

**Pro Gradu – Master’s Thesis**

**Impact Assessment of a Solar Powered Water Treatment Project**

**Jacqueline C.D. Mwakangale**



**University of Jyväskylä**

Faculty of Science

Department of Biological and Environmental Science

Environmental Science with specialization in Development and

International Co-operation

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**UNIVERSITY OF JYVÄSKYLÄ, Faculty of Science**

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**ABSTRACT**

Water treatment technologies are seen as the best alternative to be considered for adoption in developing countries where access to portable water supply that is free of pathogens is yet a challenge. This study intended to assess impact brought forth by a project, which employed a water treatment technology in rural settings of Morogoro Region in Tanzania. The project used solar photovoltaic panels to trap solar energy, converted to mechanical power to treat water with the help of sterilization ultraviolet membrane.

A comparative analysis was used as an assessment framework to study impacts of the project with respect to the quality of approach used during the project life cycle. Determinants of impacts took into account social, economic and environment aspects whereas determinants of the quality of approaches taken considered six elements which are: character of participation; success, nature of institution and capacity building efforts; diversity, multiplicity and adaptability of ideas promoted by the project; accounting for heterogeneity and dynamism; understanding and use of local knowledge, skills, initiative and constraints; and recognizing the influence of external conditions, markets and policies.

Results indicate that the project has intervened positively in the provision of safe portable water to the selected project sites. The quality of approaches taken had profound effect to the delivered impacts. These impacts are seen in the reduced recurring outburst of water-borne diseases such as typhoid and diarrhea. Another impact observed is in the downturn to a certain extent in the use of wood fuel for boiling. Reduced recurring of waterborne diseases has boosted pupils' attendance at school. Furthermore, the study argues that adoption of water treatment technologies in rural settings has a potential to conserve the environment, improve health of people through the provision of safe portable water, which ultimately contribute to rural development. However, sustainability of the installed purification systems is in question if it will continue to function over the long run. Observed barriers are lack of solid economic means for sustaining operations and maintenances.

## TABLE OF CONTENTS

<b>1. INTRODUCTION</b> .....	<b>1</b>
<b>2. RESEARCH OBJECTIVE</b> .....	<b>3</b>
<b>2.1 Specific objectives</b> .....	<b>3</b>
<b>2.2 Research questions</b> .....	<b>3</b>
<b>3. WATER SUPPLY AND TREATMENT IN RURAL TANZANIA</b> .....	<b>4</b>
<b>3.1 Rural Water Supply</b> .....	<b>4</b>
<b>3.2 Rural Water Treatment Methods</b> .....	<b>5</b>
3.2.1 Boiling method .....	6
3.2.2 Water Chlorination method.....	6
<b>4. STUDY APPROACH</b> .....	<b>7</b>
<b>4.1 Assessment Framework</b> .....	<b>7</b>
<b>4.2 Process-oriented Criteria</b> .....	<b>8</b>
4.1.1 Character of Participation .....	9
4.1.2 Success and nature of institution – and capacity building efforts.....	9
4.1.3 Diversity, multiplicity and adaptability of ideas promoted by the project.....	9
4.1.4 Accounting for heterogeneity, diversity and dynamism .....	10
4.1.5 Understanding and use of local knowledge, skills, initiative and constraints.....	10
4.1.6 Recognizing the influence of external conditions, market and policies.....	11
<b>4.2 Outcome-oriented Criteria</b> .....	<b>11</b>
4.2.1 Economic aspect .....	12
4.2.2 Social aspect .....	12
4.2.3 Environmental aspect.....	13
<b>5. CASE STUDY: SOLAR POWERED WATER PURIFICATION</b> .....	<b>15</b>
<b>PROJECT</b> .....	<b>15</b>
<b>5.1 Project description and its location</b> .....	<b>15</b>
5.1.1 Study Area .....	17
5.1.2 Project Sites .....	22
<b>5.2 Project component and design</b> .....	<b>25</b>
<b>5.3 Mechanism of the Solar Powered Water Purification System</b> .....	<b>27</b>
<b>6. MATERIALS AND METHODS</b> .....	<b>28</b>
<b>6.1 Method design</b> .....	<b>28</b>
6.1.1 Determination of Impacts with respect to the Quality of Approach .....	28
6.1.2 Determination of Sustainability of the project.....	30
6.1.3 Measuring sustainability of the project.....	32
<b>6.2 Data collection</b> .....	<b>33</b>
<b>6.3 Validity and Reliability of the research data</b> .....	<b>35</b>
<b>6.4 Data analysis procedure</b> .....	<b>35</b>
<b>7. FINDINGS</b> .....	<b>36</b>
<b>7.1 Project breakdown by Outcome-oriented Criteria</b> .....	<b>36</b>
7.1.1 Social impact of the project .....	37
7.1.2 Economic impact of the project.....	39
7.1.3 Environmental impact of the project.....	39

<b>7.2</b>	<b>Project breakdown by Process-oriented Criteria</b> .....	<b>40</b>
7.2.1	Character of participation .....	41
7.2.2	Success and nature of institution – and capacity building efforts .....	42
7.2.3	Diversity, multiplicity and adaptability of ideas promoted by the project/ account for heterogeneity and dynamism .....	42
7.2.4	Understanding and use of local knowledge, skills, initiative and constraints .....	43
7.2.5	Recognizing the influence of external conditions, market and policies .....	43
<b>7.3</b>	<b>Sustainability measure of the project</b> .....	<b>44</b>
<b>7.4</b>	<b>Feasibility of the Solar Powered Water Purification System (WP700) in portable water supply improvement</b> .....	<b>47</b>
<b>7.5</b>	<b>Challenges in the use of the system and maintenances</b> .....	<b>48</b>
<b>8.</b>	<b>CONCLUSION AND RECOMMENDATION</b> .....	<b>50</b>
8.1	Conclusion .....	50
8.2	Recommendation .....	50
	<b>REFERENCE</b> .....	<b>52</b>
	<b>APPENDICES</b> .....	<b>56</b>
	<b>Appendix I: Questionnaires</b> .....	<b>56</b>
i.	General questions to gather baseline information at project sites before the project .....	56
ii.	Specific questions to assess character of approaches used during the project life cycle ( <i>Process-oriented Criteria</i> ) .....	58
iii.	Specific questions to assess impact after project intervention ( <i>Outcome-oriented Criteria</i> ) .....	61

## **LIST OF FIGURES**

FIGURE 1: A MAP SHOWING LOCATION OF PROJECT SITES.....	16
FIGURE 2: A MAP OF TANZANIA SHOWING THE LOCATION OF MOROGORO REGION .....	17
FIGURE 3: MAP OF MOROGORO REGION SHOWING ADMINISTRATIVE DIVISIONS OF STUDY SITES: MVOMERO AND MOROGORO DISTRICTS.....	18
FIGURE 4: PROJECT IMPACT IN THE ASPECTS OF ECONOMIC, SOCIAL AND ENVIRONMENT .....	36
FIGURE 5: CRITERIA USED TO ASSESS THE QUALITY OF APPROACHES .....	41

## **LIST OF PLATES**

PLATE 1: MKAMBARANI DISPENSARY SITE .....	22
PLATE 2: VIKENGE PRIMARY SCHOOL SITE.....	24
PLATE 3: WAMI DAKAWA PRIMARY SCHOOL SITE: WATER POINT CONNECTED TO THE WATER PURIFICATION UNIT (WP700).....	24
PLATE 4: WP700 SOLAR POWERED WATER PURIFICATION SYSTEM (A SOLAR MODULE AND A WATER PURIFICATION UNIT IN THE WHITE BOX).....	26
PLATE 5: A COMPOSITION OF A WATER PURIFICATION UNIT .....	27

## **LIST OF TABLES**

TABLE 1: SUMMARY OF RURAL WATER SUPPLY POINTS.....	5
TABLE 2: PROCESS-ORIENTED CRITERIA FOR EVALUATING THE APPROACH OF SUSTAINABLE DEVELOPMENT PROJECTS.....	8
TABLE 3: OUTCOME-ORIENTED CRITERIA FOR EVALUATING SUSTAINABLE DEVELOPMENT PROJECTS .....	14
TABLE 4: ORIGINAL TEN (10) PROJECT SITES OF SOLAR POWERED PURIFICATION SYSTEMS .....	15
TABLE 5: DISTRIBUTION OF ADMINISTRATIVE UNITS IN MOROGORO DISTRICT .....	20
TABLE 6: WATER SOURCES EXISTING WITHIN THE DISTRICT .....	21
TABLE 7: TECHNICAL SPECIFICATION OF THE WP700 SYSTEM.....	26
TABLE 8: ELEMENTS OF OUTCOME-ORIENTED CRITERIA .....	29
TABLE 9: ELEMENTS OF PROCESS-ORIENTED CRITERIA.....	29
TABLE 10: DETERMINATION OF SUSTAINABILITY USING MATRIX TOOL .....	31
TABLE 11: DEFINITION OF SUSTAINABILITY LEVELS.....	32
TABLE 12: TYPE OF METHOD, TECHNIQUES AND PURPOSE USED FOR DATA GATHERING. ....	34
TABLE 13: RESULTS ASSESSED BY MATRIX TOOL, MKAMBARANI SITE.....	44
TABLE 14: RESULTS ASSESSED BY MATRIX TOOL, VIKENGE SITE .....	45
TABLE 15: RESULTS ASSESSED BY MATRIX TOOL, WAMI DAKAWA SITE .....	46

## **LIST OF ABBREVIATIONS**

EURO	European Union Currency
EWURA	Energy and Water Utilities Regulatory Authority
LGAs	Local Government Authorities
MDGs	Millennium Development Goals
MEM	Ministry of Energy and Minerals
MoW/RWSSP	Ministry of Water/Rural Water Supply and Sanitation Programme
MoW/WSDP	Ministry of Water/Water Sector Development Programme
MW	Megawatt
MWp	Megawatt peak
PV	Photovoltaic
RET	Renewable Energy Technologies
UNCTAD	United Nations Conference on Trade and Development
URT/MEM	United Republic of Tanzania/Ministry of Energy and Minerals
UV	Ultra violet
USD	United States Dollar Currency
WHO	World Health Organization
WP	Water Point
WP700	Water Purifier 700litres
WSDP	Water Sector Development Programme

### **Currency Equivalents**

Current Unit = Tanzanian Shillings (Tshs.)

1 EURO = 2,313 Tshs.

1 USD = 2,154 Tshs.

## **1. INTRODUCTION**

The global target of halving the proportion of people without access to an improved water supply had already been met since 2010. However, many people are still relying on unsafe water sources specifically large group is seen in countries of the sub-Saharan Africa. The Millennium Development Goals (MDGs) progress chart of 2015 shows a good progress with low coverage in meeting the target. This is because sub-Saharan Africa fell short of the MDG target but still managed to achieve a 20-percentage point increase in the use of improved sources of drinking water. In 2015 estimations show that about 663 million people world wide still use unimproved drinking water sources including unprotected wells, springs, surface water and sometimes from improved water infrastructures such as water points, connected pipes which necessarily do not supply safe water due to being microbiologically contaminated. Nearly half of all people using unimproved sources live in sub-Saharan Africa (UN Statistics Division 2014 & 2015).

In Tanzania, access to clean and safe water is yet a major challenge for a large group of people despite of significant progress made in recent years through the Water Sector Development Programme (WSDP). The proportion is slightly higher for rural dwellers than for urban residents. In rural settings, the challenge is contributed by insufficient number of water infrastructures including water points (WPs) and connected water pipes to the household. The situation is made worse due to the fact that most of the existing water infrastructures are not functioning properly thus limiting further safe water supply (Ministry of Water 2013). Cumulatively, chances of acquiring water borne diseases such as typhoid, cholera, diarrhea and dysentery are very high.

Moreover, another challenge is seen on the location of these WPs as many are situated far from their households therefore, time consuming. It takes about an hour (57minutes) for one trip to get water from the public WP and most responsible people for fetching water in the households are women and girls (children). This leads to many women in rural setting not engaging into other income generating activities and girls not going to school therefore increasing poverty (Twaweza Report 2014).

The most common method of water treatment in rural setting is boiling on firewood three-stone stove (SolarWave Report 2014). This method is not environmentally benign as it contributes to wood harvest leading to deforestation, one of the major challenges Tanzania is also facing (National Environmental Policy 1997). Furthermore, persistent consumption of wood fuel results into indoor air pollution due to inefficiency of wood fuel to combust completely during lighting causing health implications to users when inhaled. Frequent exposures to combustion of wood fuel have shown a direct and indirect human health effects such as coughing, asthma and other lung problems (UNCTAD 2010). (Ezzati and Kammen 2002; UNCTAD 2010) have strongly presented a connection between frequent exposures to combustion of traditional fuels and enhanced acute respiratory problems to human health in Kenya.

In the wake of this, water treatment technologies have evolved over the past few centuries to protect public health from pathogens and chemicals. These technologies are highly considered suitable to developing countries as are cost effective and can easily help to reduce the large group of people without access to safe water supply (Ray C, Jain R (eds.) 2011). Most of these technologies tap renewable energy sources such as solar, wind, geothermal to provide mechanical power, electrical and or heat energy to the treatment mechanisms.

This study seeks to assess impact of a solar powered water treatment project implemented in rural settings of Morogoro Region in Tanzania. The project used water treatment technology that tap solar energy with the help of sterilization ultraviolet (UV) membrane to treat water instead of using wood fuel for boiling drinking water. In a development context, this is an alternative method to safe water supply specifically to rural settings as a substitute to the existing methods used such as boiling on wood fuel and or using disinfectant agents. In assessing this project, a comparative approach is used to study impacts of the project in relation to the quality of approaches taken during the project life cycle.



## **2. RESEARCH OBJECTIVE**

The purpose of this study is to assess impact brought forth by the solar powered water purification project.

### **2.1 Specific objectives**

- i. To study the extent of improvement of portable water supply in the project area through the use of the solar powered purification system;
- ii. To assess the socioeconomic, environmental and technical impacts brought forth by the use of the system;
- iii. To document challenges local people face in use of the system and maintenance capacity; and
- iv. To examine the quality of approach taken during the project life cycle into delivering impact.

### **2.2 Research questions**

The following are the research questions used for the assessment.

- i. To what extent has water supply improved in the project area through the use of the solar powered purification system?
- ii. What are the social, economic and environmental impacts brought forth as the result of the system?
- iii. What challenges do local people face in the use of the system including maintenance issues?
- iv. What kinds of approaches were taken on board from the project inception to the implementation to deliver impact?

### **3. WATER SUPPLY AND TREATMENT IN RURAL TANZANIA**

#### **3.1 Rural Water Supply**

Tanzania has an estimated population of 44.9 million with current rate of population growth 2.9% per year of which about three fourths (33.7 million) of the population live in rural areas (National Bureau of Statistics 2012). The provision of public services in rural areas including water supply is inadequate. The supply of clean and safe water in rural areas of Tanzania is still yet a challenge despite progress made in recent years through the WSDP (Ministry of Water 2013). About 20 million Tanzanians still lack access to safe drinking water. According to the World Health Organization (WHO) data published in April 2011, number of deaths related to unsafe water supply had reached 35,549 or 8.09% of total deaths in Tanzania (SolarWAVE Report 2012).

Data on water supply service in Tanzania indicated that the rural areas coverage was about 57.8% and 78% in urban areas according to the Ministry of Water Budget Speech of 2011. Out of the 57.8% rural water supply coverage, about 30% of the installed capacity of water facilities were non-operating due to a number of factors such as drought, and obsolete facilities. This prompts communities to alternate to unprotected water sources that are usually microbiologically contaminated. Data on the incidence of water borne, water related and water washed diseases indicated that these are prevalent where people have inadequate access to safe, clean, affordable and reliable water (Ministry of Water 2011).

Based on Water Point (WP) mapping study (**Table 1**) conducted in 2011/2012 throughout Tanzania, there were 74,250 total water points in 2010. Out of those, 45,754 water points (62%) were functioning, serving a total of 11,438,500 beneficiaries in rural areas, equivalent to 38% of total rural population. During 2010/2011, a total of 3,556 new water points were installed (889,000 additional beneficiaries), making a total of functioning water points to be 49,310, serving 12,327,500 beneficiaries in rural areas, equivalent to 39% of rural population. In 2011/2012, a total of 3,019 new water points were installed (754,750 additional beneficiaries), making a total of functioning water points to be 52,329, serving 13,082,250 beneficiaries, equivalent to the coverage of 40% of rural population.

During the 2012/2013 financial year, greater progress was achieved because greater number of Local Government Authorities (LGAs) embarked in implementation of water scheme sub projects, which resulted in installation of 5,614 water points (1,403,500 additional beneficiaries), increasing the number of functioning water points to 57,943 that serves a total of 14,485,750 beneficiaries, equivalent to 44% of the total rural population (Ministry of Water 2013).

**Table 1:** Summary of Rural Water Supply Points

Year	2010/11	2011/12	2012/13
<b>Total no. of WP</b>	74, 250	77,269	82,883
Functional	45,754	(48,773)* <sup>1</sup>	(54,387)* <sup>1</sup>
Non-functional	28,496	(28,496)* <sup>1</sup>	(28,496)* <sup>1</sup>
<b>Total population in Rural Area</b>	<b>30,101,316</b> * <sup>2</sup>		
Population served	11,438,500	(12,193,250) * <sup>1</sup>	(13,596,750) * <sup>1</sup>
Population unserved	7,124,000	(7,124,000) * <sup>1</sup>	(7,124,000) * <sup>1</sup>
Population without any WP	11,538,816	(10,784,066) * <sup>1</sup>	(9,380,566) * <sup>1</sup>

<sup>1</sup>: Assumed that no water point stop its functionality from the previous year

\*<sup>2</sup>: Assumed that total population in rural areas remains same

**Source:** Ministry of Water - Water Sector Development Programme II (2011)

Many households in rural areas draw water from nearby waterways such as rivers, streams and rainwater tanks. These sources have the potential of being contaminated by harmful germs, chemicals and or other contaminants that may cause sickness to individuals and the community as a whole. Improved drinking water sources such as public taps or standpipes, boreholes, wells and or dams exist however are inadequate in the supply of safe water due to many WPs being out of order and not functioning.

### 3.2 Rural Water Treatment Methods

The most common method of water treatment in rural settings is boiling on a firewood three-stone stove which contributes to wood harvest a major cause of deforestation in Tanzania and other interconnected environmental problems. Another method of water treatment is through the use of chlorine base water disinfectant known as Water guard that consists of 0.75% of sodium hypochlorite.

### **3.2.1 Boiling method**

Disinfection of water by heating is normally carried out at household level using clean pots on a stove. In rural settings, biomass is the most predominant source of energy in terms of firewood and charcoal at household level and is used for cooking and heating mainly. About 92% of the total energy consumption is based on biomass, of which 85% is consumed in rural areas (Ministry of Energy and Minerals 2013). High dependence on wood is caused by the fact that wood fuel is for free (in terms of money), readily available and requires simple technology to use.

However, a continued demand for biomass-based energy is unsustainable due to environmental implications it poses. Some other critical environmental implications caused by irrational exploitation of wood fuel are soil erosion, desertification, loss of biodiversity and change in climate pattern. There is no doubt that wood fuel will continue to be the major source of energy to people living urban and rural areas at large due to its inexpensive and accessibility nature (Ministry of Energy and Minerals 2013).

### **3.2.2 Water Chlorination method**

At household level, chlorination of water can be used as an emergency measure or as part of everyday life. The amount of chlorine needed depends much on the concentration of organic matter in the water. Therefore for chlorine base water disinfectant to be active, in some cases water needs to be pre-treated by filtration to remove particulate matter.

Major problems to this kind of treatment method are that the quality of water varies with time hence recalculation of dosage from time to time is required. Another challenge is, these chlorine-producing chemicals have the tendency of losing their strength quickly especially if are not stored properly and often are not readily available.

Therefore, based on these data validates the essence of assessing the project which use an alternative means of water treatment, a solar powered water treatment and its contribution to the supply of portable water at the project sites in rural settings.

## **4. STUDY APPROACH**

### **4.1 Assessment Framework**

The assessment framework for this study is based on studying impacts of the project and compared with the approaches taken during the course of the project. Basic assumption is that, for impacts to be continuous and provide progressive change then quality of the approach used by the project planner is fundamental. The quality of approach in actual sense means good approaches that promote innovation, adaptation and learning to the locals which often facilitate a project to generate sustainable impacts even after outside support end. In a way, this view assists in the quantifiable assessment of the project. By understanding this parallel, it is easier to find alternative solutions to achieving sustainability in projects or any other development works.

Justin M. Mog (2004) constructed a framework for evaluating sustainable rural development programs using two criteria: process and outcome oriented criteria and demonstrated its application to a development program in the southern Philippines known as the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program/Southern Asia (SANREM CRSP/SEA). The program was funded by the US Agency for International Development and was selected for evaluation due to its comprehensive goal made.

In regard to this, the concept of Justin M. Mog (2004) is used as an assessment framework, which uses two criteria for a comparative assessment: process and outcome-oriented criteria. The following sections 4.1 and 4.2 describe the process and outcome-oriented criteria.

## 4.2 Process-oriented Criteria

Process-oriented criteria concentrate on the kinds of approaches taken during the project cycle. The approach has a direct influence on the specific impacts. Most assessment frameworks base much on specific indicators of sustainability without tracing back the nature of the process responsible for such change. In order to achieve a sustainable outcome, the approach chosen ought to be based on continuous learning and adaptation. This has to be incorporated in project life cycle.

The following (**Table 2**) below contains six (6) criteria proposed as the most essential elements of an effective, sustainability-oriented approach to development programmes and or projects. Justin M. Mog (2004) used these criteria to assess development programmes, however for this study, these criteria are used as a tool to assess a project. Elements three (3) and four (4) are combine into one (1) element, making a total of five (5) to suit in the matrix framework, which is an assessment method described in Section 6.

**Table 2:** Process-oriented criteria for evaluating the approach of sustainable development projects

1.	Character of participation
2.	Success and nature of institution – and capacity building efforts
3.	Diversity, multiplicity and adaptability of ideas promoted by the project
4.	Accounting for heterogeneity and dynamism
5.	Understanding and use of local knowledge, skills, initiative and constraints
6.	Recognizing the influence of external conditions, markets and policies

Source: (Mog, 2004)

#### **4.1.1 Character of Participation**

Public participation is one of the key elements researched that account for an effective sustainable development project. In a participatory process, local people receive a sense of belonging and ownership to be innovative and creative on finding proper ways on solving the problems facing. However, the most important aspect to be keenly eyed is the character of participation rather than a type of participation. The character of participation entails: (i) the respect and attention given to the opinions of locals, (ii) ideas and perspective of locals, (iii) the degree of control locals have in setting goals (in the whole of the project cycle) and, (iv) the capacity to solve the problems on their own, when the project exit.

#### **4.1.2 Success and nature of institution – and capacity building efforts**

Whatever the particular aims of development projects, if changes are to be sustained over time, then local people and their institutions need to be responsible in making them last. It is important for sustainable development projects to invest significant resources in developing the local social capital necessary to maintain performance over the long run. Practically, this means building and strengthening institutions such as people's organizations, cooperatives, units of government, schools as well as capacities of those institutions and individual actors to affect change i.e. through basic education and extension, technology transfer networking and partnering-building, specialized training and orienting people toward future learning, experimentation, adaptation and innovation.

#### **4.1.3 Diversity, multiplicity and adaptability of ideas promoted by the project**

Every development project promotes certain ideas, whether they are technologies, policies or methods designed to achieve goals. Sustainable development requires a great diversity and multitude of ideas that can be captured and adapted locally. This is necessary to fulfill the variable and evolving economic, ecological and social demands of sustainability. With a full suite of options ensures that the project's recommendations are adoptable, adaptable and locally appropriate and that ecological health will be enhanced through the promotion of diversity.

#### **4.1.4 Accounting for heterogeneity, diversity and dynamism**

Projects are more predisposed to interacting successfully with and influencing a community when it is designed around the fact that the target population and the context it is embedded in is diverse, heterogeneous and changes over time. Unfortunately, history provides numerous examples of development projects that failed, in part, because of interventions based upon an assumptions of relative homogeneity and stasis within the population, their livelihoods, and the larger forces which shape their values and decision making. Most funding schemes and government programmes have historically been structured around one size fits all model of extension, technology transfer and development. To ignore the fact that different people have different interests and motivations is to pass up a valuable opportunity to increase the program's impact by appealing to the greatest possible number of people.

#### **4.1.5 Understanding and use of local knowledge, skills, initiative and constraints**

No matter how large or small scale the project may be, the involvement of local people is imperative and they are supposed to do most of the work such as planning and implementation depending on the local environment. It is vital that the project should find ways to design on how to tap in the local skills, understanding, knowledge and initiatives through a proper investigation before the start-up of the programme or project and during implementation, as local conditions, needs, skills and knowledge are always evolving. With these efforts will influence directly and powerfully outcomes of project relevance, effectiveness, local acceptability and ability to take corrective action and thus, overall success. This should not only be on decision making happening through stakeholder involvement but rather on giving priority to local capabilities, needs and inclusion of traditional techniques.



#### **4.1.6 Recognizing the influence of external conditions, market and policies**

Any projects that intend to have an influence to a particular community and have hopes to have sustained impacts can never ignore the broader context in which such community is embedded. In designing an intervention, it is vital to include individuals or communities in a cluster of policies, markets and other external influences such as economic, demographic, political, social, cultural and environmental, which operate at national, regional, or even global scales. Therefore project staffs need to be aware of these influences, investigate their strengths and design interventions with them in mind even if the activity has no control over them.

#### **4.2 Outcome-oriented Criteria**

While the Process-oriented criteria described above aimed at assessing the quality of approach taken during project execution, Outcome-oriented criteria is much based on assessing progress towards initiated goals. Outcome-oriented criteria entail important elements of sustainable development, which are social, economic, and environment. Mog J (2004) argued that each element is thought to be as an important thread in the tapestry of sustainable development and the more threads are interwoven, the stronger the fabric grows and the design becomes more complete. This means that, each element has an equal importance and can be achieved at the expenses of one another in the long run. For instance, economic development can only be sustainable if it is accompanied by healthy ecosystems and educated people. The target elements reflect the balancing act that needs to take place in order to ensure a development path is sustainable.

Indicators of the elements of outcome-oriented criteria will differ depending on the type of project assessed. For the case of this study project, indicators will be within the realms of solar energy use, water supply context with response to the economic, social and environmental base. **Table 3** contains elements of Outcome-oriented criteria.

#### **4.2.1 Economic aspect**

Implies that sufficient local resources and capacity exist to continue the project in the absence of outside resources (external support). Time and distance savings should be important factors to observe in order to assess the level of engagement of locals into doing other income generating activities for sustaining their lives. A project with good impacts and sustainable change will fit the local's environment economic situation based upon available resources whether being monetary or non-monetary (human labor and tools). Resourcefulness in the design and implementation phases will include consideration of local labor use and resources at lower costs and increase the project efficiency. The community must be willing and able to contribute to the project construction and maintenance. It is essential to have an economic community contribution to the implementation and operation of the project, which increases local ownership and appreciation for the project (Ocwieja S. M 2010; McConville 2006)

#### **4.2.2 Social aspect**

Social aspect encompasses various factors such as education, health, cultural competence, community development, social justice, political cohesion, human rights, human adaptation and community resilience. For the purpose of this study, social aspect is narrowed into three sub-aspects: political cohesion, quality of life and socio-cultural respect.

- **Political organization** – considers the ability of the government, non-government organizations, development workers and local authorities working together to increase a sense of ownership in the process. McConville argues that cohesive efforts minimize chances of projects to become redundant. Involves increasing the alignment of development projects with host country priorities and coordinating aid efforts at all levels (local, national and international) to increase ownership and efficient delivery of services.
- **Quality of life** – ensures that communities' basic needs are met and fosters a good quality of life for all members at the individual, group and community level, for instance health, education, safety and employment.

- **Socio-cultural respect** – recognizes the significance of cultural difference and its role in the project development. A socially acceptable project is built on an understanding of local traditions, core values and gender inclusive. Understanding of local perspectives is fundamental for sustainability.

#### **4.2.3 Environmental aspect**

Implies that non-renewable and other natural resources are not depleted nor destroyed for short-term improvement. Environmental conservation and protection is an essential aspect of an improved sustainable quality of life. In order to ensure environmental sustainability is attained in projects, project implementers need to adapt to the local environmental settings such as issues of ecosystem deterioration and resource constraints. The use of technology that relies on renewable and locally available resources is important. In several cases, resource availability will affect the feasibility of a design of a project. Minimizing environmental pollution and depletion of resources is very crucial to sustaining the local environment. Environmental education can also play a significant aspect in increasing awareness of environmental issues and reinforcing sustainable practices (Ocwieja S. M, 2010; McConville, 2006).

The criteria (**Table 3**) represent an overall direction of change in a process of sustainable rural development. A sustainable rural development project is considered successful, if it helps to create significant positive change in many realms while generating little or no negative change.

**Table 3:** Outcome-oriented criteria for evaluating sustainable development projects

S/N	Outcome Elements	Indicators
1.	<b>Economic</b>	<p><b>Distance saved for other income generating activities</b> – enhanced income, employment, productivity and livelihood opportunities while reducing environment resources dependency;</p> <p><b>Time saving to other income generating activities</b> - enhanced income, employment, productivity and livelihood opportunities while reducing environment resources dependency;</p>
2.	<b>Social</b>	<p><b>Cultural acceptability</b> – project goals, methods and initiatives;</p> <p><b>Facilitate learning and knowledge sharing</b> – to empower individuals and communities, improve school attendance, better performance and school completion to students;</p> <p><b>Facilitate a process of social change</b> – to improve attitudes, values, awareness and behaviors as they relate to the goals of sustainable development;</p> <p><b>Improve health of people</b> – minimize diseases as a result of smoke and water borne diseases;</p> <p><b>Organize communities and mobilize local resources</b> – material, human, financial, institutional, political and cultural, toward the achievement of project activities;</p>
3.	<b>Environment</b>	<p><b>Minimize consumption of non-renewable resources</b> - reduce wood harvesting and the use of wood as a source of domestic fuel;</p> <p><b>Reduced indoor air quality</b> – water treatment is done by solar energy;</p> <p><b>Improved quality of water</b> – reduce wood harvesting and the use of wood as a source of domestic fuel;</p>

Source: (Mog, 2004)

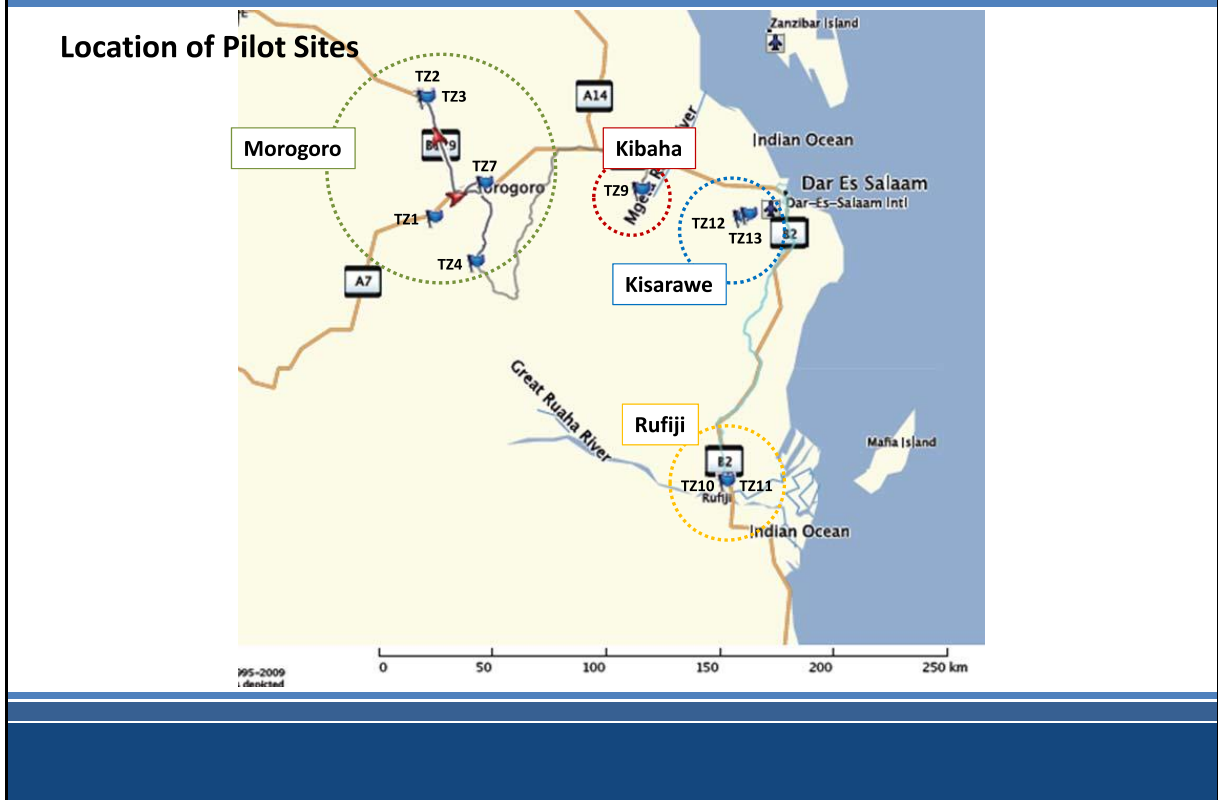
## 5. CASE STUDY: SOLAR POWERED WATER PURIFICATION PROJECT

### 5.1 Project description and its location

The solar powered water purification project implemented water purification systems to ten (10) different sites in Morogoro and Coast Regions (**Table 4**). Morogoro Region consisted five (5) sites with ID numbers: TZ1, TZ2, TZ3, TZ4 and TZ7. The rest of the five (5) sites with ID numbers: TZ9, TZ10, TZ11, TZ12 and TZ13 are located in Coast Region. **Figure 1** shows the location of the project sites.

**Table 4:** Original ten (10) project sites of solar powered purification systems

S/N	Site Name	Region	District	Village
TZ1	Vikenge Primary School	Morogoro	Mvomero	Sanga sanga
TZ2	Wami Dakawa Primary School	Morogoro	Mvomero	Wami Dakawa
TZ3	Dakawa Dispensary	Morogoro	Mvomero	Wami Dakawa
TZ4	Matombo Dispensary	Morogoro	Morogoro Rural	Matombo
TZ7	Mkambarani Dispensary	Morogoro	Morogoro Rural	Mkambarani
TZ9	Kwala Community House	Coast	Kibaha	Kwala
TZ10	Ikwiriri Health Centre	Coast	Rufiji	Ikwiriri
TZ11	Ikwiriri Kiosk	Coast	Rufiji	Ikwiriri
TZ12	Kisarawe Lutheran Jr. Seminary	Coast	Kisarawe	Kisarawe
TZ13	Minaki High School	Coast	Kisarawe	Kisarawe

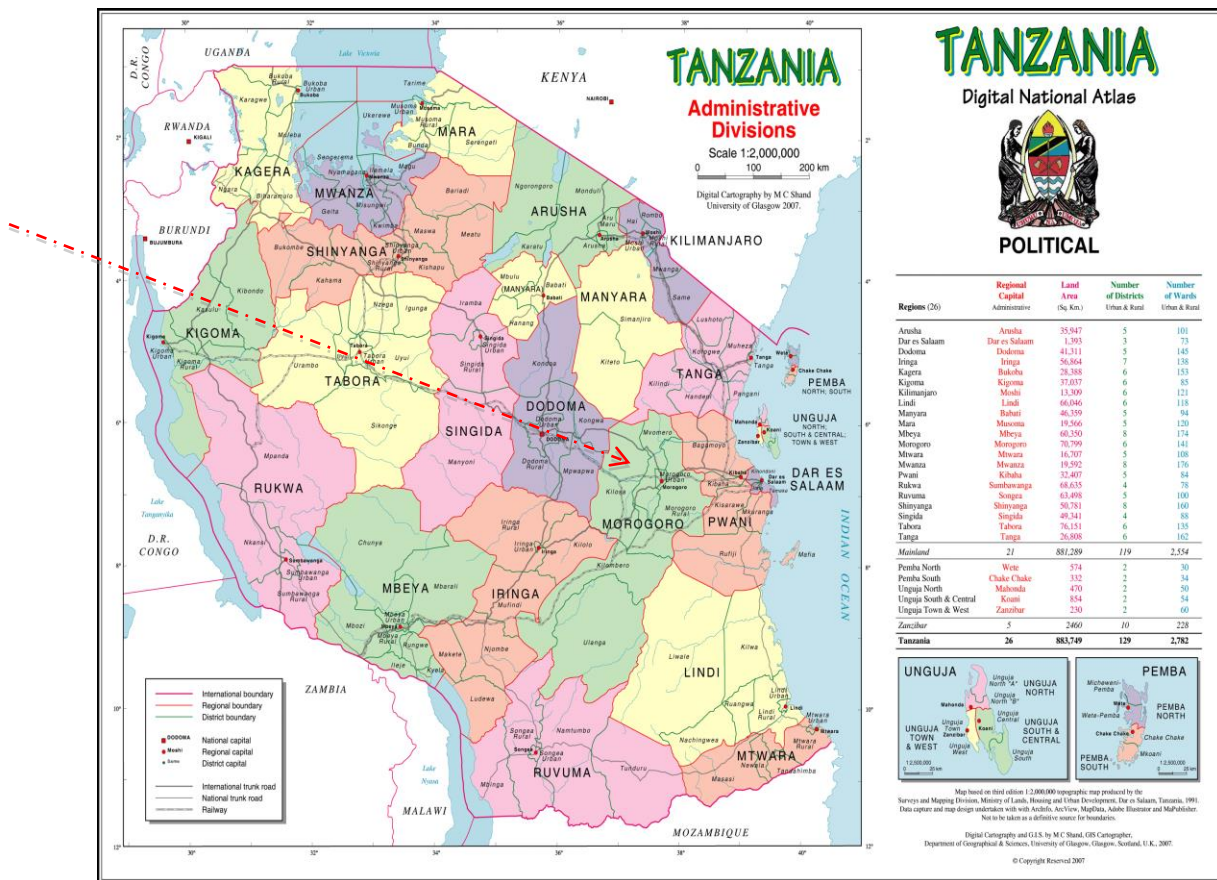


**Figure 1:** A map showing location of project sites  
**Source:** SolarWAVE Company Limited, Dar es Salaam-Tanzania

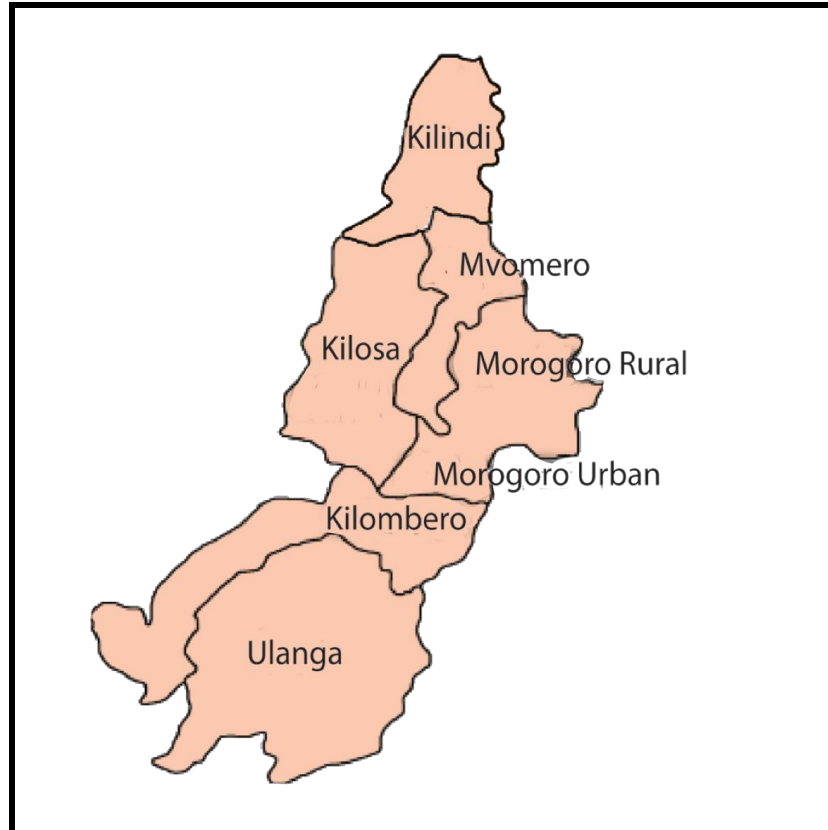
Due to time availability and cost, this study used three (3) sites to study impacts which are Vikenge Primary School (ID: TZ1); Wami Dakawa Primary School (ID: TZ2); and Mkambarani Dispensary (ID: TZ7) in Morogoro Region. The rest of the sites with IDs: TZ3, TZ4, TZ9, TZ10, TZ11 and TZ13 water purification systems are not functioning at the moment. Site (ID: TZ12) in Coast Region, the installed water system has been leased to Kisarawe Luther Jr. Seminary School.

### 5.1.1 Study Area

Morogoro is one the Regions of Tanzania (**Figure 2, presented with a dotted line**) located between Latitude  $5^{\circ} 0' 00''$  and  $10^{\circ} 0' 00''$  South of the Equator and Longitude  $35^{\circ} 0' 25''$  and  $30^{\circ} 0' 30''$  to the East. It occupies a total area of 73,039 square kilometers. Administratively, Morogoro composes six (6) districts: Morogoro, Mvomero, Kilosa, Kilombero, Gairo and Ulanga and six (6) Local Government Authorities namely Kilombero, Kilosa, Ulanga, Morogoro, Morogoro Municipality and Mvomero. (**Figure 3**) shows location of Morogoro and Mvomero districts within Morogoro Region. The region has an estimated population of 2,218,492 according to the population census of 2012. Its population growth is 2.4%.



**Figure 2:** A map of Tanzania showing the location of Morogoro Region  
Source: <http://www.vidiani.com/?p=10102> (Cited 21 July 2014)



**Figure 3:** Map of Morogoro Region showing administrative divisions of study sites: Mvomero and Morogoro Districts

Source: <http://www.skyscrapercity.com/showthread.php?t=1709978> (Cited 4 September, 2014)

**i. Mvomero District Council**

Mvomero is one of the six districts of Morogoro Region in Tanzania. It is bordered to the north by the Tanga Region, to the northeast by the Pwani Region, to the east and southeast by Morogoro Rural District and Morogoro Urban District and to the west by Kilosa District). It covers a total area of about 7,325km<sup>2</sup> or 9.98% of the total area of the Morogoro Region (Mvomero District Council Profile 2012).

**a. Socio-Demographic status**

The district has an estimated population of 312,109 whereby 154,843 are male and 157,266 are female, with an average household size 4.3 according to the population census of 2012. Its population growth is 2.6%.



***b. Socio-Economic status***

Agriculture (crop production) is the major economic activity. The major farming systems include maize-rice, agro-pastoralism and banana-vegetables. The major agricultural enterprises include:

- Cash crops: Cotton, coffee, simsim (sesame), sunflower, sugarcane, bananas, and vegetables.
- Food crops: Maize, paddy, millet, cassava, and pulses.
- Livestock: Beef and dairy cattle, indigenous and dairy goats, sheep and chicken.

***c. Water Supply status***

The district has access to clean and safe water supply through Dakawa Urban Water Authority. The utility is responsible for overall provision of water within the urban area of Dakawa (project site), the headquarters of Mvomero District. The Dakawa Urban Water and Sanitation Authority covers two wards namely Dakawa Sokoine East and Dakawa Sokoine West, these two wards comprise of 11 sub-villages. Its area of responsibility has a total population of 37,929 people in which 18% only people are served. Dakawa Urban Water and Sanitation Authority acquired borehole sources from the former community based schemes at Wami Dakawa, which include the three boreholes. The boreholes are all located at Wami Dakawa village. The present production capacity of 600 m<sup>3</sup>/day is very low compared with the estimated water demand of 2,432 m<sup>3</sup>/day, while the annual water production was 888 m<sup>3</sup>/day. The total length of the distribution system is 10 km and water is supplied at an average of 10hrs/day. The utility has no water treatment facilities and all other operational plans are not in place. The sanitation facilities in this town are mainly pit latrines with few septic tanks used under the supervision of Mvomero District Council (EWURA, 2013).

**ii. Morogoro District Council**

Morogoro District is one among the 6 Districts in Morogoro Region. The District is located at North East of Morogoro Region between 6°00' and 8°00' Latitudes South of Equator also between Longitudes 36°00' and 38° East of Greenwich. It is bordered by Bagamoyo and Kisarawe districts (Coast region) to the East, Kilombero district to the South and Mvomero district to the North and West (Morogoro District Profile, 2010).

Administratively, the district has the total area is 11,925 km i.e. 16.34% of the total area of Morogoro Region, which has 72,973 km . Initially, the district used to be Morogoro Rural District with a total land area of 19,250 km . Due large size area, the Government decided to split the District into two Districts namely; Morogoro District and Mvomero District. Currently, Morogoro District is divided into 6 Divisions, 29 Wards, 141 Villages, 716 Neighborhoods and 56,723 Households (**Table 5**).

**Table 5:** Distribution of Administrative Units in Morogoro District

S/N	Division	Ward	Villages	Sub-village
i.	Bwakira	5	20	121
ii.	Mvuha	5	26	154
iii.	Mikese	3	11	54
iv.	Mkuyuni	4	23	118
v.	Matombo	7	38	170
vi.	Ngerengere	5	23	99
<b>TOTAL</b>		<b>29</b>	<b>141</b>	<b>716</b>

Source: Morogoro District profile, 2010

*a. Socio-Demographic status*

The district has an estimated population of 286,248 whereby 140,824 are male and 145,424 are female, with an average household size 4.2 according to the population census of 2012.

*b. Socio-Economic status*

The district depends on agriculture, mainly from crop production. Major food crops are maize, paddy, cassava and sorghum while main cash crops produced are Cotton and Sisal. 82% of the adult population in Morogoro Rural earns their livelihood from agriculture though mainly at subsistence level, 6% in Business Operation, 6% in Elementary Occupations, 4% in Office Work and 1.3% in Livestock Keeping (Morogoro District Profile, 2010)

*c. Water Supply status*

Water sources in Morogoro Rural district are by gravity water - pumped water, boreholes, shallow wells, chaco-dams, rain water harvesting, traditional water sources, river waters and spring water. The following **Table 6** summarizes sources of water within the district.

**Table 6:** Water sources existing within the district

S/N	Water Source	Number	
		Working	Not Working
i.	Bore holes	12	2
ii.	Shallow wells (pumped water)	314	25
iii.	Gravity water	13	0
iv.	Electricity Powered	3	1
v.	Diesel Powered	2	1
vi.	Charcoal dams	9	2
vii.	Rain water harvesting	2	0
viii.	Traditional water sources	150	0
ix.	River water sources	35	0
x.	Spring water	15	2

Source: Department of Water, Morogoro District, 2010

Nine (9) water projects are not operating (pumped water). Most of the machines and other instruments are out of order for a long time. The district is putting efforts to rehabilitate the implemented water projects. In addition, fifteen (15) shallow wells are not operating due to drought condition and rain shortage some therefore putting pressure to accessibility of water services within the district (Morogoro District Profile, 2010).

## 5.1.2 Project Sites

### i. Mkambarani Site

Mkambarani site is located within Mkambarani village in Mkambarani ward, Morogoro District. It is situated about 67km from Morogoro town. The village is surrounded by other villages such as Pangawe, Kizinga, Mtego wa Simba, Mkono wa Mara and so forth. It has a population of 5,155 according to the population census of 2012. The project was implemented at a dispensary, Mkambarani dispensary (**Plate 1**).



**Plate 1:** Mkambarani Dispensary Site  
**Source:** MWAKANGALE (September, 2014)

The economy of the village depends much on subsistence farming. The area produces well maize, tomatoes, sunflowers and sesame. The average income per person per day is between Tshs. 2,000/= to 3,000/=. Another source of income comes from tobacco industry, which is located nearby the village. The locals usually work as casual laborers to earn something for sustaining their lives. Social aspect features education, health and gender. Within the village two schools exist: a primary school and a secondary school. The performance of the two schools is on average. Students are taught fundamentals of life from standard one (1) up to standard seven (7) for the primary system and secondary ordinary level from form one (1) to form four (4). Health and environmental issues are covered in the curriculum. Boys and girls equally receive the education.

The village has one dispensary for treating sick people and pregnant women who go for labour. The area is prone to water borne diseases especially during rainy season. Locals quite often suffer from diarrhea, typhoid and cholera. Gender wise, women participate in their usual domestic chores mostly: collecting water and fuel wood, cooking and other chores while men frequently do farming, petty business and casual laboring at the nearby industry.

Most of natural resources such as fuelwood and water supply are from the ecosystems of Usambara and Uluguru Mountains. Water supply comes from the catchment areas within the Ecosystem Mountains. Water pipes have been laid-out to tap water by gravity from the mountains to the storage tank with capacity of 50,000L, which supply water to twelve water points within the village. Within the Mkambarani dispensary premises exist two storage water tanks. One tank, the water is used for cleaning and sanitary purposes of the dispensary while the other tank with the capacity of 5,000L is specifically used for providing safe and clean water at the dispensary and the community around. The water is used for domestic purposes such as drinking and cooking.

## **ii. Vikenge Site**

Vikenge site is located within Vikenge village in Mzumbe ward, Mvomero District. It is situated about 24km from Morogoro town and 1km to Mzumbe University. The village is surrounded by other villages such as Konga and Sangasanga. It has 502 households with an average number of 6 people per family. The project was implemented at a primary school, Vikenge Primary School (**Plate 2**). The installed water purification system (WP700) caters for students and the communities surrounding the school. Majority of people within the project site depend much on agriculture for sustaining their lives. The village is governed by a Village Government, which comprises several committees a water committee being one of them that oversees water demand and supply to the locals. At the moment, Vikenge Primary School is in charge of the water purification system (WP700) water point. There are other water points within the village however does not supply safe water for domestic purposes. Water supply to Vikenge comes from the natural springs in the forest. A water tank of 90,000L capacity has been constructed at Tangeni village to collect water from the natural springs and distribute to Konga, Vikenge and Sangasanga villages.



**Plate 2:** Vikenge Primary School Site  
**Source:** MWAKANGALE (November, 2014)

**iii. Wami Dakawa Site**

Wami Dakawa site is located within Wami Dakawa village in Dakawa ward, Mvomero District. The project was implemented at a primary school, Wami Dakawa Primary School. The site is located about 40km from Morogoro town. The installed water purification system (WP700) supplies clean and safe water to students and locals surrounding the school (**Plate 3**). Water is received from Water Authority.



**Plate 3:** Wami Dakawa Primary School Site: water point connected to the water purification unit (WP700)  
**Source:** MWAKANGALE (November, 2014)

## 5.2 Project component and design

A solar powered water purification system is a water project that utilizes sustainable environmental technology to capture solar energy to purify water, making it safe for domestic purposes particularly drinking. SolarWAVE, a Swedish company with headquarters in Gävle, Sweden, supported the project in Mvomero District from the awareness raising, installation of the technology, training, operation and maintenance as well as follow-up and monitoring.

The project goal was to provide safe and inexpensive drinking water systems for use, which have the capacity to treat water making it safe for human consumption in remote areas. This goal was agitated due to serious concerns persist on the access to improved and safe water for the rural people despite of the continued progress in meeting the MDGs in the area of water supply and sanitation. This situation threatens the outbreak of waterborne diseases that poses one of the world's biggest public health challenges.

Technically, the project deployed a sustainable environmental technology, solar powered water purification system WP700 (**Plate 4**). The WP700 consists of two main parts: a solar cell module and a water purification unit. The solar cell module unit has two 12 volts outputs that provide clean reliable electrical power for all needs such as electrical light, charging mobile phones, laptops, radios and others. The water purification unit cleans water using proven ultra violet (UV) disinfection technology. The process is a chemical free. The WP700 solar powered water purification system has the capacity to purify 700 liters of water an hour (4, 200 liters per day) therefore supply up to 1,400 people with safe drinking water.

The system eliminates bacteria, virus and protozoa, thus providing clean and safe drinking water which meets the WHO's and Health Department's standards for potable water. The system itself does not require virtual installation. For extra safety, it has a built-in alarm function: if the purification unit is out of order, an alarm instantly sounds, following which the pump automatically shuts down. In (**Table 7**) technical specifications of the system are shown.



**Plate 4:** WP700 solar powered water purification system (a solar module and a water purification unit in the white box).  
**Source:** SolarWAVE Company Limited, Dar es Salaam-Tanzania

**Table 7:** Technical Specification of the WP700 system

Solar Power	85 W
Battery Capacity	60 Ah
Electrical Output	12 V / 7.5A
Water Cleaning Capacity	Nominal 700 liters per hour
Current	Nominal 5 Amp (max 8.3 A)
Dimensions	560 x 600 x 140 mm
Weight	16 kg
Recommended max. water input temperature	40 °C
Security and safety	Auto shut-off in case of lamp mal function



### 5.3 Mechanism of the Solar Powered Water Purification System

A solar powered water purification system (WP700) contains two units: solar module units and water purification unit. The solar module consists of two solar panels with power capacity of 250W (500W in total). These solar panels capture solar radiation from the sun and transform it to electric current. The electric power charges the battery to provide mechanical power for pumping and sterilization in the water purification system. The water purification unit contains the following: a pump – pressure setting, filter, ultra violet (UV) sterilization membrane, a meter and an accumulator tank with a volume capacity of 65 liters. The accumulator tank provides smooth flow of water, reduces noise and improves pumping cycling.

Water purification mechanism starts with water from the storage tank pumped into the water purification unit, which is first filtered to remove impurities in the water such as particulate of dust/mud. Then, water flow to the Sterilight component consisting a sterilization UV membrane. The UV membrane helps in killing all microorganisms such as bacteria, protozoa, viruses, which cause water borne-diseases. From the sterilization unit, treated water flows to the accumulator tank, which then provides a smooth flow of water to the tap ready to be taken for domestic use (**Plate 5** and **Appendix II**) provides a water purification flow mechanism of WP700 system).



**Plate 5:** A composition of a water purification unit  
**Source:** SolarWAVE Company Limited, Dar es Salaam-Tanzania

## **6. MATERIALS AND METHODS**

### **6.1 Method design**

This study employed the before and after design, which involved observations and interviewing a group of locals within a village, schools and a dispensary where water treatment systems were installed. Key variables of the study focus have based on process-oriented criteria and outcome-oriented criteria as described in Chapter 4. These variables were incorporated into the before and after design to study the extent of the impact. The logical reason is to grasp an understanding of the impact of the project with respect to quality of approaches deployed during project inception and execution into producing progressive change towards project goals.

Therefore with this, the design method has established two components: (i.) determination of impacts of the project with respect to the quality of approach based on the assessment approach of outcome-oriented criteria and process-oriented criteria; and (ii.) determination of the sustainability of the project using matrix approach.

#### **6.1.1 Determination of Impacts with respect to the Quality of Approach**

Impacts and Quality of Approach used for this project were assessed independently based on the formulated questions; structured, semi-structured, closed and open ended in **Appendix I (ii)** and **(iii)**.

Outcome-oriented criteria contain five aspects, which were assessed as impacts of the project. Each of the aspect in **Table 8** has several questions with each carries **0 – 2** points whereas **0** signifies lowest point and **2** signifies highest point. Some of the questions carried **0.5** points, **1** points, **1.5** points depending on the weight of the question. More of the clarification can be seen in **Appendix I (iii)**.

**Table 8:** Elements of Outcome-oriented Criteria

<b>Outcome-oriented Criteria (<i>impacts</i>)</b>					
<b>ASPECTS</b>	Political organization ( <i>social aspect</i> )	Quality of life ( <i>social aspect</i> )	Socio-cultural respect ( <i>social</i> )	Economic aspect	Environmental aspect
<b>SCORES</b>	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2

Process-oriented criteria contain five aspects, which were assessed as quality of approach taken during project execution. Each of the aspect in **Table 9** contains several questions as well as in the Outcome-oriented criteria with each carries a maximum score of **2** points. Some of the questions carried **0.5** points, **1** points, **1.5** points depending on the weight of the question. More of the explanation can be seen in **Appendix I (ii)**.

**Table 9:** Elements of Process-oriented Criteria

<b>Process-oriented Criteria (<i>quality of approach</i>)</b>					
<b>ASPECTS</b>	Character of participation	Success and nature of institution- and capacity building efforts	Diversity, multiplicity and adaptability of ideas promoted by the project	Use of local knowledge and skills	Influence of external conditions, markets and policies
<b>SCORES</b>	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2

### 6.1.2 Determination of Sustainability of the project

Sustainability of the project was assessed through matrix approach. This assessment tool is preferred due to its character of highlighting strengths and weaknesses of a particular activity therefore allowing decision makers to identify key areas for improvement (McConville, 2006). Based on this study, the matrix tool is defined by vertical direction and horizontal direction, which combines two criteria: process and outcome-oriented criteria. The vertical direction is defined by process-oriented criteria (*quality of approach*) while the horizontal direction is defined by outcome-oriented criteria (*impacts*) **Table 10** describes. Each matrix cell defines how a certain aspect in the criteria can be dealt with in the vertical and horizontal direction based on the specifics of the project.

In determining sustainability for this project, process-oriented criteria and outcome-oriented criteria were combined. Each matrix cell rates (**0 – 4**), where **0** signifies a poor score and **4** signifies an excellent score. This comes from adding maximum values of **2** from process-oriented criteria and **2** from outcome-oriented criteria resulting into **4**; therefore each cell carries a score of **4**. The potential score for each cell of the criteria; process-oriented criteria and outcome-oriented criteria is **20**, making a total score of the whole assessment to be **100**.

**Table 10:** Determination of Sustainability using Matrix Tool

<b>Process-oriented Criteria (Approach)</b>	<b>Outcome-oriented Criteria (Impact)</b>					
	Political organization ( <i>social aspect</i> )	Quality of life ( <i>social aspect</i> )	Socio-cultural respect ( <i>social aspect</i> )	Economic aspect	Environmental aspect	<b>Total</b>
Character of participation	4	4	4	4	4	<b>20</b>
Success and nature of institution – and capacity building efforts	4					<b>20</b>
Diversity, multiplicity and adaptability of ideas promoted by the project	4					<b>20</b>
Use of local knowledge and skills	4					<b>20</b>
Influence of external conditions, markets and policies	4					<b>20</b>
<b>Total</b>	<b>20</b>	<b>20</b>	<b>20</b>	<b>20</b>	<b>20</b>	<b>100</b>

### 6.1.3 Measuring sustainability of the project

A sustainable rural development project is considered successful, if it helps to create significant positive change in many realms (social, economic and environment) while generating little or no negative change. This will depend on the quality of approach taken during the project life cycle. Positive impacts are those that can be enhanced to produce more benefits to the beneficiaries in the project area such as employment opportunities, improved health situation whereas negative impacts are adverse impacts.

There are several dimensions to project sustainability depending on the nature of a sector or a project however the basic ones are: economic, social and environmental dimensions. Each of these dimensions has the capacity to influence project sustainability in one way or another, therefore consideration of these dimensions is key to sustainability of projects. Experience suggests that weakening of any one of these has the potential to endanger the sustainability of the entire project over the long run (M. Adil Khan 2000; Mog. J 2004). For this project sustainability is judged based on the categorization levels described in **Table 11**.

**Table 11:** Definition of Sustainability Levels

Range (%)	Sustainability category	Description
0 – 33	Low	Existing conditions are slightly altered. The quality of approaches used produce impacts, which are short term to the beneficiaries. The beneficiaries are dependent and unable to continue over the long run even after the project ends.
34 – 66	Medium	Existing conditions are notably altered. The quality of approaches used produce moderate impacts to the beneficiaries in terms of economy, social and environment. The beneficiaries are still dependent on external support in order to continue even after

		project ends
67 – 100	High	Existing conditions are significantly altered. The quality of approaches used produce positive impacts with more benefits to the beneficiaries in terms of economy, social organization and environmental practices. Beneficiaries are independent and able to continue over the long run even after project ends.

Source: On construct

## 6.2 Data collection

In achieving study objectives mixed-method, a combination of qualitative and quantitative methods is applied. (Gould, Lectures 2011) expounded that the use mixed methods have proved to be excellent among researchers due to its easy analysis and object interpretative. Through mixed-method, direct participation and observation were used at the study area where the project was implemented. Primary data is collected from textual analysis which includes: project reports analysis, baseline studies and other literature materials are used to capture an understanding of specific aspects of the topic, study area and objectives of the project.

Interviews and in-depth focus discussion were used as secondary source. **Table 12** shows kinds of methods and techniques used for this study. Questionnaire survey was used to acquire more information in the relevant project sites. Open-ended and closed questions were chosen to collect perspective and opinions from the beneficiaries at the bottom level (**Appendix I**). Questions were administered to 45 people in all of the three (3) project sites: fifteen people (15) from each site (Mkambarani, Vikenge and Wami-Dakawa). Four (4) questions were administered to project implementers (Solar WAVE). These surveys allowed for a qualitative and quantitative assessment of changes across time as well as differences across distance including closeness to the project.

**Table 12:** Type of method, techniques and purpose used for data gathering.

Type of method	Technique for data gathering	Data obtained from	Purpose	Data processor
Qualitative	Focus group discussion  Field walk, observation and Discussion  Interviews	Villagers (Village Govt.),  Students, Teachers (at the project study area)  Project Implementers	- Getting perception on the energy source, use; health status with respect to water supply and energy use; health status with respect to education, enrollment of students  - Actual situation of the sites  - Capacity building	Notebook,  Photographs
Quantitative	Baseline info vs. present <i>Literature review</i>  Questionnaires	Implementers of the projects (Project Inception Report)  Villagers (village govt.),  Students,  Teachers	Assessing a change in the quality of life	Project reports,  Documents  Interviewing implementers



### **6.3 Validity and Reliability of the research data**

As with any other method, case study design method needs to establish its scientific credibility. Two key criteria are considered to be important in assessing the quality of research results: validity and reliability.

Validity refers to the degree to which the researcher has investigated what is set out to investigate. In other words, validity deals with the quality of being logically sound. Since case study relies on subjective understanding, validity is of concern. Impact analysis deals with more than one variable. For instance using sustainable energy to purify water helps to improve the quality of life of people: economically - time spent for gathering wood is reduced for other income generating activities, socially - diseases are reduced, better school attendance and performance are maintained, environmentally - sustainability is retained. Therefore, this interconnection is examined for this study for the purpose of maintaining the validity of results.

Reliability deals with consistence in giving the same results. For the situation of the case study, reliability cannot be claimed. The observer records the events that they occur and will never recur under any constant conditions. Therefore for this case, reliability is threatened by data collection errors and errors in learning process between the interviewer and interviewee.

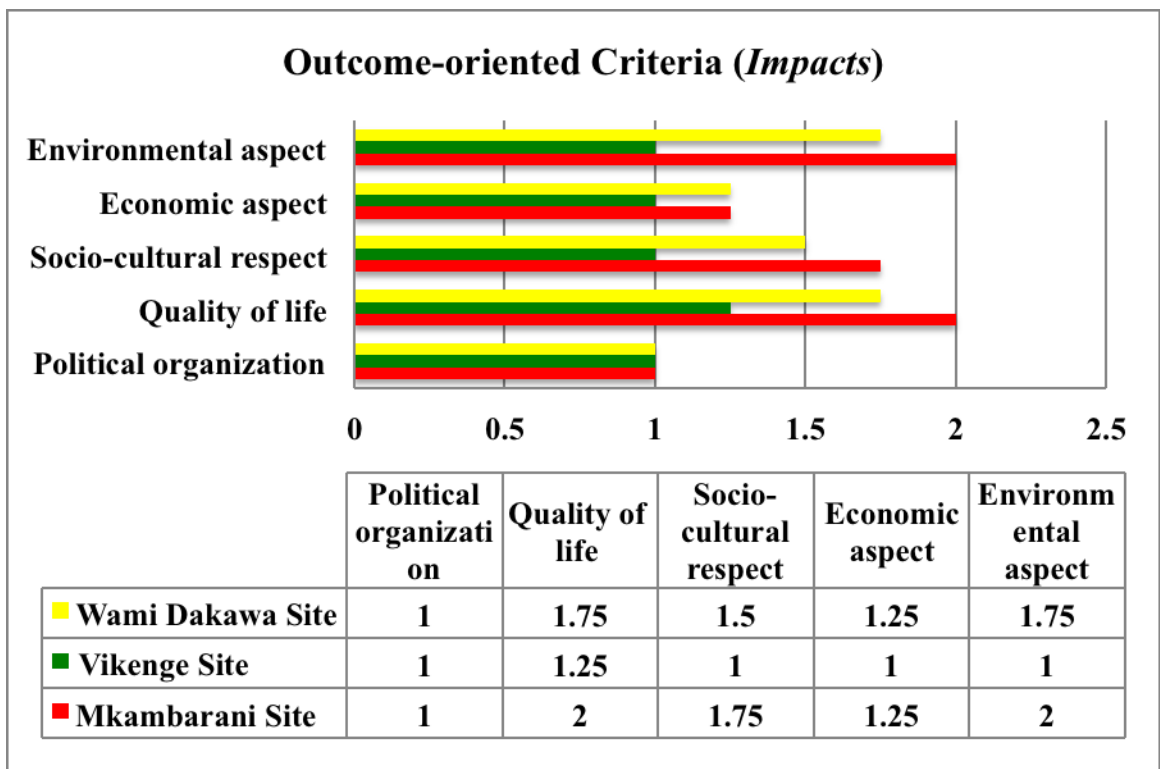
### **6.4 Data analysis procedure**

Data was analyzed based on the matrix tool and presented through tables and graphs. The analyzed variables are coded by names and labeled descriptively. Controlled comparison is used to study the project area before and after the intervention based on the checklist of questionnaires in **Appendix I**. In one way or the other, control comparison helps to identify impacts and the extent of project intervention to the beneficiaries. It should be noted that results of this study lack intense information on baseline data of the project sites prior to the implementation. Gathering of data and measuring of impact has been done based on responses collected during surveying and discussions. Six failed sites are also discussed to capture the overall execution of the project.

## 7. FINDINGS

### 7.1 Project breakdown by Outcome-oriented Criteria

The overall objective of the project was to promote improved and safe water supply by substituting fuelwood use in boiling water to solar energy use to the locals living in rural areas. Impact of the project is assessed based on social, economic and environment aspects by linking the three sites to each of the aspects distinctively. In general, aspects of quality of life and environment score high followed by socio-cultural respect and economic. Political organization scores the least (**Figure 4**).



**Figure 4:** Results of project breakdown by outcome-oriented criteria

### **7.1.1 Social impact of the project**

Social impact is categorized between quality of life, political organization, and socio-cultural respect.

#### **i. Quality of life**

Quality of life constituted education and health perspectives. Education refers to pupils' school attendance and performances in the class while health aspects involve main health problems occurred in the area. In the social aspect, quality of life scores high to all of the sites compared to socio-cultural respect and political organization. **Figure 4** shows Mkambarani site scores (**2/2**), Vikenge site (**1.25/2**) and Wami Dakawa site (**1.75/2**). Based on interviews and discussions made at the project sites, the project has intervened positively in reducing the frequency of waterborne diseases such as diarrhea, typhoid and cholera. At Mkambarani site chances of getting water-borne diseases has been reduced to about 90% of the total population, which is 5,155. Before the project, chances of getting diarrhea and typhoid were 50% - 75%. Improved health situation at the village has also increased chances of children going to school and perform well in the class.

Therefore since the installation of the water purification system, Mkambarani dispensary does not receive a lot of patients suffering from diarrhea and typhoid as compared to previous years.

For Vikenge and Wami Dakawa sites, teachers, pupils and the communities nearby the project sites confessed to the reduction of getting diarrhea, typhoid and other water-borne diseases frequently since the installation of water purification system (WP700). Pupils go to school and attendance rate has increased to 95% - 97%.

#### **ii. Socio-cultural respect**

Socio-cultural respect reflects local customs, beliefs and gender roles playing in project development. The project has intervened the barriers of cultural differences. Mkambarani site scores (**1.75/2**), Vikenge site (**1/2**) and Wami Dakawa site (**1.5/2**) according to **Figure 4**. At Mkambarani site, majority of people use water for domestic purposes such as drinking and cooking. It is only the minority group, about 10% - 15% of the people within the village still

has the perception and belief that using water purified by solar energy causes infertility to men and women, therefore they do not use solar treated water.

Vikenge and Wami Dakawa sites, pupils and teachers have accepted the project and are using solar treated water for drinking. However, some of the interviewed pupils confessed that when they are out of school, they use water that has not being boiled.

In all of the three project sites, gender role is 55% female while male is 45% in doing domestic chores. During data collection, men, women and children of Mkambarani and Wami Dakawa sites were seen fetching water at the water points. Vikenge site was not functioning during the time of data collection. The pump of the water purification system was clogged.

### **iii. Political organization**

Political organization refers to organizational and ruling of people within a locale with particular governing purposes for instance local institutions and village government. Cohesive effort between community members and involvement to the project minimizes chances of failures of projects.

Results in **Figure 4** displays that political organization scores the least in the category of social aspect. Mkambarani, Vikenge and Wami Dakawa sites score (1/2) which signifies that the project has not influenced that much on that particular feature. In all of the project sites, local village government governs the area, where chairperson is the leader. Within the village government exist different committees for instance water committee, which coordinates water issues within the village. Village leader and other members not exceeding ten (10) people do decision-making within the village making the level of participation and decision-making among the locals in the village to be low, as many do not do only a few representatives.

### **7.1.2 Economic impact of the project**

In the economic aspect, reduced distance and time saved for fetching water and collecting fuelwood was observed in order to balance for other economic activities. **Figure 4** shows that Mkambarani site scores (1.25/2), Vikenge and Wami Dakawa sites (1/2) and (1.25/2) respectively. At the moment time and distance use for fetching water has been saved. Water points are close enough to the surrounding communities and schools; therefore it takes five to ten minutes to fetch water from their households to the water point than previously which used to take five to eight hours per day fetching water from other water points and or water streams. The time saved and reduced distance has made people to concentrate more on other economic activities such as farming.

Another economic juncture that the project has influenced is on the formulation of a revolving fund at Mkambarani site. Local users of the water point within the Mkambarani site pay Tshs. 20/= per bucket of 20litres of water and Tshs. 10/= per bucket of 10litres. Other users outside Mkambarani village from the neighboring villages such as Fulwe, Pangawe and Kizinga uses water however are charged Tshs. 100/= per bucket of 20litres.

The money is collected into a revolving fund, which is used by the Water Committee for maintenance purposes of the installed system (WP700) and water pipes. With the existence of the revolving fund, the community intends also to use the money for buying a tractor or a mini-bus, which will be used for economic purposes of the area. Vikenge and Wami Dakawa sites have not introduced that system of revolving fund yet.

### **7.1.3 Environmental impact of the project**

Environmental impact reflects on the change in the use of energy resource and water supply improvement. Mkambarani site scores (2/2), Vikenge site scores (1/2) and Wami Dakawa scores (1.75/2). The project has managed to influence change in the perception of people in the use of fuelwood to some extent. Primary source of energy in the project sites is fuelwood, which is used for cooking and boiling. Boiling of water to reach 100<sup>0</sup>C needs a lot of energy therefore consumes much fuelwood for heating compared to cooking. However, since the installation of water purification systems (WP700) at the sites, the use of solar energy to treat

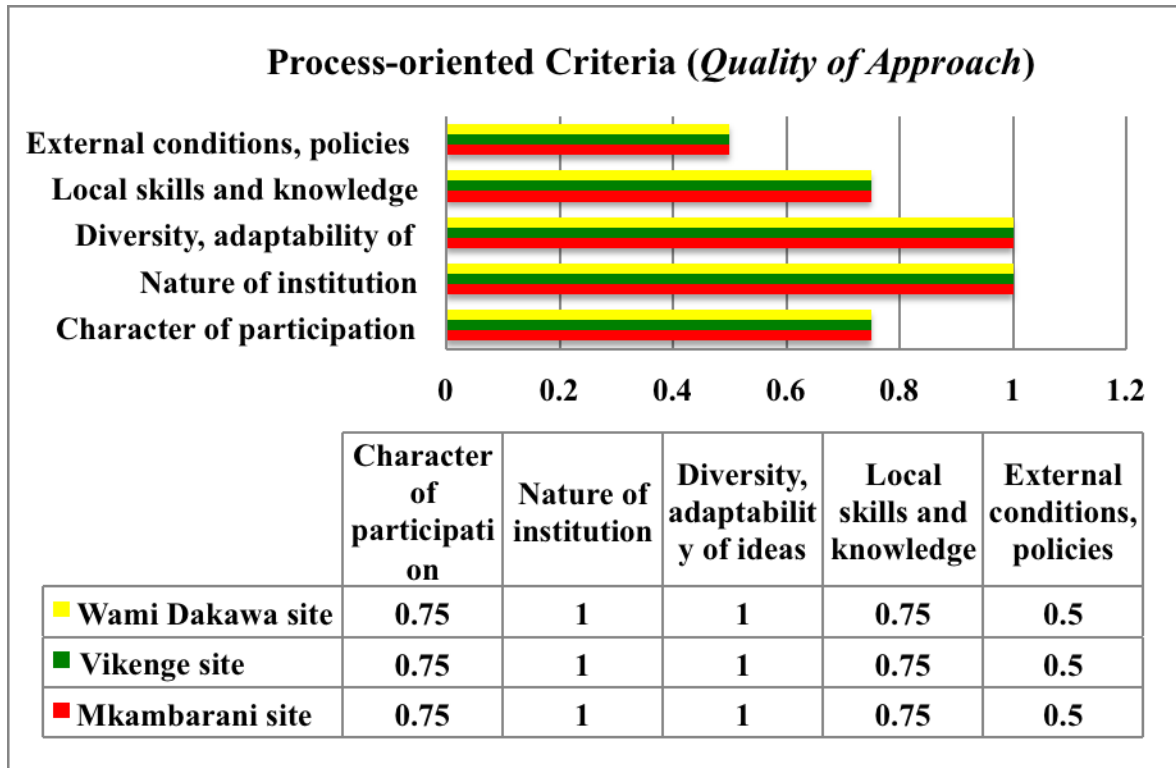
water has reduced to some extent the use of fuelwood to boil water. At the moment, fuelwood is used only for cooking particularly those living at Mkambarani and Wami Dakawa sites.

Another positive influence of the project was observed at Mkambarani site, whereas before the project the dispensary used a kerosene lamp for lighting during labour. However, after the installation of the water purification system (WP700) with solar panels, the dispensary has connected to solar panel therefore getting electricity for lighting.

Water supply in the project sites has been improved and made safe for drinking. Before the project, water was supplied from public water points that were unimproved and unsafe to use. Locals were supposed to boil water before using. Now, the supply of water has improved, safe and reliable to use as water points are constructed closer to the surrounding community. However, during the time of data collection, two project sites Mkambarani and Wami Dakawa their systems were functioning properly except for Vikenge site. The system was not functioning due to failure of the pump, shortage of water and poor quality of water, which has been affecting the design of the system not Vikenge alone but other sites as well.

## **7.2 Project breakdown by Process-oriented Criteria**

Impacts of certain projects depend much on the quality of approaches taken during the project cycle. Based on the results of impact in **Section 7.1**, the project has succeeded to some extent in achieving target of providing safe water through solar energy and UV sterilization treatment hence reducing diseases stemming from unimproved water supply as well as reducing fuelwood consumption which ultimately have environmental consequences through cutting-down trees. **Figure 4** has shown high scores in the aspect of quality of life and environment than in political organization, socio-cultural respect and economic aspect. With the results of impact, it is undoubtedly that the most important factors contributed to the impact would be the quality of approaches used by the project. **Figure 5** below shows results of the criteria used to assess the quality of approaches used. Nature of institution and diversity of the promoted idea score high than character of participation, local knowledge use and external conditions. Since implementer of the project is one, SolarWave, the quality of approach used for all sites is the same therefore scores of each element in all sites is the same.



**Figure 5:** Results of project breakdown by process-oriented criteria

### 7.2.1 Character of participation

Character of participation carries the weight of local people involvement and flexibility of contributing existing ideas within the village area into the project from the first stage of the project until the closure stage i.e. involvement in the project life cycle. In most cases, full local participation into the project is an engine for project success since the locals get that sense of belonging and responsibility into the project from the beginning, which ultimately contributes, to the success over the long run even after project exit.

With this study, Mkambarani, Vikenge and Wami Dakawa sites score (**0.75/2**), based on the results in **Figure 5**. According to the interviews and group discussions conducted at the sites, participation of local people into all stages of the project cycle was not fully specifically in setting goals, making decisions and planning, which are fundamental stages of the project. Local people were only involved into the implementation stage and this was done by initially installing the solar water purification systems (WP700) into the sites followed by organizing community discussion and awareness to the locals.

### **7.2.2 Success and nature of institution – and capacity building efforts**

In **Figure 5**, success and nature of institution with capacity building efforts score (1/2) for Mkambarani site, Vikenge site and Wami Dakawa site. During the implementation stage of the project, SolarWAVE Company managed to provide trainings to the beneficiaries regarding on the uses and maintenances of the solar water purification system (WP700). Maintenance of the system (WP700) is done by changing of the filters regularly once get muddy. To each of the sites, there is a chosen person from within the project site who is in charge of the operations and maintenances of the installed systems. Trainings plans continue to exist into the project sites until now; and are conducted after every three months.

### **7.2.3 Diversity, multiplicity and adaptability of ideas promoted by the project/ account for heterogeneity and dynamism**

In this category Mkambarani site, Vikenge site and Wami Dakawa site score (1/2). Solar water purification project promoted a cost-effective technology that uses solar energy from the sun to purify water making it safe for human consumption. The promoted idea supported project objectives, which were on encouraging safe supply of water, awareness raising on substituting solar energy to fuelwood consumption and its ultimate implications to the environment over the long run. These were promoted through seminars and group discussions with the beneficiaries during implementation stage of the project.

Diversification and adaptability of the ideas has been a success especially to Mkambarani and Wami Dakawa sites (**Figure 5**). In interviews and discussions, the beneficiaries confessed that not only their project sites are using solar water treated but also other people from the nearby villages are consuming solar water treated. However, multiplications of the promoted ideas to other villages have failed due to the expensiveness of the technology. The locals living nearby to the project sites anticipate for the same kind of project to be promoted again. With the diversification and adaptability of the promoted ideas have accelerated improved quality of life in the area of health and education as well as in environmental aspect.



#### **7.2.4 Understanding and use of local knowledge, skills, initiative and constraints**

Strength of the project lies in the ability to tap into local knowledge, skills and initiatives while thriving local constraints. With this project, results shown in **Figure 5** depict moderate score (**0.75/2**) to three of the sites; Mkambarani site, Vikenge site and Wami Dakawa site. To a certain extent, the idea of solar water purification technology promoted by the project did not use indigenous local knowledge existing into the project sites.

#### **7.2.5 Recognizing the influence of external conditions, market and policies**

In assessing the quality of approach taken in recognizing the influence of external conditions, market and policies towards this project, all sites score (**0.5/2**). Scores on this particular element are the lowest compared to the rest of the elements categorized in the process-oriented criteria. In interviews with project implementers (SolarWAVE Tanzania Ltd), this project used respective national policies to support project objectives. These policies were Environmental Policy, Water Policy, Energy Policy and Health Policy. In general, these policies address and support the use and supply of environmental resources in a sustainable way without degrading the environment and cause implications to the health of people.

The situation of local market in support of solar energy use is very wide. There is a growing strong market potential for off-grid lighting products in rural and peri-urban areas, as many Tanzanians are not connected to the grid. In addition, grid-connected electricity is expensive and supply is unreliable. The price range of all alternative lighting products on the market is in the range between USD 5 – 250, depending on the significant differences in type, features and quality. The only problem that exists to people at the local level is affordability of solar panels since investing in solar energy or any other renewable energy sources is very expensive. In carbon market trading, this project has failed to sell its carbon emission to the external market due to failing in meeting the conditions.

### 7.3 Sustainability measure of the project

Measure of project sustainability is obtained from combining values obtained from process-oriented criteria and values of outcome-oriented criteria by using matrix framework **Table 10**. A total score from the matrix table after adding elements of process and outcome-oriented criteria signify average value for sustainability. The following **Tables 13, 14** and **15** below shows sustainability value for each of the project sites: Mkambarani, Vikenge and Wami Dakawa.

**Table 13:** Results assessed by matrix tool, Mkambarani site

	<b>Outcome-oriented Criteria (Sustainability Dimensions)</b>					
<b>Process-oriented Criteria (Approach)</b>	Political organization ( <i>social aspect</i> )	Quality of life ( <i>social aspect</i> )	Socio-cultural respect ( <i>social aspect</i> )	Economic aspect	Environmental aspect	<b>Total</b>
Character of participation	1.75	2.75	2.5	2	2.75	<b>11.75/20</b>
Success and nature of institution – and capacity building efforts	2	3	2.75	2.25	3	<b>13/20</b>
Diversity, multiplicity and adaptability of ideas promoted by the project	2	3	2.75	2.25	3	<b>13/20</b>
Use of local knowledge and skills	1.75	2.75	2.5	2	2.75	<b>11.75/20</b>
Influence of external conditions, markets and	1.5	2.25	2.25	1.75	2.5	<b>10.25/20</b>

policies						
<b>Total</b>	<b>9/20</b>	<b>13.75/20</b>	<b>12.75/20</b>	<b>10.25/20</b>	<b>14/20</b>	<b>59.75/100</b>

**Table 14:** Results assessed by matrix tool, Vikenge site

	<b>Outcome-oriented Criteria (Sustainability Dimensions)</b>					
<b>Process-oriented Criteria (Approach)</b>	Political organization ( <i>social aspect</i> )	Quality of life ( <i>social aspect</i> )	Socio-cultural respect ( <i>social aspect</i> )	Economic aspect	Environmental aspect	<b>Total</b>
Character of participation	1.75	2	1.75	1.75	1.75	<b>9/20</b>
Success and nature of institution – and capacity building efforts	2	2.25	2	2	2	<b>10.25/20</b>
Diversity, multiplicity and adaptability of ideas promoted by the project	2	2.25	2	2	2	<b>10.25/20</b>
Use of local knowledge and skills	1.75	2	1.75	1.75	1.75	<b>9/20</b>
Influence of external conditions, markets and policies	1.5	1.75	1.5	1.5	1.5	<b>7.75/20</b>
<b>Total</b>	<b>9/20</b>	<b>10.25/20</b>	<b>9/20</b>	<b>9/20</b>	<b>9/20</b>	<b>46.25/100</b>

**Table 15:** Results assessed by matrix tool, Wami Dakawa site

	<b>Outcome-oriented Criteria (Sustainability Dimensions)</b>					
<b>Process-oriented Criteria (Approach)</b>	Political organization ( <i>social aspect</i> )	Quality of life ( <i>social aspect</i> )	Socio-cultural respect ( <i>social aspect</i> )	Economic aspect	Environmental aspect	<b>Total</b>
Character of participation	1.75	2.5	2.25	2	2.5	<b>11/20</b>
Success and nature of institution – and capacity building efforts	2	2.75	2.5	2.25	2.75	<b>12.25/20</b>
Diversity, multiplicity and adaptability of ideas promoted by the project	2	2.75	2.5	2.25	2.75	<b>12.25/20</b>
Use of local knowledge and skills	1.75	2.5	2.25	2	2.5	<b>11/20</b>
Influence of external conditions, markets and policies	1.5	2.25	2	1.75	2.25	<b>9.75/20</b>
<b>Total</b>	<b>9/20</b>	<b>12.75/20</b>	<b>11.5/20</b>	<b>10.25/20</b>	<b>12.75/20</b>	<b>56.25 /100</b>

In overall, total values for each project site are: Mkambarani site scores **59.75%**, Vikenge site scores **46.25%** and Wami Dakawa site scores **56.25%** as **Table 13, 14 and 15** describe. With these values, the whole project can be categorized to fall within the range of **34 – 66%**, which signifies a category of medium sustainability. Based on the description of **Table 9**, medium sustainability defines that the project has notably altered the existing conditions. The quality of approaches used produce moderate impacts to the beneficiaries in terms of economy, social and environment aspects. These moderate impacts are still inadequate, leaving beneficiaries dependent on external support even after the project ends and if external support is never reached or accessed by these beneficiaries when the project ends, leaves everything as it used to be, earlier before the project was implemented.

#### **7.4 Feasibility of the Solar Powered Water Purification System (WP700) in portable water supply improvement**

The main goal of the project was to promote the development of a mechanism that will provide improved and safe drinking water supply to people in rural areas hence reducing the frequency of getting waterborne diseases. Based on the findings, the project has succeeded to impact most on the quality of life and environment aspects. In the quality of life, intervention was observed in health and education.

Majority of the users of water from WP700 system have asserted that since the use of solar treated water, health situations within the project sites have improved. Cases of water borne diseases have been reduced specifically diarrhea and typhoid which were the recurring diseases. With reduced diarrhea and typhoid, pupils are going to school and their attendance reported to have increased 95% to 97%, based on the interviews. This is an indicator of the achievement in the goal of safe portable water supply proposed by the project (SolarWave-Tanzania, 2014).

Environment aspect specifies fuelwood consumption in relation to reforestation. Boiling of water on three-stone stoves consumes a lot of wood for heating due to nature of the cooking stoves. Design of the traditional cooking stoves (three-stone stoves) has space in between stones therefore most of the released energy in the wood is wasted heating the surrounding air rather than heating the cooking/boiling vessel. The inefficient transfer of energy requires the use of more wood fuel, increasing the amount of wood harvested from the surrounding environment. The increased demand for wood can further deplete the already stressed local natural environment. Findings of this study have shown a moderate improvement in the use of fuelwood at the project sites. At the moment, the villagers are using less fuelwood for cooking only.

### **7.5 Challenges in the use of the system and maintenances**

Major challenge the users of the water purification systems (WP700) face is on the maintenances. The systems wears-off every now and then due to pump failure which is contributed by shortage of water supply from the main reservoirs or clogging of the system due to water being highly turbid especially during rain season. Technical capacity of the local people to repair the systems on their own is very low as they lack technical know-how. An engineer from Solar Wave Company-Dar es Salaam does systems' repairing every now and then. This was observed during field visit as Vikenge site, the system was not functioning due to shortage of water, which resulted to pump-failure. And teachers at Vikenge Primary School were waiting for an engineer to come and repair the pump.

Due to the problem of shortage of water, the school with the help of SolarWave has initiated an alternative system of getting reliable water, which is harvesting rainwater. Four (4) jars of 5,000litres each have been constructed jointly with gutters to collect rainwater, which is going to be connected to the water purification system to provide safe water to the school (**Appendix II; photo 11a and 11b**). The problem of shortage of water was also faced at Mkambarani and Wami Dakawa sites but was repaired later on by adjusting the heights of the water storage tanks in which previously the tanks were situated on the ground therefore caused problems to the flow of water to the water purification system (WP700).

Moreover, cultural perception of people hindered the diversity of the water purification system (WP700) to other sites especially in the Coast Region. Five (5) sites failed to exist due to cultural resistance. Many believed negatively that solar treated water when use could have effects to the reproductive systems as will have problem of infertility later on. However, this could have been contributed due to the approach taken during the project cycle, character of participation. Many of the interviewees confessed to be involved at the last stage of the project cycle, which is implementation. At this stage, idea of the mechanism of the system was demonstrated while in a normal situation of the project cycle, character of participation is supposed to involved at the earliest stage, project inception. Therefore, this could have been a weakness to the failure of five (5) sites in Coast Region of Tanzania.

Another foreseeable challenge that most of the existing project sites will face is on the sustainability of operating and maintaining these water purification systems in the long run. Based on the observations and interviews, the project has not provided a strong economic platform for the local communities to be independent once technical support from SolarWave ends. At the moment, only Mkambarani site has managed to create a revolving fund where Water Committee collect money from charges per bucket of water collected. However, the charges (20Tshs per 20litres bucket of water) are not feasible to make maintenances of the system in the long run when wears off, since there will be replacing of filters, pump, solar panels once their life span expires. Therefore, for local communities to maintain the system alone will be difficult unless the Government through the Local Government Authority are involved and work together in sustaining these water purification systems.

## **8. CONCLUSION AND RECOMMENDATION**

### **8.1 Conclusion**

Based on the findings, solar powered water purification system (WP700) has the potential for adoption by rural households, schools and dispensaries. The solar powered water purification system (WP700) can be useful in the provision of safe potable water in the remote villages, which lack the supply of safe water due to water infrastructures being far away or contaminated or not functioning. The use of purification system (WP700) directly substitutes fuelwood, which are usually used for boiling. In a way, this can be used as a strategy for energy saving and cost reduction in energy expenditure for rural settings as well as fulfilling the objectives of the Sustainable Energy for All initiative, which resulted from (Rio + 20) Summit. In addition, adoption of the purification system will assist in improvement of the health of people through reduction of indoor air pollution whilst conserving the environmental resources through lessening of cutting-down trees.

In actual fact, solar powered water purification systems (WP700) are expensive technology especially on the initial cost of acquiring and installing the equipment as well as maintenances every time when it wears off. To be adopted in rural settings without any form of assistance or intellectual capacity building to the local people will not be easy as people living in remote and rural areas majority are still poor.

### **8.2 Recommendation**

This study recommends the promotion of water treatment technologies that uses renewable energy sources to rural Tanzania. The government should be highly involved to support these initiatives in terms of technologies and finance once are handed over to the local communities. Through this research study, more studies should be done to comprehend:

- i. The extent of using these technologies into reduction of mortality rate with respect to water born diseases, health hazards generated from burning of fuelwood and treatment costs;
- ii. To what extent deforestation rate can be reduced through adopting technologies that tap renewable energy sources; and



- iii. The extent of carbon reduction into the atmosphere through carbon emission reductions (CERs) calculations through the substitution of solar energy into purification of portable water.

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## APPENDICES

### Appendix I: Questionnaires

#### i. General questions to gather baseline information at project sites before the project

(Mkambarani dispensary, Wami Dakawa School, Vikenge Primary School and Kisarawe Seminary Jr. Secondary School)

Aspect	Questions	Means of verification	Source of verification
<b>Economic</b>	<ul style="list-style-type: none"> <li>- What is the primary source of employment locally?</li> <li>- How stable is the employment level?</li> <li>- What is the average income?</li> <li>- How much time is spent on domestic and/or economic activities? (e.g. spend on gathering water) and what is the distance, how far?</li> </ul>	<p>Focus Group</p> <p>Discussion (FGD)</p> <p>Observations</p>	<p><b>Institutions</b></p> <ul style="list-style-type: none"> <li>- Village Government</li> <li>- Water Committee</li> <li>- Health Centre (dispensary)</li> <li>- Schools</li> </ul> <p><b>Users</b></p> <ul style="list-style-type: none"> <li>- Local people: women, men and children</li> <li>- Students</li> </ul>
<b>Social</b>	<p><b>Political organization</b></p> <ul style="list-style-type: none"> <li>- How is the area governed?</li> <li>- Who are the decision makers in the community?</li> <li>- What is the level of participation in community decision-making?</li> </ul> <p><b>Quality of life (education, health and gender issues)</b></p> <p>*Education</p> <ul style="list-style-type: none"> <li>- What is the available educational system and background?</li> <li>- Are health and environmental education covered in schools? On what issues?</li> </ul>	“	“

	<p><i>*Health</i></p> <ul style="list-style-type: none"> <li>- <i>What was the health situation in the area before the project?</i></li> <li>- <i>How often did people get sick? What was the cause?</i></li> </ul> <p><b>Socio-cultural respect</b></p> <ul style="list-style-type: none"> <li>- <i>Are there any traditional beliefs or values within the area?</i></li> <li>- <i>Are there certain resources (e.g. water sources) preferred over others?</i></li> <li>- <i>What is the traditional method of water source protection and treatment?</i></li> </ul> <p><i>*Gender</i></p> <ul style="list-style-type: none"> <li>- <i>Who receives education? Boys or girls?</i></li> </ul>		
<p><b>Environment</b></p>	<p><b>On energy use</b></p> <ul style="list-style-type: none"> <li>- <i>What is the primary source of energy use? And used for what?</i></li> <li>- <i>If source of energy is fuelwood, how much time and distance is spent on gathering fuelwood?</i></li> </ul> <p><b>On water supply</b></p> <ul style="list-style-type: none"> <li>- <i>Where is the primary source of water supply?</i></li> <li>- <i>How far does it take to fetch water?</i></li> <li>- <i>How reliable are they?</i></li> <li>- <i>How do people perceive the threats to the environment connecting fuelwood use and water supply?</i></li> </ul>	<p>“</p>	<p>“</p>

ii. Specific questions to assess character of approaches used during the project life cycle (*Process-oriented Criteria*)

Aspect ( <i>*Approach</i> )	Questions	Means of verification	Source of verification
<b>Character of participation</b>	<p><i>Were you involved in the project? Yes or No. (Marks 0.25)</i></p> <p><i>If Yes, How was the involvement done? And which phases specifically? (i.e. a. in setting goals; b. making decision; c. planning; and d. implementation) (Marks 1)</i></p> <p><i>What local ideas and perspectives exist in the project on water treatment? (Marks 0.25)</i></p> <p><i>Were local opinions given priority and respected? How? (Marks 0.5)</i></p>	<p><i>FGD</i></p> <p><i>Observations</i></p>	<p><i>Institutions</i></p> <ul style="list-style-type: none"> <li>- <i>Village Government</i></li> <li>- <i>Water Committee</i></li> <li>- <i>Health Centre (dispensary)</i></li> <li>- <i>Schools</i></li> </ul> <p><i>Users</i></p> <ul style="list-style-type: none"> <li>- <i>Local people: women, men and children</i></li> <li>- <i>Students</i></li> </ul>
<b>Success and nature of institution – and capacity building efforts</b>	<p><i>How are operations and maintenances of the installed system done? (Marks 0.5)</i></p> <p><i>Is there a supervisor in place? Does s/he have enough technical capacity to operate and provide maintenances to the system? And are operation and maintenance responsibilities clear? (Marks 1)</i></p>	<p>“</p>	<p>“</p>



	<p><i>Are training plans continuing to exist until now?</i> <b>(Marks 0.5)</b></p>		
<p><b>Diversity, multiplicity and adaptability of ideas promoted by the project</b></p>	<p><i>What ideas were promoted during project execution? How were they promoted, by what means/approach?</i> <b>(Marks 0.5)</b></p> <p><i>To what extent the ideas promoted have managed to be diversified and adapted by people?</i> <b>(Marks 0.5)</b></p> <p><i>How have these ideas promoted have influenced specific impacts (social, economic and environment)</i> <b>(Marks 1)</b></p>	<p>“</p>	<p>“</p>
<p><b>Understanding and use of local knowledge, skills, initiative and constraints</b></p>	<p><i>What local skills, knowledge, initiatives and constraints exist in the area esp. in water treatment exist? Were they investigated before the project was implement and given primacy during project execution?</i> <b>(Marks 1)</b></p> <p><i>How and to what extent local skills, knowledge and constraints have impacted the area, economic, social and environment?</i> <b>(Marks 1)</b></p>		

<p><b>Recognizing the influence of external conditions, markets and policies</b></p>	<p><i>Which policies were used to support this kind of project intervention?</i> (Marks 0.25)</p> <p><i>What is the situation of local markets in support to Solar Energy use?</i> (Marks 0.25)</p> <p><i>What is the situation of external market in carbon market trade?</i> (Marks 0.25)</p> <p><i>How have these influence specific impacts: economic, social and environment?</i> (Marks 1.25)</p>		<p><i>SolarWAVE Tanzania Limited</i> (Project Implementers)</p>
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iii. Specific questions to assess impact after project intervention (*Outcome-oriented Criteria*)

Aspect ( <i>*Impact</i> )	Questions	Means of verification	Source of verification
<b>Economic</b>	<p><i>In what ways the project has affected the economy in the project area? (Marks 0.5)</i></p> <p><i>How has the project affected time use? (Marks 0.5)</i></p> <p><i>How the project has affected distance of going to fetch water and fuelwood collection? (Marks 0.5)</i></p> <p><i>How the project has affected costs that were used to treat people? (Marks 0.5)</i></p>	<p><i>FGD</i></p> <p><i>Observations</i></p>	<p><b>Institutions</b></p> <ul style="list-style-type: none"> <li>- <i>Village Government</i></li> <li>- <i>Water Committee</i></li> <li>- <i>Health Centre (dispensary)</i></li> <li>- <i>Schools</i></li> </ul> <p><b>Users</b></p> <ul style="list-style-type: none"> <li>- <i>Local people: women, men and children</i></li> <li>- <i>Students</i></li> </ul> <p><b>SolarWAVE Tanzania Limited</b> <i>(Project Implementers)</i></p>
<b>Social</b>	<p><b><u>Political organization</u></b></p> <p><i>Has the project affected power roles within the project area? How? (Marks 1)</i></p> <p><i>Are you involved in monitoring of the project? (Marks 0.5)</i></p> <p><i>Are periodic reports on operation and maintenance shared? (Marks 0.5)</i></p>	<p>“</p>	<p>“</p>

	<p><b>Quality of life</b> (health, education and gender issues)</p> <p><i>*Health</i></p> <ul style="list-style-type: none"> <li>- What is the present health situation within the project area? (<b>Marks 0.5</b>)</li> <li>- Has the project affected reduction of waterborne diseases e.g. diarrhea, typhoid? Frequency? (<b>Marks 0.5</b>)</li> </ul> <p><i>*Education</i></p> <ul style="list-style-type: none"> <li>- How has the project affected the involvement of children in the enrollment of girls and boys, school attendance and performance? (<b>Marks 0.5</b>)</li> <li>- How has the project affected the involvement of children in doing domestic chores (e.g. long distance of going to fetch water and collecting fuelwood)? (<b>Marks 0.5</b>)</li> </ul> <p><b><u>Socio-cultural respect</u></b></p> <p>Has the project affected socio-cultural values and beliefs of the project area? How? Is it positive or negative? (<b>Marks 1</b>)</p> <p>If negative, how can the design of the system address this concern so that the system will be culturally acceptable? (<b>Marks 0.25</b>)</p> <p>If positive, are the behavioral changes reinforced? (<b>Marks 0.25</b>)</p> <p><i>*Gender</i></p> <ul style="list-style-type: none"> <li>- Women are often in charge of household water supply and fuelwood collection. Has this project affected the</li> </ul>		
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	<p><i>traditional way of gender balance? (Marks 0.25)</i></p> <ul style="list-style-type: none"> <li>- <i>What are the roles of men, women and children play in the system? (Marks 0.25)</i></li> </ul>		
<b>Environment</b>	<p><i>What is the present situation of resource use (water and fuelwood) after the installation of WP700 system?</i></p> <ul style="list-style-type: none"> <li>- <i>Is the system functioning properly?</i></li> <li>- <i>Are you satisfied with the quality of water?</i></li> <li>- <i>Does the quality of water vary seasonally? Does it affect the design of the system?</i></li> </ul> <p><i>(Marks 1)</i></p> <p><i>Are there any changes observed in relation to traditional fuelwood use and solar energy use? (Marks 0.5)</i></p> <p><i>Are people aware of the self-role in maintaining a healthy environment? And are they motivated to continue to work for environmental improvements? (Marks 0.5)</i></p>	“	“

## Appendix II: Photos of the Project Sites

### i. Mkambarani Site



**Plate 1:** Community water point that does not use WP700  
**Source:** MWAKANGALE (Sept. 2014)



**Plate 2:** A water tank and a tap  
*(Water is used for washing and cleaning purposes at the dispensary)*  
**Source:** MWAKANGALE (Sept. 2014)



**Plate 3:** A solar panel installed on a roof  
**Source:** MWAKANGALE (Sept. 2014)



**Plate 4:** Community water point that uses WP700 (SolarWAVE)  
**Source:** MWAKANGALE (Sept. 2014)



**Plate 5:** Connection of the water purification unit in the store  
**Source:** MWAKANGALE (Sept. 2014)



**Plate 6:** A water tank (5000L) connected to the water purification unit  
**Source:** MWAKANGALE (Sept. 2014)



**Plate 7:** A battery to run the installed system (WP700)  
**Source:** MWAKANGALE (Sept. 2014)

**ii. Vikenge Site**



**Plate 8:** Connection of the Purification System WP700 at Teachers' Office  
**Source:** MWAKANGALE (Nov. 2014)



**Plate 9:** School's water point that uses purification system (WP700)  
**Source:** MWAKANGALE (Nov. 2014)





**Plate 10:** A water tank (5,000ml) connected to the water purification system  
**Source:** MWAKANGALE (Nov. 2014)



**Plate 11a:** Alternative system of harvesting rainwater  
**Source:** MWAKANGALE (Nov. 2014)



**Plate 11b:** Alternative system of harvesting rainwater  
**Source:** MWAKANGALE (Nov. 2014)

**iii. Wami Dakawa Site**



**Plate 12:** Water tank (5000L) connected to the WP700  
**Source:** MWAKANGALE (Nov. 2014)



**Plate 13:** Connection of water purification unit in the store  
**Source:** MWAKANGALE (Nov. 2014)