unsafe. With control measures you can reduce the risk of a hazard causing harm to your community. Make sure that these control measures work effectively: a fence with an open gate or inadequate disinfection procedures may not reduce the risk and will give you a false feeling of safety. You should always maintain several control measures to prevent contamination at different steps along your water supply for the best results. Using this approach you can greatly reduce the risk of contamination reaching the consumers of your water supply.

2.12.6 WSP Task 4. Develop and Implement an Incremental Improvement Plan
As a result of the previous WSP task you have a list of risks to your water supply system, which you ranked according to how important you think they are. You also identified whether you are
already doing enough to prevent those events from happening or whether improvements are needed to protect water safety. Based on this, you can now develop a detailed action plan describing what you will do to address important risks and thereby improve the condition and operation of your water supply. You will typically achieve these improvements either by adding new control measures or by enhancing existing controls. Your improvement plan should always explicitly state who is responsible for the improvement action, when it will be done and with which resources. Be specific when defining these details: the more clearly you describe the actions needed, the more likely it is that they will be done.

This principle also holds true for other WSP tasks. Typically, the plan includes improvements you can make straight away with limited resources: for example, cleaning faeces or garbage from the cover of a spring box and its surroundings, or putting up a poster with pictures and diagrams describing basic hygienic water collection principles. Other actions or system upgrades may take more time and financial resources: for example, installing a chlorination unit to address microbial contamination in your system. Improvement plan. This plan should reflect all the steps you intend to take, including both small steps you are taking straight away and larger steps you have identified as important, even though you may lack the required resources at the moment. With a detailed improvement plan, you can show that you have thoroughly assessed what needs to be done in your system, and use this as a basis for seeking financial or other support for larger upgrades and improvements you need, for example, from donors or NGOs.

2.12.7 WSP Task 5. Monitor Control Measures and Verify the Effectiveness of the WSP

Two types of monitoring are integral parts of the WSP: compliance monitoring and operational monitoring. The first is the testing of drinking-water quality to confirm that it complies with water quality standards, which is typically done by the local health office on a regular basis. In the language of the WSP this is called “compliance monitoring”. Regular testing of your drinking-water is very important. It confirms the safety of your drinking-water at certain points in time, and it helps you to verify from time to time whether or not your WSP is working properly. To document your compliance monitoring plan in collaboration with your local health office,. Compliance monitoring plan.

Although compliance monitoring is an important part of your WSP, always remember that this testing alone cannot assure you that your water supply system continuously delivers safe drinking-water for two reasons. First, compliance monitoring is typically done only once or
twice a year. It will therefore not reflect drinking-water quality between testing dates. Second, test results will be available to you only after people have already drunk the water. The results will always come too late to prevent people from drinking contaminated water. Consequently, in addition to compliance monitoring by the health office, the WSP team should conduct “operational monitoring”. Operational monitoring checks and confirms that the control measures you have in place are working properly to prevent contamination from occurring. For example, rather than relying solely on compliance monitoring to detect faecal contamination of the water supply, you can regularly check the integrity of your fence to prevent animals from accessing the well area and contaminating your water.

2.12.8 WSP Task 6. Document, Review and Improve all Aspects of WSP Implementation
Regular and diligent maintenance of water supply infrastructures and ongoing attention to important operational tasks are essential to ensuring a continuous supply of safe drinking water in your community. Your next task is therefore to make sure that the caretaker or operator responsible for running the water supply has step-by-step instructions for carrying out important operational and maintenance tasks (often referred to as “standard operating procedures”) such as cleaning of reservoirs and operating the chlorination unit. These instructions will give the caretaker confidence that he or she always knows what to do and when. The instructions will also be useful when new caretakers need to be trained, or when the caretaker happens to be ill or on leave and needs to be replaced. If you already have a caretaker manual for your water supply system, you should review it to make sure it is up to date.

It is also important to consider and document what you would do in case of a water supply emergency: for example, inform the local health office and consumers that the water is not safe at the moment and that consumers should boil it to avoid ingesting microbial contaminated water.

The full WSP documentation helps you to manage your water supply effectively and to show its status and changes over time to others who are not as familiar with the system as you are. In this way, even when you are ill or on vacation the person filling in for you will have the basic information needed at hand. As part of your WSP team meetings, you should periodically review your WSP to check whether it still reflects the actual situation. To do so, go through all the WSP tasks described above again and ask yourself the following questions.

- Is this still the case?
Has my supply system changed?
Have I identified new risks?
Do my control measures work?
Are the water quality test results satisfactory?
What improvement actions have I already completed?

2.13 Implementation Challenges

2.13.1 Institution Roles, Rules and Regulations
Small community water supplies consist of the system(s) used by the community to collect, treat, store and distribute drinking-water from source to consumer. The definition of a small community water supply can vary widely within and between countries. Some countries define small community water supplies by, for example, population size, and the quantity of water provided, the number of service connections or the type of supply technology used. However, it is the operating and management challenges they face that most commonly set small community water supplies apart. Small community water supply operators are often untrained or undertrained and sometimes unpaid. They may work only part-time and may be charged with other responsibilities within the community or privately.

The other challenges in the water safety planning are in the overall implementation strategy where less focus is given to the water quality as a system. Now days the implementing partners have scattered efforts in water safety maintain, some of them just focus only in chlorinating the water at the tank and then follow the measure quality at the downstream without consideration of the upstream chain where the source could be contaminated with different external factors.

Other challenges that face the water supply quality as general and the water safety planning in particular especially in the context of the humanitarian program and even the urban water supply is that the allocation of the resource from the government at different level is very big challenges. (more analysis will come in Chapter 4), Water safety planning in Sudan also still quite away from what happening in the globe interim of technology and knowledge use in water supply management. for example still the main water treatment is either chlorine or polymer while other technologies and methods can be widely used in very effective away like solar disinfection for the rural areas for example.
CHAPTER THREE
MATERIALS AND METHODS

3.1 Study Area
Nyala, city, southwestern Sudan, located at an elevation of 623 meters above the mean sea level, it is the capital of south Darfur state where 513, 288 individuals living inside Nyala town and the surrounding rural (Sudan statistical survey 2007-2008). Local industries produce textiles, as well as processed food, and leather goods. Nyala has terminus ends for both road and railway, and has a domestic airport, Nyala Airport. Nyala serves as a trading place for gum Arabic. The metrological data for forty years obtained from Nyala stations showed that the minimum and maximum temperature were 20.98 C and 43.14 C respectively, the lowest temperatures were reported in January-February while the highest temperatures were reported in May (Abd Elrahim, A, 2015).

Wadi Nyala, receives annual runoff about 75 million cubic meters each years during the rainy rain season which is fall between June-November, some runoff receive from Jebel Mara located about 90 Km north-west, where the rainfall is small reliable even in drought years and according to united nations environment report, the annual rainfall in Nyala is 384 mm per year which is estimated, from 1978-2007 Wadi Nyala, remains the unique recharging source for the whole ground water shallow aquifers in the area where the most of the water users including the displaced people depend on it. For the benefit of the displaced people, a total of 461 water sources have been drilled mainly inside the settlement of the IDP camps (WASH sector Camp profile, 2017).

The general topography dips gently from west to east in the watershed and its layer in the basement complex (rocky area) covered by alluvial sediment). Nyala suffers from severe water infrastructure caused by droughts and poor water management. Most of the water used in Nyala is ground water. This ground water is heavily contaminated due to human activity, such as inadequate waste management. The lack of proper sanitation has contaminated ground water in the region. Water resources in the city have tested to contain bacteria levels higher than permissible amounts. The poor water quality in the city creates health issues. The water source in combination with the water delivery methods add to the contamination of water resources in
Nyala. In many cases, the water collected for distribution is not properly chlorinated, allowing further increase in bacteria levels. Otash is part of Nyala north where it is considered as city skirt and the rural area, the total host community estimated around 25000 individuals and after. Armed conflict occurred in 2003 where many people displaced to this area making the total of 97000 IDPs settling now in Otash camp.

In 2016, new conflicted occurred in Jebel Mara area caused new wave of displacement toward the camp and added new caseload, International Organization Migration which the main agency for population tracking has conducted registration exercise which resulted in extra 16 new IDPs arrived and settled in, Otash (Humanitarian Bulletin Sudan 10 May 2017). In Otash area there are 30 borehole drilled closed to the small Wadi passing through the area with very limited recharges capacities leading to borehole (hand pumps and min water yards dry out during the dry season and according to the camp profile, (water and sanitation and hygiene sector tools for monitoring and mapping) the drinking water is around 10 liters per person in the settlement of the IDPs camp and this monitoring data is the quarterly follow up used by the sector partners operating on the camp and been shared at national level.
Figure (3.1): Study area map

3.2 Data Collection Methods

3.2.1 Design of Questionnaire

For the purposes of the research objectives, the questionnaire was designed to reflect the findings along the water supply chain and its connectivity to the beneficiaries from both the IDPs and the host communities' collecting water from the sources. In the area looking into the contamination factors in the chain and the behavior of the water users at their households, therefore, the questionnaire designed and divided into three main sections: first parts focused on the general condition of the water supply facilities including water sources, storage and distribution points. Second section concentrate on the household members' behavior and practices with the water at home and the main responsibilities distribution among the members while the third section focused on the services providers and their existing plans and implementation in ensuring the safety of the water in the different stages of the water project implementation. This included the
International Origination working in the humanitarian response in the area, the government Water and Environmental Sanitation (WES) sector lead as the guiding body for these implementing partners and finally the Ministry of Health at the state level.

3.3 Random Sample Selection for Household
The IDP camp divided to 4 blocks (North, South, West & East). Firstly, a random direction from the center of the cluster is selected, usually by spinning a pen. The houses along that direction are then counted out to the boundary of the cluster, and one is then selected at random to be the first household surveyed. This process favors households towards the center of the cluster (Emerg Themes Epidemiol. 2007).

3.4 Focus Group Discussion
After the data collection from both the water supply system and the household, it was necessary to have the view of the other part of the stakeholders, which are mainly the implementing partners and the sector lead, therefore focus group discussion on water safety planning was conducted in Nyala with Water and Sanitation Project beside the Ministry of Health from the government side and the World Vision international which currently handling the water supply in Otash IDP camp as the implementation partner. Finally, the data was analyzed using simple statistical frequencies and percentages and the results were shown in graphs, figures and tables to easily compare been the designed indicators.
CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Water Source Result
Generally, water sources in the study are in a condition lacking sustainability factor hence requires very high attention. The drilled borehole has no periodic diagnoses in terms of macro and micro level and the main water supplier focus is to pump water. The results illustrated under this section are efforts of looking in-depth into the system quality and procedure of the operation and maintenance put in place to run these facilities and to provide quality and safe water across the water supply chain up to the mouth of the beneficiaries. The results under this section clear justify the judgment of diffidence approaches in the place and how the current water quality control mechanisms are somehow not fit for the purpose since the water quality results that use to be conducted by the different partners still keep the continuation and accumulation of the risk of water contamination.

4.2 Distribution Points
After the international non-governmental organizations (INGO) and UN agencies that has been intervened in Darfur through providing water and sanitation and hygiene; the water infrastructures status were improved in terms of quality and quantity water supply. From the Figure (4.1) indicated that 84 percent from water storages that existed in study area are metallic elevated tanks scattered in the settlement area and 13 percent were Oxfam tanks equipped with permanent foundation and only 3 percent has sand slab. The elevated tanks that are existed improved the way of water storage and also facilitate the water supply treatment process and contributing to reduce of water supply contaminations.

The Figure (4.2) shows 81 percent of the water schemes are followed the water quality standards (Sudanese standards and WHO guideline), which is means that each water schemes has trained chlorinators and those chlorinators are responsible to chlorinate the systems at elevated tanks and chick the free residual chlorine concentration (which should be around 0.5 milligram per liter at elevated tanks), also monitor it at water points (which should be around 0.3 -0.5 milligram per liter) and sometime at household level. On emergency status the water related
disease considered as one of the biggest health risk which associates to increase mortality thus the WASH sector provided chlorine as chemical component which is very actively killing the pathogens and has been widely used.

Figure (4.1): Water storage type
Figure (4.2): Water quality monitoring system against WASH standards
One of the critical factors to ensure safe drinking water is handling of water at different stages transportation and storing at household level. Therefore, water containers that used by beneficiaries to transmit drinking water from water points to households should be clean and safe. Therefore, WASH sector partners are conducting Jerri cans cleaning campaigns in regular bases and monitor the clearness closely. Figure (4.3) showed that 81% of the community members does not practicing cleaning activity to their water containers. Dirty Jerry cans will increase the exposure of drinking water contaminations due to existence of bacteria colonies and algae.

Figure (4.3): Jerry can be cleaning activity at water points

4.3 Sanitary Inspection Result
Figure (4.4) shows 49% of distribution point did not have fencing for protection and segregation human and animal and others does not have doors. this mean that there are animal intervention and the animal excreta existence considered as most critical factor which is lead to human health risk through increasing the illness such as Typhoid, acute water diarrhea and other types of diarrhea. In addition to that there is 33% of the water containers are dirty, Existence of algae in water containers considered as one of the suitable media for pathogens. There are other sources of drinking water contamination due to personnel hygiene behaviors and practices such as safe
water handling and storage at household level and solid waste that gathered surrounding the water sources and pipeline distribution which presented only 3%.

Figure (4.4): Sanitary risks at the water distribution point

Figure (4.5) indicates that 82% of elevated tanks have been inside painted by anti-rust to protect the drinking water from contamination through mixing with the metallic elements. However, there was no indication or measures from the operating partners showing the arsenic level in these tanks. Also having 18% of the water tanks remained with any anti rusting paint is critical and an action should be taken. Strong electrolyte is formed by stored water that creates a type of vehicle for ion transfers as well as current flow in the steels microstructure. Although, painting may be used to interrupt this type of process and help to prevent corrosion. When there is a high dielectric strength, the coating will restrict the electron passage and then prevents metal from having the solution at the anode. If electrons are not able to travel to cathode, the corrosion process will be stopped.
4.4 Community Involvement

The community participation has long been associated with rural development. Rural development planners opine that for rural development projects to succeed the host community must take active part in the development and management of such projects. Figure (4.6) shows that, 68% of the community members were not contributed effectively in water supply sustainability. The big gap in community participation and contribution has been filled by the international organizations (WASH partners). On the other, it is very clear the negative impact resulted from the absence of the operation policies that explains and organizes the community contribution approach therefore almost the partners use their own implementation modalities which made the coordination quite difficult. The ownership sense also is the main element which is not clearly transmitted to the water users from the government overall plan as a right and important concept. Therefore the partners are just continue piloting the community contribution in wrong methods sometimes which already contributed in demotivation of the communities in regards of WASH program sustaining. Also as a results of no participation, the expensive system that was provided by the agencies at the emergency period now getting declined and damaged.

Figure (4.5): Tank painted in and outside by the anti-rust paint
From the Figure (4.7), 99 percent from the available tanks did not have leakage that maybe the great effort that offering by WASH partners in operation and maintenance, which reduce the water supply losses at elevated tanks. The integrity of well-managed distribution systems is one of the most important barriers that protect drinking water from contamination. However, management of distribution systems often receives too little attention. Distribution systems can incorrectly be viewed as passive systems with the only requirement being to transport drinking water from the outlets of treatment plants to consumers. There is extensive evidence that inadequate management of drinking-water distribution systems has led to outbreaks of illness in both developed and developing countries. The protection of conveyance pipeline system could be through deep excavation of pipeline and with well covered by soil and carry out regular maintenance for fitting and any breakage that could happened due to the water pressures. From the Figure (4.8), the conveyance pipeline system well protected and that decrease the possibility of water contaminations.
Figure (4.7): Leakage seen in the water tanks

Figure (4.8): Improvement in the water collection points

4.5 Water Treatment Methods

The water treatment practices in the camp remained under two major water treatment approaches that are used in similar cases of water supply in emergency, powder chlorine and 1.67mg chlorine tablets are used in treating the water at shortage level while 0.33 mg chlorine also being distributed to the households to treat water from the hand pumps and open sources. Figure (4.9) described 54% of water systems using slow dissolved chlorination which very easy to use and do not need to carry out the mother solutions. There is 32% using powder chlorine (70 % concentration) which requiting to determine the Jar test and prepare mother solution and these two methods using storage tanks to apply chlorination protocol.
4.6 Water Quality Monitoring

Water quality analysis conducted by State Ministry of Health showed that 50% of boreholes remain as safe drinking water sources however 100% of the water at storage tanks remain safe for human consumption while the water collection points showed only 40% safe for human use as indicated in Figure (4.10). This is a very clear example of absence of proper water safety planning in the whole water supply chain resulting in appearing the contamination at water collection point after eliminating it at the water storage tanks using chlorine. Since the situation at water distribution points is having contamination then it even worst to think any type of improved water quality at household which will remain another concern for the partners. The camp lays in north part where there is mainly basement complex aquifer and it is depend on the rain water recharging thus the most boreholes were drilled in the same aquifer. The groundwater at its best condition in terms of quantity during the rainy season and the flowing months (winter) however the depletion occur during the summer period as the discharge rate increase.

In all the investigated borehole there was no systematic measures in place to minimize the risk of the deletion either from the community owned water sources nor from the agency operated sources. The government through Water and Sanitation Project is playing big role in minimizing the risk depending on such aquifer through drilling more boreholes in areas close to the nearby Wadies and supply water through pipeline. But these initiatives require resources as we speak.
about big numbers of the population and under category of very poor and conflict affected people.

![Figure (4.10): Drinking water quality status in Otash camp](image)

The aquifer in the area is depending on rainwater to recharge and the water source are extremely being over pumped to meet the high demand of water in IDPs camp and surrounded community. This led over 11% of the available boreholes being dried during the dry season of the year and accordingly the need of the people not been covered as well. On the other hand, the sector partners are losing resources by drilling in such aquifer with reaching the targets, which is meeting the water demand for the population.
Figure (4.11): ground water depletion for the current boreholes

4.7 Distance of Recharge Source to the Existing Boreholes

Figure (4.12) below showed that 67% of the water boreholes only with the accepted distance from the recharging sources while 33% were away from these recharge. This is indicated that how ease the water sources being dry during the dry season and then the whole water supply system will be affected during that time.
4.8 Community Contribution to the Water Supply System

The community contribution and as mentioned earlier, it's not systemized with the different levels of the government (both local and state level), policies therefore the community contribution become subject to different understanding and usage from the partners, the results showed that 45% of the community contributed in maintaining lands and spaces to have water facilities installed and used by the everybody while only 9% of the pump operator's salaries been paid by the community, 18% of the community members answered that they were not even contributed at any level of the water supply system while 27% of the community contributes as well but not with specific factor of contribution but also they think of the important of contribution as well.

4.9 Focus Group Discussion Output

The research has interviewed the stakeholder engaged in WASH program at different level to get the common understanding on water supply management and the basic services provision level in terms of the quality and quality as well. The focus group discussion targeted group of sector coordination team and community members.
### Table (4.1): Focus Group Discussion

<table>
<thead>
<tr>
<th>Topics: Satisfaction of water quality and quantity in the camp.</th>
<th>FGD characteristics</th>
<th>Subthemes/identified issues</th>
<th>Description of discussion</th>
<th>Current mechanisms of responding to issues</th>
<th>Solutions suggested for the future</th>
<th>Quotes, examples, case stories from the FGD(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location: Nyala</td>
<td>Water quality</td>
<td>The majority of participant confirmed that the quality itself is not clear for them and mainly the treatment is not taken please on regular basis. The women in the group confirmed that they have received the chlorine aqua Tabs but they do not have enough training on how to do it in the house level.</td>
<td>The partners wo use to provide water to the IDPs have different metrologies and approach, for instant, hand pups are not being chlorinated anymore expect at some outbreak period or sometime at the beginning of the rainy season. The communities are stayed not aware of the program that implemented</td>
<td>Sustainable and systemized community engagement in all the details of water intervention need Communities need to be involved in design phase</td>
<td>Note interesting quotes or case stories that illustrate the data for the better understanding during analysis and/or for usage in the reporting.</td>
<td></td>
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<tr>
<td>Water quantity</td>
<td>The participants confirmed that the water quantity is the major problem as the number of the boreholes in the settlement is not enough to supply the camp, moreover they said they are not fully aware of the plan that the sector partners have to make water quantity sufficient for every body</td>
<td>The majority of the water supply sources were drilled in early phase of the displacement and partners use to operate and maintain them</td>
<td>Clear plan of community water supply system and possibility of having water sources sustained even if other alternatives need to be put on the table and discussed with all the partners.</td>
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<tr>
<td>Community willingness in water supply system contribution and participation</td>
<td>The participant confirmed that they have no objection in participating and contributing in the water supply system. They also confirmed that they already contributing in some cash and labors. When asked if they are contributing in systematic way leading to owning the system then the answers were negatives</td>
<td>There are scattered initiatives of community engagement at agencies level and it is more or less just to run the system but there is no good design where system cost calculation taken place</td>
<td>The sector partners to have harmonized approach where system need to be calculated and the facts will be put on the table of the community which clear road map showing the value of their contribution with clear answer when the cost will be recovered. This is need the lead of the government to play role and guide the partners</td>
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CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion
The results of this research which aimed to focus in the whole water supply chain in Outash Camp where sources, household water and distribution system were carefully investigated. Findings in sources, storage system and household levels showed a bit flagged many areas for improvement not only for a single partner but collective efforts are really needed to provide good water safety planning approaches.

One of the main finding is that the whole water supply system is getting old and need type of renovation and rehabilitation in most of its parts mainly the pipeline and the nature of the water distribution system beside the improvement of the storage tanks water of the population. From the interview made for selected group, it is clear the absence of the systematic design of community water including water safety planning ad this remain area for improvement for individual partners and collectively under umbrella of the government.

5.2 Recommendations
Looking to the quantity and provided water per person which even not exceeding 10 liters per person per day therefore more emphasis is required to top up the water supply deficit (demand versus the supply) from Bagara basin hence the government need to accelerate the completion of this project on time.

- As the rain falls have record with which rain water harvesting technique could be applied in institutes like schools and others therefore it highly recommended to pilot and apply it at different scales at least to maintain the needs of the children and other institutes users.
- Nyala has very large valleys which almost even cause flooding therefore construction of subsurface damps could be a solution for the ground water conservation.
- Review water tariff system to cover the full cost and improve the tariff collection system.
- Engage water users in water supply issues and decision making to help into improvement and sustainable water supply.
- Install water meter in all households to easily manage supply and demand of water.
- Establishment of water master plan to include SDG targets (By 2030, achieve universal and equitable access to safe and affordable drinking water for all).
More coordination between the state water corporation and other projects and related institutions is highly required.

More studies are needed to enhance water supply services in Nyala town.

Repair the water supply network leakages in regular bases to increase water use efficiency through minimizing the water loses.

Enhance monitoring system of water supply distribution networks and water allocation to the town.

The water distribution point needs to be designed to answer the requirement of the water safety planning factors.

The chlorination needs a significant review and the different actors need to unify the chlorination protocol.

According to the finding of the ministry of health report, the water quality monitoring is currently having challenging at different levels hence the partners should coordinate well to have harmonized approach for water quality monitoring.
REFERENCES


QUESTIONNAIRE HELPS TO UNDERSTAND:

CHALLENGES AND OPPORTUNITIES OF WATER SAFETY PLANNING

APPLICATION IN COMMUNITY WATER SUPPLY IN NYALA, SOUTH DARFUR STATE, SUDAN

Prepared by Student: Mohammed Ishag Altaib

Name of the person filling survey ……………………… Phone number……………………

Name Household interviewee …………………….. Phone number

A. Water Sources

   Name of Borehole…………………………. GPS points: N………………….. E…………………..

1. What is the type of the aquifer?
   a. Basement
   b. Permanent

2. What was the borehole yield upon drilling?....... m³/hr

3. What is the current yield? (….. units)

4. Is this borehole got dry since drilled?
   a. Yes
   b. No

5. How far the recharging source
   a. Less than 10 meters
   b. More than 50 meter
   c. No nearby recharging sources

6. Any observation of desertification at water sources and the surrounding that can affect the water source in near future?
   a. Yes
   b. No

7. Any land issues that affect the water supply identified since water source established?
   a. Yes
   b. No

8. If you answered yes in question 6, what are the exact land issue that challenged the community to benefit from the sources?
   a. Framing activities
   b. Private natures water supply
   c. Extension of city
9. At what stage the community contribution to water supply occurred?
   a. Getting the land
   b. Cash contribution in the Drilling stage. How much in percentage (%)?
   c. Provision of the generators and other accessories
   d. Salaries of pump operators.
   e. No contribution at all
   f. Others

10. What is the pumping component of the water supply
    a. high KVA generator
    b. Solar
    c. Low capacity generator
    d. Others

11. Is the WASH sector standards been used in the protection?
    a. Yes.
    b. No

12. What are the main breakage learnt from this source?
    a. Theft
    b. Pipeline attack
    c. Spare parts
    d. Lack Technical expert
    e. Operation cost covering

13. Who is taking care of this water sources
    a. INGO
    b. Community
    c. Private
    d. Government
    e. Shared (agency and community)
    f. None

14. What are the sanitary risks around the water source
    a. Latrines are too close to the water source
    b. Solid and liquid waste are being disposed close to the source.
    c. Open defecation observed near to the source
    d. Dead animals are dropped close to the source
    e. Others
B. Distribution

1. What is the storage type at the settlement
   a. Oxfam tank with sand slab
   b. Oxfam tank with permeant slab.
   f. Concrete tank
   g. Metallic elevated tank
   h. Others

2. Is the tank painted in and outside by the anti-rust paint?
   a. Yes
   b. No

3. Any leakage from the tank?
   a. Yes
   b. No.

4. Type of the chlorination method
   a. Slow dissolved chlorination
   b. Manual chlorination
   c. Fixed pipeline chlorination
   d. Injection at the water point
   e. No chlorination

5. Is Water quality monitoring system maintains the standards of WASH sector?
   a. Yes
   b. No
   c. Somehow but need improvement.

6. Community contribution/participation to the project significantly?
   a. Yes
   b. No
   c. Somehow but need improvement

7. Is water distribution point protected well?
   a. Yes
   b. No
   c. Somehow but an improvement is needed

8. Is there any Jerry can cleaning activity at water points?
   a. Yes.
   b. No.

9. What are the sanitary risks at the water distribution point?
a. Animals are sharing water with human
b. Bad hygiene surrounding the water points
c. solid waste observed in surrounding
d. no proper drainage
e. Jerry cans are dirty
f. No fencing or doors are open
g. Others

C. Household questions

Household questionnaire is to know the current income and who is the main responsible, how far the families can contribute to water cost and how they maintain their latrines.

1. How many people in your family in total?
2. How many of them are:
   a. Men……………
   b. Women……
   c. Boys ……………
   d. Girls ……………
3. Who is responsible of family in term of income?
   a. Father
   b. Mother
   c. Brother
   d. Sister
   e. Others
4. Is your family pays for water
   a. Yes
   b. No
5. If yes, how much the family pays……..SDG per Jerry can
6. Do you have any objection in paying water tariff?
   a. Yes
   b. No
   c. I do not want to answer
7. How many Jerry can you collected yesterday ( date ……..)? Jerry can.
8. How many people including the guests were here last night?............. persons
9. From the water you collected last night, how many jerry can were used for

<table>
<thead>
<tr>
<th>Drinking</th>
<th>Cooking</th>
<th>Washing and bathing</th>
<th>Animals</th>
<th>Irrigation of trees</th>
<th>Bricks</th>
</tr>
</thead>
<tbody>
<tr>
<td>….. Jerry cans</td>
<td>….. Jerry cans</td>
<td>….. Jerry cans</td>
<td>….. Jerry cans</td>
<td>….. Jerry cans</td>
<td>….. Jerry cans</td>
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Which type of treatment your household uses?

1. Boil
2. Chlorine
3. Filter
4. Others
5. Do not know

How far the home from water source?

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<tr>
<th></th>
<th>&lt;5 minutes</th>
<th>5-10 minutes</th>
<th>15-30 Minutes</th>
<th>More than 30 minutes</th>
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How water transported from source to home?

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<thead>
<tr>
<th></th>
<th>We have tap in the home</th>
<th>By Jerry cans</th>
<th>By donkey carts</th>
<th>Others</th>
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Who is responsible for water transportation? Mother, father, or children?

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<tbody>
<tr>
<td>Mother</td>
<td>Father</td>
<td>Brother</td>
<td>Sister</td>
<td>Children</td>
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Where you store your Water

<table>
<thead>
<tr>
<th></th>
<th>In Jerry can</th>
<th>In Zire</th>
<th>In plastic Durm</th>
<th>In metallic</th>
<th>Others</th>
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