Solar versus Diesel Powered Water Pumps in Meeting Sustainability Goals in Somalia, a qualitative study

Mulatu Tiruneh Kassa [1], Teshome Bekele Elema [2] [3], Peter Redding [1]

[1] Institute of Business, Industry and Leadership, University of Cumbria, UK
[2] School of Public Health, University of Washington, Seattle, USA
[3] Centre for Food Science and Nutrition, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia

*corresponding author's Email: mulat_tiruneh@yahoo.com
ORCID: https://orcid.org/ [0009-0006-9479-7541]

Preprint statement: This manuscript is a non-peer-reviewed preprint submitted to EarthArXiv.

Journal information: This manuscript has not yet been submitted to a peer-reviewed journal.

Conflict of interest: The authors declare no competing interests.

Data availability: The qualitative data supporting this study are not publicly available because they contain information that could compromise participants' privacy and confidentiality. Anonymized data may be available from the corresponding author upon reasonable request, subject to ethical and confidentiality restrictions.

Abstract

Somalia endowed with high solar energy is still using diesel energy as the major source of energy to pump drinking water. This put the country under question from achieving SDG 6 which targets universal access to clean and sustainably managed water. Therefore, this study gathers qualitative data from relevant key stakeholders in Puntland, Somalia through individual in-depth interviews and analyze the data qualitatively to identify and explore the barriers and concepts to its successful implementation in meeting sustainable goals in Somalia.

The interview data were transcribed and analyzed thematically using template analysis style with the aid of NVIVO 12 qualitative analysis software. The study found a narrowed notion and incomplete understanding of what 'sustainable water supply' means in Puntland and it was identified as one of the bottlenecks from achieving its target successfully. The study also found out very low level of community participation, non-inclusive program for marginalized people as main challenges in achieving the targets of SDG 6. The study also identified theft and vandalism, limited financial and other resources, lack of clear policies and guidelines and low awareness, low level of community participation, limited suppliers and skilled technicians as the major barriers to achieving the targets of SDG 6. It was also identified that the need for building the capacity of government, NGO and water operators, improving the quality of solar system components, conducting research and studies, formulating clear policy and guidelines favoring solar energy and raising community awareness and participation as the main success factors for the successful implementation of solar powered water supply system.

The study also recommends similar future studies but with more inclusive data from water users, women and marginalized people not only from Puntland but also from other regions of the country through in-depth interviews and focus group discussions so as to make more generalized conclusions at national level.

Key words: Solar Power, Diesel-run water pump, Water supply, Puntland, Somalia, Sustainable development goals

Chapter 1: Introduction

1.1 Background

According to (United Nations, 2015), the two main 2030 agendas of Sustainable Development Goals (SDGs), that were adopted by the United Nations Sustainable Development Summit in September 2015, were ensuring access to affordable, sustainable and clean water and energy for all which were described under goal numbers 6 and 7 respectively. It is also important to note that these two goals are highly linked to SDG 13 which deals on climate change. More specifically, it means that the targets for these goals is to create access to safe and affordable drinking water and at the same time to ensure access to affordable, reliable and sustainable energy to everyone on earth by 2030. SDG 6 aims to achieve its target sustainably. (Martin & Schouten, 2013) simply defines the word sustainability as the ability of a system to maintain or renew itself perpetually like the renewable photosynthesis cycle that is without causing any damage and or any imbalance to the planet, the people living in it both at the present and in the future. This notion of sustainability comprises mainly of the three major categories of sustainability called Triple Bottom Line Approach, that is, people (social sustainability), planet (environmental sustainability) and profit (economic sustainability). Similarly the word 'sustainable' in the 2030 agenda of UN mentioned above, has the same idea and concept as the Triple Bottom Line Approach which is a holistic approach to sustainability. The 2030 agenda consists of 17 agendas or objectives along with a total of 169 targets and gives due emphasis to areas of critical importance such as people, planet, prosperity, peace and partnership to each agenda (United Nations, 2015).

However only 29 percent of Sub-Saharan Africa have access to safely managed water and because of population growth in the region, more people now live without electricity than 1990 (World Bank, 2018). Somalia being Sub-Saharan African country and one of the least developed countries suffers from both poor access to clean water and energy.

In order to ensure access to water, a water pump had to be powered either using traditional energy sources like fossil fuel or renewable energy technologies such as solar or wind energy. The two most common source of power for water pumps in Somalia are diesel and solar power. Solar powered rural water supply is now the new and preferred approach to water pumping where governments in developing countries and development organizations are moving towards as the main strategy to use environmentally friendly and renewable energy source (Aliyu, et al., 2018), (Blakers, 2015), (Campana, et al., 2015), (United Nations, 1991), (World Bank, 2018) and (Chandel, et al., 2017). In spite of high solar insolation availability in Somalia (average insolation

ranging from 5-7 kWh/ m2/day) (World Bank, 2018) and the general perception and understanding as a clean energy source (Aliyu, et al., 2018), at the same time it is perceived as expensive alternative to water pumping among development agencies and local government in Somalia. This is because of its high initial costs related to its capital expenditure, installation and commissioning cost. However there is also a general consensus that it is having very low operation and maintenance cost compared to diesel powered water pumping systems. This can mislead government and other development actors involved in the sector to make uninformed decisions and thereafter formulate strategy and policy based on such non-comprehensive information.

Another important question worth mentioning herewith is that if Somalia is continuing using diesel powered water pumps which is not environmentally friendly, the achievement of SDG 6 will be under question. Therefore the challenges and bottlenecks from not moving from such traditional energy sources to a renewable energy technologies in Somalia had to be identified and analyzed to drive measures to address them.

Somalia is an Eastern Africa Country bordered by Gulf of Aden, Djibouti, Ethiopia, Indian Ocean and Kenya with a total area of 637,657 square kilometer (Central Intelligence Agency, 2018) and with 12.3 million population (The United Nations Population Fund (UNFPA), 2014). Somalia had stayed in more than two decades of war and conflict since 1991 and all the major infrastructures had been destroyed and it had been a failed and collapsed state up to 2012 (Rotberg, 2004), (World Bank Group, 2015), and (African Development Bank Group, 2015). However the two regional states of Somaliland and Puntland have been experiencing relative political development, economic recovery and stability, while the remaining region that constitutes central and south zones remains dangerous and unstable (World Bank Group, 2015) and (Central Intelligence Agency, 2018). Therefore, this dissertation seeks to analyze the relative merits of diesel sources of power and solar sources of power to water pumping through case studies carried out in these two regional states; Somaliland and Puntland.

1.2 Justification of the Study

As mentioned in the background sub-heading of this introductory chapter, provision of access to safe drinking water supply universally, sustainably, and equitably has been one of the top agenda set under The 2030 Agenda for Sustainable Development by the United Nations Sustainable Development Summit in September 2015 (United Nations, 2015) and (UNICEF, August 2016). In addition to this, (United Nations Development Group , 2016) and (UNICEF, 2018) affirms that

Somalia National Development Plan for water supply is well aligned with the SDGs and therefore it is imperative to identify and analyze barriers, opportunities and relative merits of the power alternatives to water pumping in meeting sustainable goals in Somalia. Such studies would be very valuable for the future planning and implementation of sustainable water supply projects. Sustainability of rural water supply projects have remained to be the central issues with government, humanitarian and development non-governmental and UN agencies for long now but little effort has been exerted in Somalia in studying renewable energy resources such as solar energy for water pumping.

Therefore, the result of this research study will enable government, NGO, UN agencies and private public partnership and other actors involved in implementing drinking water supply projects in Somalia to better understand the better and effective energy alternative to drinking water pumping and service delivery in meeting sustainable goals in Somalia. Therefore, this will help them make informed and relevant investment decisions. This will make them to understand the various challenges, barriers and measures associated to diesel powered and solar powered water pumping better and thereby enable them to allocate budget for a sustainable water supply service.

This will also help decision makers involved in planning, budgeting and implementation of water supply projects in Somalia to formulate an appropriate and sustainable policy and strategy in the sector.

1.3 Aims and Objectives

The aim of the dissertation is to critically analyze the relative merits of solar versus diesel powered water pumps in meeting sustainability goals in Somalia. Various categories of factors such as technical factors (technology selection, complexity of technology, technical skill, technical capacity, availability, accessibility and cost of spare parts, etc.), community factors (community ownership, community participation, demand for improved service, etc.) and environmental factors (the impact of the technology on the environment and waste disposal) which ultimately affect the decision of which technology to use are identified and analyzed. The study also identifies factors related to infrastructure, politics, community relations, security, communications and training which have an effect in the decision making process of alternative energy selection.

The specific objectives of this study can also be stated as follows:

1. To explore the concepts underlying the successful implementation of alternative energies in developing areas

2. To gather qualitative data from the various stakeholders who might impact the choice of energy for water pumping
3. To identify the most relevant factors which might determine the choice of technologies within the specific context
4. To derive conclusions and recommendations for future practice.

The research will also identify the easier and the more reliable sources of power to water pumping, that is, easiness and reliability. The research will also seek to identify the safest alternative for operators and users. Through case studies in selected water supply projects in Somalia, the research critically analyses the relative advantages of the two energy alternatives which will assist Somalia to meet the sustainable goal number 6 of the 2030 Agenda for Sustainable Development better.

Chapter 2: Research Methodology and Methods

2.1 Research Paradigm and Approach

As explained in the previous chapters of this dissertation, the reason why socially, economically and environmentally superior solar powered water pumping system is not replacing the traditional diesel powered water pumping system in Somalia in particular and in developing countries in general, is not precisely known. And this could not be known by focusing only on quantitative research based on secondary data as found out in the literature review and the problem is much complex to be explained by such narrowed approach (Creswell, 2014). Due to that the focus of this study was not on a single reality rather on multiple views, attitudes, feelings, understanding, experiences and perceptions of participants (Saunders, et al., 2009) and (Creswell, 2014). Accordingly the purpose of this research could be restated as to explore and clarify this complex underlying problem or to understand the fundamental meanings attached to this by conducting qualitative research to participants. For such studies (Saunders, et al., 2009) and (Creswell, 2014) argue that the interpretive paradigm and or subjective interpretivism is most appropriate research paradigm to qualitative research and to achieve such research purpose. Due to that this study was also conducted from this interpretive perspective. The research approach adopted for this study could also be fairly labelled as an inductive one as the theory was developed as a result of the data collected and analyzed as well as it put more emphasis in using qualitative data (Saunders, et al., 2009).

2.2 Research Design

The qualitative design using semi-structured one-to-one (face-to-face) interview were utilized for data collection adopting a case study research strategy in Puntland regional state of Somalia. The case study strategy was adopted as this strategy was believed to be the best in exploring the existing concepts and factors underlying the choice and successful implementation of alternative energies for water pumping in Somalia (Saunders, et al., 2009) and (Merriam, 1998). Though case study strategy is criticized of its inability to generalize its results, it considered to be very good tool to examine data within a specific context and to explore factors affecting a situation (Yin, 2014), (Hancock & Algozzine, 2006), (Zainal, 2007) and (Starman, 2013).

Face-to-face interview to key informants selected from six key stakeholders were conducted. Individual face-to-face interview was selected to gather information about the research question which could provide a deeper understanding of the views, experiences and perspectives of participants through open and free conversation as this allows the researcher to seek clarity and

probe for deeper understanding. Moreover compared to other data collection methods such as surveys, a researcher could gather more detailed information using face-to-face individual interviews methods though it could be more time consuming exercise because of the time it takes in conducting interviews and then in transcribing and analyzing the data (Boyce & Neale, 2006). As such a researcher can best learn participants' feelings, opinions, experiences and insights about the research problem through such dialogues.

2.3 Data Collection Process

Purposive sampling was used in selecting both the key stakeholders and key informants as this study targeted particular stakeholders and people who were rich in information required for the study. According to (Creswell, 2012), individuals and sites are selected intentionally to obtain information rich people for the study when purpose sampling is adopted in qualitative research. Contrary to quantitative research method, the idea in qualitative research is not random sampling or selecting large number of participants either, rather it is to purposefully select participants that can best help the researcher understand the research question (Creswell, 2014). The stakeholders selected for interview were key in decision making in regards to the choice of alternative energy for water pumping and for the implementation of water supply projects in the region. As mentioned above the six key stakeholders and their respective key informants were selected based on this ground.

The six key stakeholders were selected from Puntland regional government offices, United Nations Agency (UNICEF), NGOs (World Vision International and Norwegian Church Aid) and PPP (Public-Private Partnership) company. The two government offices were PSAWEN (Puntland State Authority for Water, Energy and Natural Resources) and Puntland State of Somalia Ministry of Environment, Wildlife & Tourism (MoEWT). PSAWEN is the ultimate authority that is responsible for ensuring the health access to safe water for all peoples living within the region and for the formulation of policy, implementation and controlling water supply schemes in the region whereas MoEWT is in charge of environmental protection including conservation of rangelands, environmental inspectorate, water conservation, wildlife and bio-diversity conservation among others. The PPP (Public-Private Partnership) company was NUWACO. NUWACO is responsible to run, operate and maintain the water supply schemes in the capital state town of Puntland regional state. In total ten participants (key informants) from these stakeholders were interviewed; three from PSAWEN, two from MoEWT, two from NUWACO, one each from UNICEF, NCA and WVI.

It is important to mention that the researcher also works for WVI which is one of the key stakeholders that implements water supply projects in the region. Due to that the researcher works in close collaboration with all the above mentioned stakeholders in the assessment, design, implementation, monitoring and evaluation of water supply projects. Due to that the researcher was privileged to be known by the stakeholders as a co-worker for some and as a colleague for others. Because of this getting permission to be at their offices at any given time was not a challenge. This helped the researcher to build trust with the participants and hence access to data or getting permission to interview key informants from this key stakeholders was quite smooth. Due to this the researcher conducted the interviews himself with all the key informants in English language and they had been open and free to discuss and share their ideas freely. This was also done intentionally as the researcher had better be part of the study involving an induction research approach (Saunders, et al., 2009) and as the researcher plays fundamental role as instrument of data collection (Creswell, 2012). (Miller , 2000) argues that the researcher's social interaction with the interviewee is having valuable contribution in qualitative studies.

According to (Cassell & Symon, 2004) the relationship between the researcher and the interviewee is part of the research process and should not be taken as something which distracts the study and that is the reason behind the use of the term 'participant' in place of interviewee. The interviewee is not passive in the research process, rather is an active participant. The trust and familiarity with the participants also enabled the researcher to use his time in the best possible way. However, once the participants agreed for the interview, the appointment was scheduled at the time convenient to them. The appointments were easily made and arranged at their own offices for some and at the researcher's office for others by their own choice. Their choices were also dependent based on the place where participants get their privacy protected most. Due to that all the interviews were conducted in a place where the setting was providing the at most protection to the privacy of the participants.

Pilot interview was conducted to one of the WASH officers working at WVI before conducting the main interviews to test the interview design and accordingly some of its limitations and weaknesses were corrected and the questions were a bit refined further to suit to the understanding and awareness level of the participants. Then after the main interview was conducted to ten key informants selected for the study. The key informants who were interviewed were the CEO and two water supply senior engineers of PSAWEN, CEO and WASH expert from NUWACO, two environmental protection experts from MoEWT, WASH engineer from UNICEF, WASH Manager from NCA and WASH and infrastructure officer from WVI. Accordingly the

selected interviewees do have rich information about the research question and do have key significance in the decision of the alternative energies for water pumping in the region.

Semi-structured, one-to-one interviews were utilized in interviewing the key informants to obtain in-depth information about the research question. As mentioned above, the interview was conducted face-to-face involving one interviewer (in this case the researcher) and one participant. An interview guide was prepared (attached as **Error! Reference source not found.**) and handed over to the participants for transparency ahead of the interview time. In order to show the researcher's commitment and hence to get the participant's seriousness, the researcher used to arrive at the interview place well ahead of time equipped with recording equipment along with a power house which enables to charge the recording equipment in case it run out of power, interview guide, and notebooks. This also enabled the researcher to prepare psychologically and to brainstorm the interview guide well ahead before the interview started. The interviews were all audio recorded except one who was not comfortable and due to that only notes were taken for this particular participant. For the rest, in addition to the audio recording back notes were taken at the same time. As such the participants' behavior, any contextual events and non-verbal information observed during the interviews were also jotted down as part of field notes. Immediately after each interview was concluded, the researcher took extra time to either expand this field notes or to complete the uncompleted ones.

It would be worth mentioning that interview protocol was also prepared (attached as **Error! Reference source not found.**) which had clearly specified what to say to interviewees when setting up, beginning and concluding the interviews, and at the same time it had clearly specified what to do during and following the interview (Boyce & Neale, 2006). This interview protocol was critically followed for each interviews. The interview also took into considerations all the necessary ethical research standards during this interview as specified in a separate sub-heading below.

2.4 Ethical Considerations

In addition to the interview protocol that was mentioned above and was strictly followed, this research also strictly followed the ethical standards of the University of Cumbria and it would be good to note that the study was conducted by the researcher as a student of University of Cumbria purely for academic exercise. As such the 'The Checklist of Ethical Principles for Research' form of the University was utilized and signed (see **Error! Reference source not found.**). All participants were requested to sign the consent form that stated about the participants right to terminate their participation at any time and that participation was purely voluntary (see **Error! Reference source not found.**). As this study utilized audio recording during the face-to-face

interview sessions, a written consent form for their permission to be audio recorded was also presented to the participants and signed (see **Error! Reference source not found.**). Participants were also promised and assured that confidentiality and anonymousness would be kept to what they would say in the interview.

2.5 Analytical Procedure to Data Analysis

As mentioned in the previous sub-headings of this chapter, this study used an inductive approach in collecting qualitative data through semi-structured face-to-face individual interviews. Due to this, it used inductively based analytical procedures to analyze the qualitative data gathered. (Saunders, et al., 2009) recommend six inductively based analytical procedures to analyze qualitative data; these are data display and analysis, template analysis, analytical analysis, grounded theory, discourse analysis and narrative analysis. This study utilized template analysis. The justifications why this study used template analysis (TA) analytical procedure to analyze the qualitative data gathered and not others have also been described as follows. First, TA application cannot be limited to a specific theoretical and epistemological position; rather it can be used in both 'realist' and 'constructivist' (Brooks & King, 2014), (Brooks, et al., 2015) and (Cassell & Symon, 2004). Due to this TA can be applied to a study such as this one which is having subjective interpretivism research paradigm as described under the 'research paradigm and approaches' sub heading of this chapter. Second, TA offers a more flexible route to analysis with fewer specified procedures, allowing researchers to amend its use to the needs of the researcher. Moreover it offers flexibility in its coding structure which allows the researcher to explore rich data in its real depth (Cassell & Symon, 2004), (Brooks & King, 2014) and (Brooks, et al., 2015). Third, TA is less-time consuming compared to the other mentioned analytical procedures above (Brooks, et al., 2015) and the principles behind its techniques are easy to be understood by first time researchers in qualitative analysis (Cassell & Symon, 2004). Fourth, though analytic induction and grounded theory analytical procedures could suitably be applied for this study, they are identified as highly time consuming and resource intensive by (Saunders, et al., 2009) in which they are out of the scope of this study. Fifth, discourse analysis is more suited to analysis of language whereas narrative analysis is suited to explore linkages, relationships and socially constructed explanations (Saunders, et al., 2009) and due to that, both of them were not considered suitable for this particular study.

All the audio recorded interviews were transcribed manually as the transcribing software such as NVIVO 12 were not transcribing them properly as it failed to understand the African accent (non-

native and non-fluent English Speakers) very well and hence it took a lot of time to transcribe them manually.

Procedural Steps in the Data Analysis

In this study, the following main procedural steps were adopted in carrying out the TA (Brooks, et al., 2015) and (Brooks & King, 2014). First, the researcher familiarizes with the data well by fully reading the transcripts and field notes; second, priori themes were identified from research objectives and literature review and was used for initial phase of coding aided by NVIVO 12 qualitative data analysis software; third, emerging themes were organized into meaningful categories and defined the relationship between them and through the process the initial version of the coding template was developed; fourth, using the initial coding template and aided by NVIVO 12 software, the template was modified to the full data set until the final template was developed. Finally interpretation of data was carried out using this final template.

2.6 Research Limitations

The first limitation of this study was related to the inductive research strategy adopted. According to (Saunders, et al., 2009) using inductive approach can be a difficult strategy to follow for first time researcher as it may not lead to success. The second limitation was that the result could not be generalized nationally as the study was a case study conducted only in Puntland regional state of Somalia with small sample size. The third limitation and source of error could be that there were no participants from the water users' side; all were from implementers and service providers in which the perspectives and perceptions of water users were not captured.

The fourth limitation was based on the fact that government line offices such as PSAWEN and MoEWT could have been biased in the answers they provided. They could have been biased in that they were trying to make the government look good rather than reporting the real situation on the ground.

2.7 Summary

This chapter outlined the research paradigm and approaches used to conduct the qualitative study, how the research was conducted, demonstrating the process used to select the participants, the method used to collect data as well as the analytical procedure that was used in analyzing the data collected through the face-to-face individual interviews. Accordingly it was underlined that this study followed the subjective interpretivism research paradigm, an inductive research approach, a case study research strategy and utilized template analysis analytical

procedure to analyze the qualitative data gathered through the audio-recorded individual interviews.

The aim of this study was to collect qualitative data from key stakeholders about the perception, feelings, experiences, understanding and attitudes of participants towards the barriers and factors determining the selection of alternative energy and to explore the concepts underlying its successful implementation and thereby to critically analyze the relative merits of solar versus diesel powered water pumps in meeting sustainability goals in Somalia.

The next chapter details the analysis process and describes the results of the research.

Chapter 3: Results

As discussed in the methodology chapter, audio recorded in-depth interviews were transcribed, coded and analyzed thematically using template analysis with the aid of NVIVO 12 qualitative data analysis software. Accordingly the template was modified in an iterative process during the coding and analysis process to the full data set and the final template was developed. In the final template as shown in **Error! Reference source not found.**, a number of themes/nodes and sub-themes/child nodes were identified from the analysis. The final template consisted of five main themes: 1) understanding of what 'sustainable water supply' means; 2) awareness level of the communities on solar-powered water supply system; 3) pros and cons of solar versus diesel powered water pumps; 4) barriers to the successful implementation of solar powered drinking water supply projects in Puntland, Somalia; and 5) the concepts to the successful implementation of solar powered water supply.

3.1 Understanding of what 'sustainable water supply' means

There exists narrowed understanding to what 'sustainable water supply' or what sustainability means among participants. None of the participants but one addressed their understanding of sustainable water supply system holistically; that is people (social sustainability), planet (environmental sustainability) and profit (economic or financial sustainability). In the introductory and literature review chapters of this study, it was noted that the United Nations' 2030 Agenda for Sustainable Development Goals encompassed all the three dimensions of sustainability. However, as it can be seen from Figure 3-1, below, 40 percent of the participants' understanding about sustainable water supply was confined to only operational sustainability (such as running of the system without interruption because of operation and maintenance issues) or technical sustainability (things related to the proper engineering design of water supply system). Herewith it is worth noting that the names of the participants were kept confidential and was not directly used in the data analysis as well as in the display of the results. Rather they were given coded names such as PSAWEN #1, UNICEF #1 and the likes as shown in Figure 3-1 below. Environmental sustainability and social sustainability were the two most missed dimensions of sustainability in the participants' responses and understanding; both were addressed by only two participants. For example, a comparison carried out with the aid of NVIVO 12 between environmental and operational sustainability in regards to the participants' response clearly showed that much of the understanding did not involve environmental aspect of sustainability (Figure 3-2).

In addition to the narrowed understanding mentioned above, a significant finding was the differing understanding of what a ‘‘sustainable water supply’ means among participants within the same government office. For example, according to one of the participants from MOE explained sustainability as, *“A given water supply system is sustainable when it shouldn’t rely on temporary sources of water, you cannot just supply to village that source as it dries two to three months later.”* No additional discussion was provided by the participant other than this though the interviewer queried for additional understanding on what ‘sustainable water supply development’ meant to him. On the other hand the other participant from the same MOE office included all the dimension of sustainability in his responses as can be seen from Figure 3-1 below.

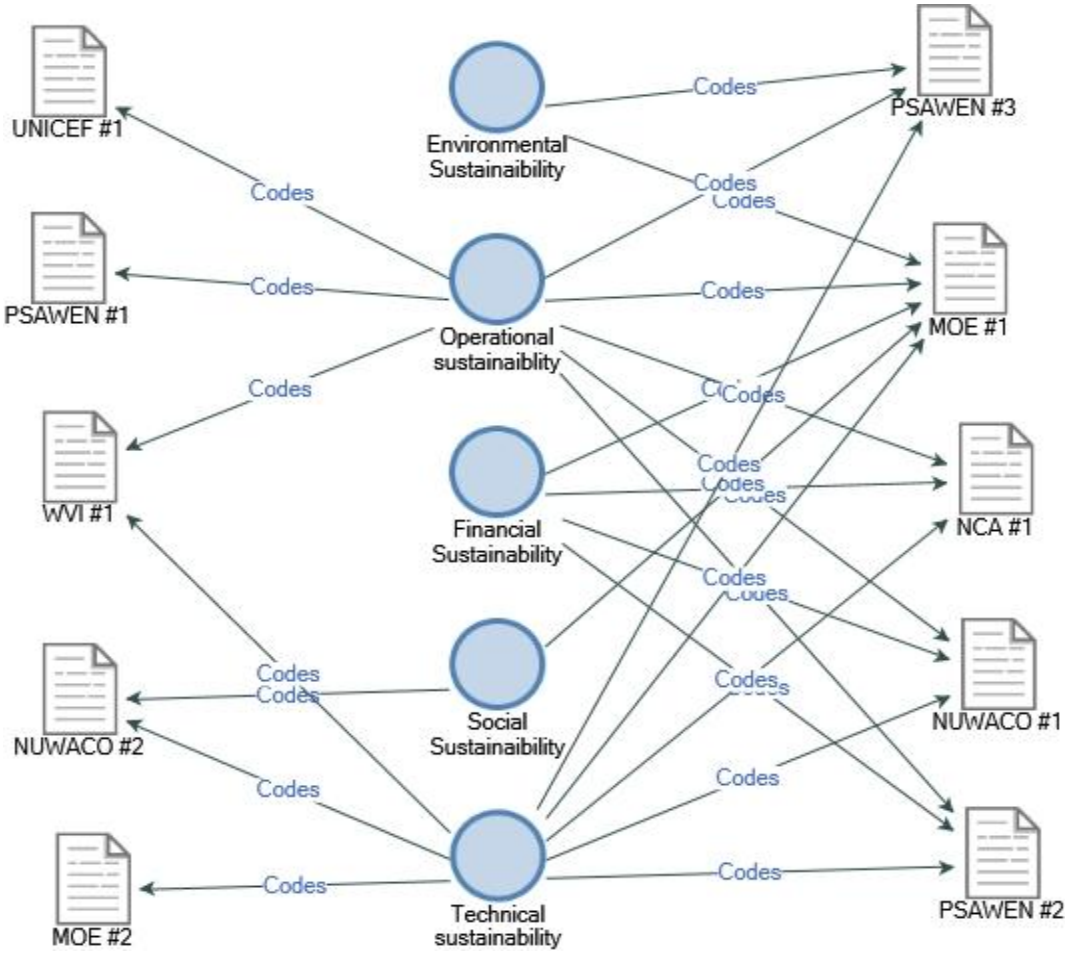

Figure 3-1: Diagrammatic map of Participants’ understanding on what ‘Sustainable Water Supply’ means (from NVIVO 12)

In the conclusion sub-section of the literature review chapter, narrowed understanding and or notion of sustainability among development actors were identified as one of the major barriers to the successful implementation of SDGs and this case study affirmed this at least for Puntland regional state of Somalia. On the other hand this result might also indicate the area of the

immediate challenges where Puntland is currently facing as 80 percent of the participants talked about operational and technical sustainability and hence issues related to these shall be seriously looked into. They focused on the immediate challenges they were facing day by day but also it showed the extent of the problem Puntland is facing in regards to operational and technical sustainability.

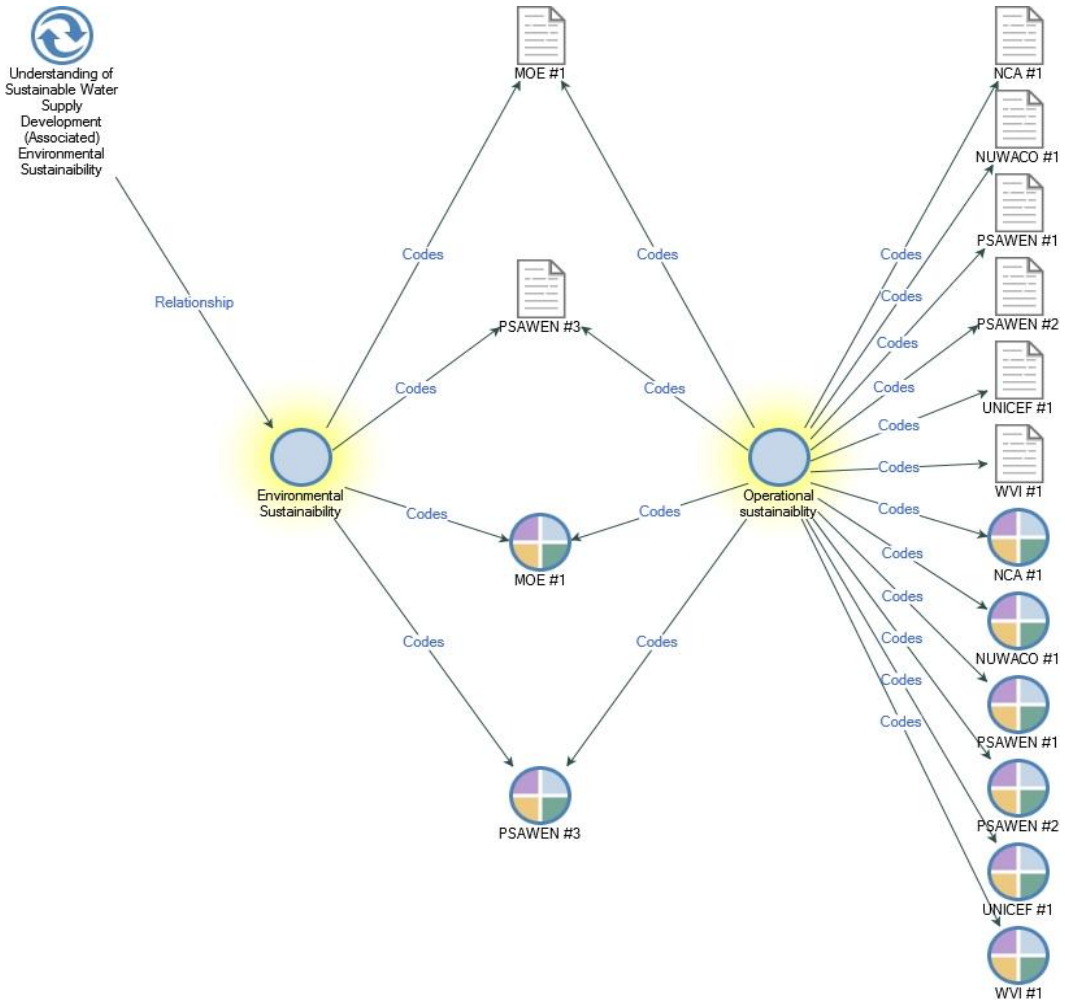

Figure 3-2 Environmental versus Operational sustainability dimensions in the participants'' responses to their understanding of 'sustainability'

3.2 Awareness level of the communities on solar-powered water supply system

The second major theme that was identified in the analysis of the interview transcripts was the awareness level of the communities in Puntland on solar-powered supply system. This main theme was emerged into two main sub-themes: 1) familiarity to solar powered alternative to drinking water supplies; and 2) Participation and involvement of communities in problem

identification, consultations and workshops. And accordingly these are discussed in the following sub-sections.

3.2.1 Communities' familiarity to solar powered alternative to drinking water supplies

One major finding identified in this study was that the communities of Puntland in Somalia are well familiarized with solar energy source for purposes like as a source of light for their household, for charging their mobiles and in some places for minor cooking but they do lack similar level of familiarity in using solar energy for water pumping. One of the participant from MOE said:

> "The awareness level at community level is very good because I see them charging their mobile phones, I see them using solar for lighting at shops, prayer places like Mosques. They understand that solar system doesn't require them to have skills. But what is still not there is motivation to take action." (MOE #1, Ministry of Environment)

The other participant working for NGO said:

> "Yes, the people have a good awareness about solar. But they cannot afford it. Solar is more benefiting. We are now using for street light. …they use it at household level. They have more awareness and they like it." (NCA #1, NGO)

A participant from Public Private Partnership said:

> "Yes, the rural community use and know that. If you go to market you will see rural areas using for mobile, lighting, and radios. They know and they are familiar but the problem is that they are not using solar for water pumping." (NUWACO #2, PPP Company)

The participants also indicated that the reason for not using solar energy for water pumping is related to the high installation cost associated to it but not because they prefer diesel energy to solar energy for water pumping. One of the participant from government line office (PSAWEN #1) who is primarily responsible for ground water supply for Puntland said, *"nowadays, the communities are familiar with solar. They are interested; all the operators say please we need solar, because they know the cost they are incurring from running generators daily."* This could be partly related to the fact that the NGOs, UN agencies and government have been installing solar powered water pumping system for the communities in Puntland free of charge as part of emergency response following disasters due to fighting, draught and flood for long time now and hence they might not worry about the high cost of the installation cost for solar water pumping.

3.2.2 Communities' Participation and involvement in problem identification, consultations, workshops and the likes

In the first part of the discussion, 50 percent of the participants believe that communities had been involved adequately but with the follow up questions and when the discussion went into the details, some of them said that the involvement of the communities in all stages of project implementation had never been quite adequate. While the rest 50 percent believed that communities' participation and involvement in solar powered water supply projects had never been adequate. Particpant from UNICEF expressed:

> "Community participation is something which is really missing. There is very limited participation; I can say zero participation. Every participation includes only mayor and operators, not more than that." (UNICEF #1, UN agency)

Similarly a participant form an NGO (WVI #1) said, *"That is a good question, but my understanding is that the community doesn't more or less participate in the decision making of this kind of things."* One of the participant from the responsible government line offices for water supply also said:

> Concerning community participation, no one consults individual households or there has never been any valuable community mobilization in this regards. Only few representative of the communities are involved only at the beginning of the project; not more that. (PSAWEN #2: Government)

It indicates that there is some level of participation but only involving few individuals and hence not adequate.

One of the key finding in regards to community participation was related to the level of participation of marginalized populations in Puntland, Somalia. One of the participant from an NGO shared:

> "There is very low level of participation when it comes to marginalized people. When we want to conduct training the first thing we do is we explain what we are doing and the people we need to train. So you may see those marginalized people not selected for participation. I have seen in one village at "chirire" "Madiban" they didn't get water supply. …it is the mayor who usually does such discrimination. The mayors usually disfavors marginalized people. (NCA #1: NGO)

In the literature review chapter, it was discussed that without the participation of communities, all partners, and women and marginalized people fully during all the stages of the intervention of water supply projects, it is impossible to ensure its sustainability. Inclusiveness of marginalized

people and equity distribution of resources were given especial place in the literature review for achieving SDGs successfully.

3.3 Pros and cons of solar versus diesel powered water pumps

The pros and cons of solar versus diesel powered water pumps were discussed by the participants and accordingly a number of sub-themes have emerged under this main theme during the analysis as shown in the final template in **Error! Reference source not found.** and in Figure 3-3 they are discussed in the following sub-sections.

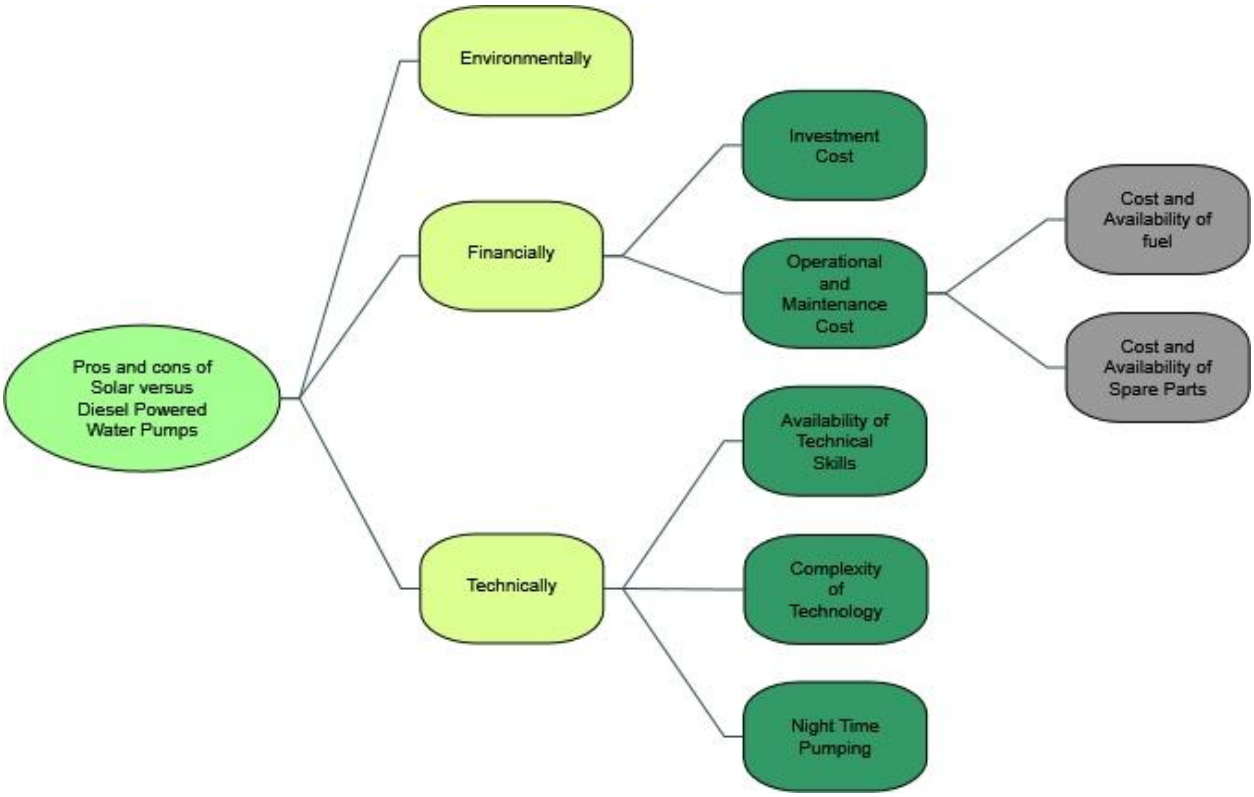

Figure 3-3: Main themes of Pros and cons of solar versus diesel powered water pumps

3.3.1 Technically

3.3.1.1 Complexity of technology

90 percent of the participants agreed that solar water pumping system is much easier technically than the generator run system once it is installed. However they also agreed that solar is a bit more complex and is new technology which requires skilled technicians during the first installation. However the maintenance and operation of solar powered water supply system is very simple and does not require skilled technicians. The diesel run water pumping system on the other hand is too complex and difficult to manage. For example, NUWACO #1 from PPP Company, who is

directly managing a number of water supply projects which run using both diesel and solar power, said, *"generator is more complex. I prefer solar and it would be easier."* And the other participant from PPP Company also explained:

> "Generator is complex. The whole system can be completely shut down just because of one fuse. One single fuse costs us two or three dollar, which we cannot find it in the local market. So solar system is more suitable in this county. Other issue there is no qualified technicians for generators too. But solar doesn't need much maintenance, only to protect from outside, external to protect from child and from anybody who can damage it. That is the challenge to solar. (NUWACO #2: PPP Company)

3.3.1.2 *Availability of technical skills to operate the system*

Similarly the finding showed that solar water pumping system is superior to diesel run system in terms of availability of technical skills to operate the system except the initial installation time. MOE #2 from the Ministry of Environment said, *"Yes, they are available locally."* This might be related to the less complexity of the solar technology compared to the generator discussed above. However it was also explained that there are limited skilled professionals for the design and installation of solar powered pumping system, for example PSAWEN #3 from the government said:

> "You know, there are some problems with renewable energies especially solar system energy, we have lack of technicians especially during installation, and in some projects we are receiving complaints for under-sizing and or over-sizing of solar pumps. (PSAWEN #3, government)

3.3.1.3 *Night time pumping*

One of the common challenge explained by 50 percent of the participants was the inability of solar pumps to pump at night time and the need to include battery system in the installation to store energy for night time. UNICEF's participant said, *"The only advantage for generator is night time pumping."* And NUWACO #2 from the PPP Company said, *"Solar has a lot of advantages and if we add batteries for night time pumping, then it will be complete."* However this was identified in the literature review chapter as one of those challenges that could be easily mitigated with either applying careful design of system or by adding some additional facilities.

3.3.2 Environmentally

100 percent of the participants agreed that solar powered pumps are much superior to the diesel run water pumps in regards to the damage they are causing to the environment. Though it was

only 20 percent of the participants who included environment in their understanding on what 'sustainable water supply' mean, all emphasized the negative impact of diesel run water pumps on the environment. UNICEF #1 said, *"Generator produces carbon and disposes oil and causes problem to the environment."* WVI #1 said, *"Yes, it is clear to me that environmental pollution is more related to generator power system."* NUWACO #2 also said, *"Generator has a lot of waste production and pollutes the environment."*

3.3.3 Financially

The analysis of the data financially concerning the pro and cons of solar versus diesel water pumps in Puntland, resulted into two sub-themes: investment cost and operation and maintenance cost. They are presented and discussed below.

3.3.3.1 Investment cost

All participants agreed that investment cost of solar powered water pumping system is very high compared to diesel powered water pumping system. MOE #1 said, *"Of course when it comes to solar, solar is initially expensive. … In general, the initial cost is a problem." For example, NUWACO #2 expressed his concern:*

> "…Somalia imports solar from abroad. Personally I asked dealers to buy solar, they requested me 4000 USD for less than two kilowatt power. So the initial cost is far beyond your imagination."

And UNICEF #1 went on to compare through its life time cost and explained in detail:

> "Initial cost of solar water pumping is a bit more expensive than generator run water pumping system but in shallow wells it is even cheaper option at the beginning. The cost of operation and maintenance is very high for generators. And in general life-time cost of solar water pumping is very low. Moreover life time of generator is much shorter than solar panels." (UNICEF #1, UN Agency)

In the literature review chapter, the same conclusion had been made.

3.3.3.2 Operation and maintenance cost

3.3.3.2.1 Cost and availability of spare parts

One major finding was that availability of spare parts for generators was mentioned as the major bottleneck compared to solar pumping system. NUWACO #2 from PPP Company said:

> "For generators, there no available spare parts. We import them from abroad and you have to wait a lot of time. That alone makes much difference between generators and solar. Also it creates a lot of work and needs money because generators needs every time to control, to start to shut it down, to change oil every time. Solar only needs to be cleaned up. (NUWACO #2, PPP Company)

This shall be mainly related to the fact that the solar water pumping system does not need much maintenance during its life time. As PSAWEN #1 from the government explained:

> "In my experience solar doesn't need many spare parts and it is also available in towns. Mainly the problem I have seen is with converter but it is available; there are many companies that supply solar spare parts." (PSAWEN #1, government)

3.3.3.2.2 Cost and availability of fuel and oil

Not only the cost of fuel was mentioned so frequently by all participants as the cause for high operation cost for diesel powered water pumps but also the poor quality and the limited availability of fuel had been emphasized. UNICEF #1 said, *"Diesel is coming from the Gulf and its quality is not even certified and causes problems to generators. Moreover diesel is very expensive."* This is partly related to lack of strong government institutions who formulates policies, guidelines and standards to control quality of imported items to Puntland.

3.4 Barriers to the successful implementation of solar powered drinking water supply projects

The study identified five major barriers as to the successful implementation of solar powered drinking water supply project in Puntland (see Figure 3-4). The study also found out that there is no social and cultural related barriers to the use of solar power for drinking water pumping. All are discussed into six sub-themes below. It is worth noting herewith that these barriers identified in the analysis of the transcribed interviewed data were also identified in the literature review part of this study and hence the study was looking forward to confirming if these were barriers in Puntland context too and if there were additional ones. The study did not find any barrier different from what was identified in the literature review.

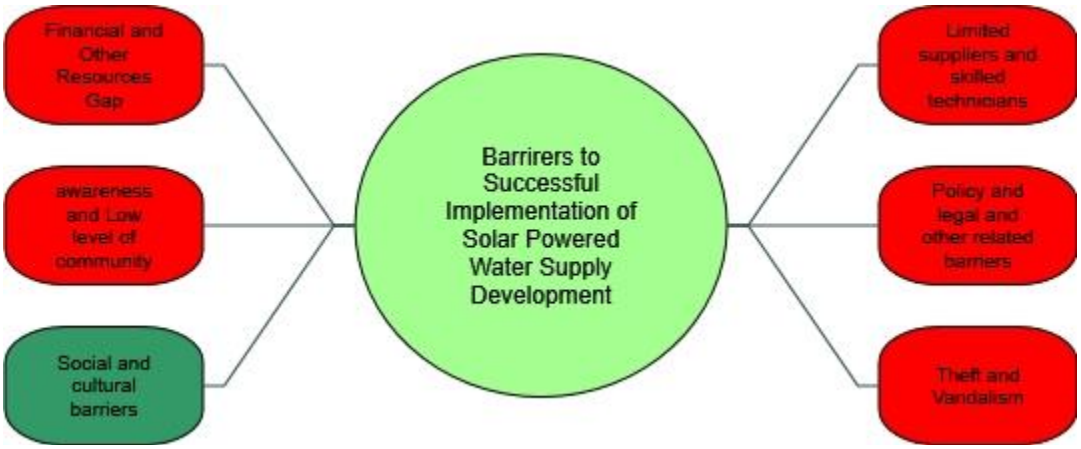

Figure 3-4: Major Barriers to successful Implementation of Solar Powered Water Supply Development

3.4.1 Theft and Vandalism

One of the major barrier identified in the analysis of the interview transcripts was theft and vandalism in solar water pumping systems especially related to the solar panels. 70 percent of the participants raised theft and vandalism of solar panels as the major problem that Puntland is facing. MOE #1 said, "… there is a risk of vandalism for reason I don't understand. So the only issue with solar is protection, especially in remote areas." Similarly MOE #2 said, *"… the only thing people are afraid of is because they have to employ somebody to protect solar panels in remote areas."* NCA #1 also said, *"You may fear that someone will remove the solar. And you need to pay someone to keep it."* According to NUWACO #2, this is also related to the low awareness of the community and expressed, *"… because of our community have no knowledge for public goods protections, someone who walk along the street can throw stones, then the panels will get damaged easily."* However as discussed in the literature review chapter, this is one of the barriers which could be mitigated by carefully designing the system or adding additional features to the system along with the raising the awareness of the communities.

3.4.2 Financial and other Resources Gap

Financial and resources gap in Puntland was identified as a huge gap in Puntland to the successful implementation of solar powered drinking water supply projects. 80 percent of the participants discussed this as one of the biggest challenges to achieving SDG 6 in Puntland. UNICEF #1 mentioned that donors are not also willing to fund solar because of its high investment cost, *"There is a huge financial gap and especially since the initial cost is high, donors are also not willing to fund."* In the literature review chapter two key challenges were identified that would affect countries' effort to fully achieve SDG 6: 1) financial and resources gap would be one of the key challenges for LDC like Somalia; and 2) following this challenge, United Nations SDG agenda

was to commit developed countries to finance LDCs like Somalia. However according to the findings of analysis of the interview transcripts, Puntland, Somalia has never been getting this aid for renewable energy alternatives like solar water pumping that enable the country/region to achieve its SDG 6 targets for reasons that need further exploration. PSAWEN #1 expressed his concerns:

> "… I can say there is little funding for solar water pumping in Puntland. Even our partners also focus on generator fearing the initial investment cost of solar powered water pumping system. Very few interested to support solar system, even NGO's."

3.4.3 Policy and Legal related Barriers

There had never been clear finding on the availability of clear policies and strategies which encourages the use of solar water pumps in Puntland. Only 20 percent of the participants said that there was available water act. UNICEF #1 said, *"Here is Water Act but it is too general and lacks details and practicality."* Whereas PSAWEN #2 said, *"Yes, part of the water act in Puntland included solar water pumping."* The rest of the participants either did not know about its availability or they believed that it was not available. NUWACO #1 said, *"There is no clear policy in Puntland."* And similarly NUWACO #2 said, *"We don't have clear policy and guidance."* Whereas PSAWEN #3 said, *"I don't have much idea about that."* It is also worth noting that the researcher's personal request for the Water Act from PSAWEN was a vain attempt. Accordingly this study concluded that lack of clear policy which encourages the use of solar powered water pumping is one of the main barriers in Puntland. So the either the policy is has never been formulated or it has been formulated but no one is using it.

3.4.4 Low Awareness and Low level of community participation

In sub-section 3.2 of this same chapter, low awareness and low level of community participation were identified findings and discussed in these sections. Though the communities are well familiar with solar energy for various other purposes it was mentioned that their familiarity for water pumping was low. Again the low awareness and the need for capacity building for government and NGOs had been mentioned as one of the challenges in the implementation of solar powered drinking water supply projects in Puntland. Moreover as it was identified and discussed both in literature review and in 3.1 subsection of this chapter, narrowed understanding of what 'sustainable water supply' means affects the successful implementation of solar powered drinking water effectively.

3.4.5 Limited Suppliers and Skilled Technicians

Similarly limited suppliers and availability of skilled technicians were identified both in the literature review and in sub-section 3.3.1.2 as key challenges for successful implementation of solar-powered drinking water supply projects in Puntland. For example, NUWACO #2 expressed his concern, *"…there are no enough dealers in this country. Only two to three dealers. Somalia imports solar from abroad."*

3.4.6 Social and Cultural Barriers

All participants confirmed that there is no any social or cultural barrier with Puntland communities to solar powered alternative to drinking water supplies. They never came across such social and or cultural barrier which hinders the communities from using solar power for water pumping. For example, the participant from the PPP Company (NUWACO #1) said, *"There is no such acceptance problem to solar in the community."* PSAWEN #1 from government also said, *"They prefer too much solar system. Even they usually come and ask us for solar pumps saying that we have no money to buy fuel. They are interested."*

3.5 Concepts to the successful implementation of solar powered water supply

Though not exhaustively, a number of concepts that contribute to the successful implementation of solar powered drinking water supply projects in Puntland were identified in the analysis of the interview transcripts as can be seen from the diagram below (see Figure 3-1). The main ones were capacity building for government, NGO and water operators, improving the quality of solar system components, need for planning, research and studies in the sector, need for clear policy and guidelines favoring solar energy for powering water pumps and raising community awareness and participation.

NCA # an NGO staff expressed her need for capacity building saying, "*For a staff like me I need training concerning solar. …capacity building for staffs are very necessary. "* PSAWEN #1 from the government also commented on the need for training of water operators on solar powered water pumping, *"To improve capacity of the operators, one time training is not quite enough but give more."*

The need to improve the quality of the components of solar powered water pumping system especially the quality of solar panels and solar inverters were given due consideration by 60 percent of the participants. Due to that the need to standardize the quality of products that are being imported is suggested by the participants. This connected to the challenge they are facing with supply of poor quality solar panels and inverters which fails to provide the rated power. It was

partly contributed by the lack of strong government institutions which control the quality of imported items to Puntland based on established standards. It was also related to either the under sizing of solar panels or incomplete facilities or components such as solar batteries during the design. PSAWEN #1 said, *"We should have good quality of solar, converter and all equipment. If we don't have good quality it will get out of use after few months."* PSAWEN #2 also commented:

> "Getting good system, standard and acceptable one is very important. We need to also come up and identify what 'good solar system is' or not. As we have seen some solar system that have a capacity of; let's say 300 watt/hour but producing less than 150. We need good equipment that last long that reduces the overall cost for water and so on than having new generator every five year. So we need to install good system that has longer life and which is sustainable." (PSAWEN #2, Government)

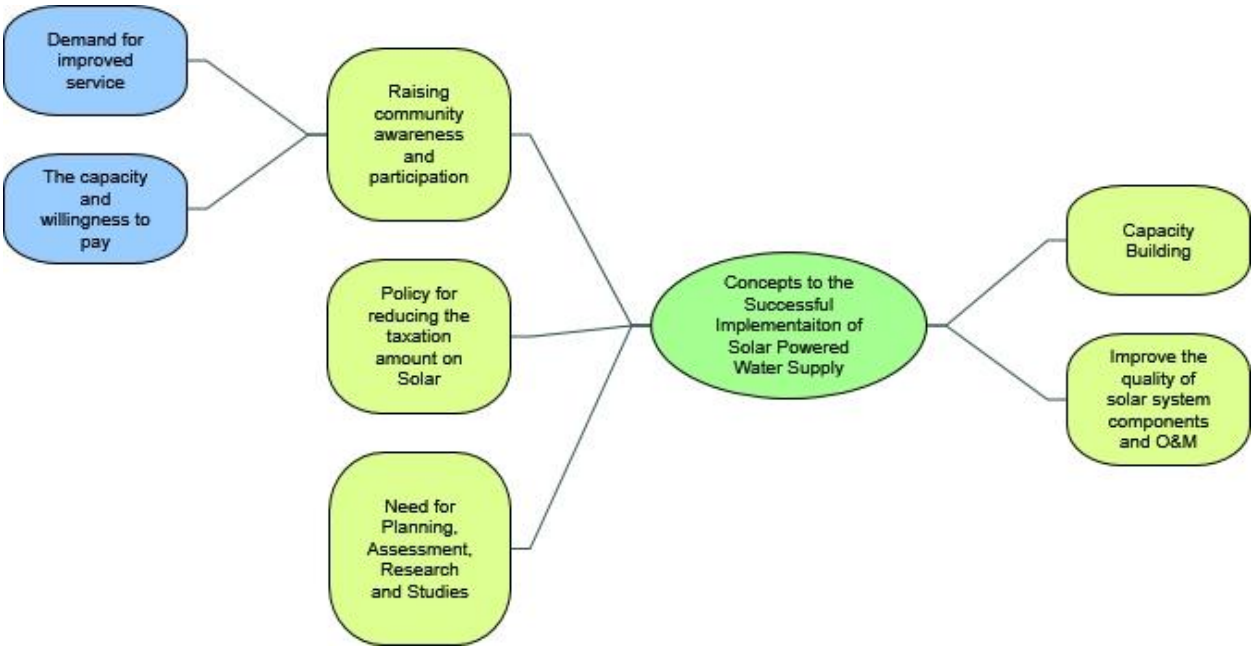

Figure 3-5: Concepts Underlying successful implementation of Solar Powered Water Supply System in Puntland

Another major concept identified from the analysis of transcribed interviews was the need for planning, assessment, research and studies on solar powered water pumping for successful implementation of such projects. NUWACO #1 said, *"Do survey or study first before jumping to propose and implement solar powered water pumping system."* This was also partly related to design of such systems based on limited data and hence collection of data through assessment was highly recommended. For example, PSAWEN #3 recommended:

> “Identify locations, get borehole drilling completion report, demand of water, flow rate, elevation, number of population and animals and all shall be computed very well. Consider the addition of night time storage tanks too.” (PSAWEN #3, Government)

The need to have separate and clear policy and guidelines which encourages and promotes the use of renewable energy alternatives such as solar power for drinking water pumping for Puntland was also identified as one concept for successfully achieving SDG 6 in Puntland. UNICEF #1 suggested, *“We need to have guidelines and policies. The guideline will lead us.”* And MOE #1 also said, “*In rural areas, solar power should be number one and there should be subsidies.”*

Finally the analysis of the interview transcripts indicated that raising the awareness of communities on solar powered water pumping system and participating them from problem identification, selection of technologies, its implementation to the operation and maintenance of such projects are very essential for their success. For example, UNICEF said, *“Participation of communities is also another thing that had to be seriously considered.”* And this was also something which emerged from the literature review chapter as one key concept that should be considered to ensure the sustainability of such water supply projects powered by solar. Moreover it was concluded in the same chapter that to ensure effective selection of alternative technologies, there shall be a move from ‘resource driven approach’ to ‘demand driven approach’ which involves full participation of communities.

Chapter 4: Conclusions

This dissertation is designed to study the relative merits of solar versus diesel powered water pumping system in Puntland regional state of Somalia from the perspective of meeting sustainable development goals specifically SDG 6. However it was noted that SDG 6 is highly inter-connected to SDG 7 and SDG 13 which targeted affordable and clean energy to all and which urges UN member countries to take urgent action to combat climate change and its impacts respectively (United Nations, 2015). In the literature review, whether these targets of the United Nations' 2030 Agenda for Sustainable Development will be achieved in LDCs like Somalia or not was put under question. Taking into consideration just part of SDG 6 alone which targets universal access to clean and sustainably managed water for all, for Somalia with more than 63 percent of the rural population lacking access to safe drinking water (UNICEF, 2018) and with continued conflict, terror attack (ongoing fighting), insecurity, instability and recurrent draughts (Central Intelligence Agency, 2018), this question becomes more frustrating. In spite of this big and crucial question which is out of the scope of this study, through literature review it was found out that solar powered water pumping systems were economically, socially and environmentally more viable and superior over diesel powered water pumping systems. In spite of this and the fact that Puntland in Somalia is endowed with high solar insolation ranging on average from 5-7 KWh/m^2/day (World Bank, 2018), Puntland remained to use diesel as the major source of power to pump drinking water and the real bottlenecks and barriers for this has never been clearly known.

However most of these studies were based on quantitative studies through collection of secondary data in which all of them were conducted outside Somalia context. In addition to the fact that Somalia is one the least developed countries, the country has stayed more than two decades of war and conflict since 1991 and major infrastructures had been destroyed and hence it had been a collapsed state up to 2012 (Rotberg, 2004) in which this had made the context very different from the countries where these quantitative studies were conducted through the collection of secondary data. Moreover it was found out in the literature review that the feelings, perceptions, experiences, understanding and attitudes of people which can affect the decision on the choices of alternative energy to water pumping could not be explored and identified using quantitative and secondary data alone (Creswell, 2014) and (Saunders, et al., 2009). Due to these reasons, this study collected qualitative data through face-to-face individual in depth interviews from ten participants selected through purposive sampling from six key stakeholders in Puntland who are directly or indirectly involved in the intervention of drinking water supply in Puntland.

The study followed the subjective interpretivism research paradigm, a case study approach and an inductive research strategy through qualitative data analysis to identify the barriers and to explore the concepts underlying the successful implementation of solar powered water pumping in Puntland, Somalia. The interviews were then transcribed and analyzed thematically using one of the thematic analysis styles called template analysis aided by NVIVO qualitative data analysis software. The analysis resulted in five major themes: 1) understanding of what 'sustainable water supply' means; 2) awareness level of the communities on solar-powered water supply system; 3) pros and cons of solar versus diesel powered water pumps; 4) barriers to the successful implementation of solar powered drinking water supply projects in Puntland, Somalia; and 5) the concepts to the successful implementation of solar powered water supply.

It is found out that there is a narrowed notion and or incomplete understanding of what 'sustainable water supply' means in Puntland. The analysis shows that it is not understood holistically or in its full dimension, that is, economically, socially and environmentally. And this is one of the bottlenecks from achieving its target successfully (Jickling, 1994). However it was identified that communities in Puntland are well familiarized with solar power for charging mobile phones, for lighting and radios. However they don't have similar familiarity level in using it for drinking water pumping. This was related to the high installation cost of solar powered water pumping system. It is also concluded that community's participation in problem identification, consultations and workshops is not adequate. This has been found out even worse when it comes to marginalized communities.

The analysis of the transcribed interview shows that the participants understand and feel that solar powered water pumps are superior technically, financially and environmentally over diesel powered water pumps. However the study shows that users are facing challenges by the inability of solar to pump water during night time and suggested the need to include battery charging system to save power for night time pumping.

The study also identified theft and vandalism, limited financial and other resources, lack of clear policies and guidelines and low awareness, low level of community participation, limited suppliers and skilled technicians as the major barriers to the successful implementation of solar powered water pumping system in Puntland. On the positive side, the study does not indicate the existence of any social and cultural barriers in using solar energy for drinking water in Puntland. Moreover the study suggested the need for building the capacity of government, NGO and water operators, improving the quality of solar system components, conducting research and studies in the sector, formulating clear policy and guidelines favoring solar energy for powering water pumps and

raising community awareness and participation as the main success factors for the implementation of solar powered water supply system.

Finally, the study recommends that future studies which include water users' as participants, focus group discussions including women and marginalized people to be conducted so as to able to capture their perception, experiences and attitudes and make the data collection more inclusive data for such qualitative studies. This might enable to capture other key non-identified barriers and success factors by this study for achieving SDG 6 targets. It also recommends that similar studies should be conducted to other regions of Somalia so as to able to make generalized conclusions at national level.

References

African Development Bank Group, 2015. *Somalia - Energy Sector Needs Assessment and Investment Programme,* Abidjan: African Development Bank Group.

Aliyu, M. et al., 2018. A review of solar-powered water pumping systems. *Renewable and Sustainable Energy Reviews.*

Amos, J., 2017. *BBC.* [Online]
Available at: https://www.bbc.com/news/science-environment-38745937
[Accessed 8 December 2018].

Archel, P., Ferna´ndez, M. & Larrinaga, C., 2007. The Organizational and Operational Boundaries of Triple Bottom Line Reporting: A Survey. *Springer Science+Business Media, LLC.*

Asumadu-Sarkodie, S. & Owusu, P. A., 2016. A review of renewable energy sources, sustainability issues and climate change mitigation. *Cogent Engineering,* Volume 3.

Blakers, A., 2015. Sustainable Energy Options. *Asian Perspective ,* Volume 39, p. 559–589.

Boyce, C. & Neale, P., 2006. *Conducting In-depth Interviews: A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input.* Watertown, MA: Pathfinder International.

Brikké, F. & Bredero, M., 2003. *Linking technology choice with operation and maintenance in the context of community water supply and sanitation.* Geneva, Switzerland: World Health Organization and IRC Water and Sanitation Centre.

Brooks, J. & King, N., 2014. *Doing Template Analysis: Evaluating an End of Life Care Service.* s.l.:Sage Research Methods Cases.

Brooks, J., McCluskey, S., Turley, E. & King, N., 2015. The Utility of Template Analysis in Qualitative Psychology Research. *Qualitative Research in,* 12(2), pp. 202-222.

Campana, P. et al., 2015. Economic optimization of photovoltaic water pumping systems for irrigation. *Energy Conversion and Management ,* Volume 95, p. 32–41.

Campari, J., 2018. *How our food system is eating away at nature, and our future.* [Online]
Available at: https://www.weforum.org/agenda/2018/11/we-must-rethink-our-food-system-from-planet-to-plate/
[Accessed 28 December World Economic Forum].

Campari, J., 2018. *World Economic Forum.* [Online]
Available at: https://www.weforum.org/agenda/2018/11/we-must-rethink-our-food-system-from-planet-to-plate
[Accessed 16 Novemeber 2018].

Carant, J. B., 2017. Unheard voices: a critical discourse analysis of the Millennium Development Goals' evolution into the Sustainable Development Goals. *Third World Quarterly,* 38(1), pp. 16-41.

Cassell , C. & Symon, G., 2004. *Essential Guide to Qualitative Methods in Organizational Research.* 1st ed. London: SAGE Publications.

Central Intelligence Agency, 2018. *Central intelligence Agency.* [Online]
Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/so.html
[Accessed 12 September 2018].

Chandel, S., NagarajuNaik, M. & Chandel, R., 2015. Review of solar photovoltaic water pumping system technology for irrigation and community drinking water supplies. *Renewable and Sustainable Energy Reviews,* Volume 49, p. 1084–1099.

Chandel, S., Naik, M. N. & Chandel, R., 2017 . Review of performance studies of direct coupled photovoltaic water pumping systems and case study. *Renewable and Sustainable Energy Reviews,* Volume 76, p. 163–175.

Creswell, J. W., 2012. *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research.* 4th ed. Boston, MA: Pearson.

Creswell, J. W., 2014. *Research Design: Qualitative, Quantitative and Mixed Methods Approaches.* 4th ed. Los Angeles: SAGE Publications, Inc..

Dagnet, Y. et al., 2018. *Setting the Paris Agreementin Motion: Key Requirments for the Implementing Guidelines.* s.l.:World Resources Institute.

FAO, 2014. *The Water-Energy-Food Nexus: A new approach in support of food security and sustainable agriculture,* Rome: FAO.

Fransen, T., Northrop, E., Mogelgaard, K. & Levin, K., 2017. *"Enhancing NDCs by 2020: Achieving the Goals of the Paris Agreement." Working Paper.* Washington DC: World Resources Institute.

Gao, X. et al., 2013. Feasibility evaluation of solar photovoltaic pumping irrigation system based on analysis of dynamic variation of groundwater table. *Applied Energy ,* Volume 105, p. 182–193.

Gopal, C., Mohanraj, M., Chandramohan, P. & Chandrasekar, P., 2013. Renewableenergysourcewaterpumpingsystems—A literaturereview. *RenewableandSustainableEnergyReviews,* Volume 25, p. 351–370.

Green Climate Fund, 2018. *Green Climate Fund.* [Online]
Available at: https://www.greenclimate.fund/how-we-work/resource-mobilization
[Accessed 28 December 2018].

Green Climate Fund, 2018. *Green Climate Fund.* [Online]
Available at: https://www.greenclimate.fund/home
[Accessed 28 December 2018].

Grooten, M. & Almond , R., 2018. *Living Planet Report - 2018: Aiming Higher,* Gland, Switzerland: WWF.

Gupta, J. et al., 2015. *Sustainable Development Goals and Inclusive Development and Inclusive Development.* Tokyo, Japan: United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS).

Hancock, D. R. & Algozzine, B., 2006. *Doing Case Study Research: A Practical Guide for Beginning Researchers.* New York: Teachers College Press.

Hartung, H. & Pluschke, L., 2018. *The benefits and risks of solar-powered irrigation - a global overview.* s.l.:the Food and Agriculture Organization of the United Nations and Deutsche Gesellschaft für Internationale Zusammenarbeit.

Hossain, M. A., Hassan, M. S., Mottalib, M. A. & Ahmmed, S., 2015 . Technical and economic feasibility of solar pump irrigations for eco-friendly environment. *Procedia Engineering ,* Volume 105 , p. 670 – 678.

International Energy Agency, 2016. *Water-energy nexus: Excerpt from the World Energy Outlook 2016,* Paris: International Energy Agency.

Iqbal, I. & Pierson, C., 2016. *A North-South Struggle: Political and Economic Obstacles to Sustainable Development.* Washington: American University Washington College of Law.

Jickling, B., 1994. Studying sustainable development: problems and possibilities. *Canadian Journal of Education,* 19(3), pp. 231-240.

Kaplan, M., 2018. *CNN.* [Online]
Available at: https://edition.cnn.com/2018/01/26/world/eco-solutions-bp-solar/index.html
[Accessed 8 December 2018].

Kativhu, T., Mazvimavi, D., Tevera, D. & Nhapi, I., 2017. Factors influencing sustainability of communally-managed water facilities in rural areas of Zimbabwe. *Elsevier.*

Khouri, N., 2018. *CNN.* [Online]
Available at: https://edition.cnn.com/2018/01/25/world/eco-solutions-sonnen-battery/index.html
[Accessed 8 December 2018].

King, N., 1998. *"Template Analysis," in Qualitative Methods and Analysis in Organisational Research: A Practical Guide.* Symon, G and Cassell, C. ed. London: Sage .

Lenzen,, M. et al., 2014. Cultural and socio-economic determinants of energy consumption on small remote islands. *Natural Resources Forum,* Volume 38, p. 27–46.

Light, A., 2018. *World Resources Institute.* [Online]
Available at: https://www.wri.org/blog/2018/05/world-moving-trump-announced-intent-withdraw-paris-agreement-climate-change
[Accessed 28 December 2018].

Li, G., Jin, Y., Akramb, M. & Chen, X., 2017. Research and current status of the solar photovoltaic water pumping system – A review. *Renewable and Sustainable Energy Reviews ,* Volume 79 , p. 440–458.

Lixue, W. & Hossain, S. A. A. M., 2017. Solar Power Pumping in Agriculture: a Review of Recent Research. *Agricultural Research and Technology Open Access Journal,* 4(3).

Mack, N. et al., 2005. *Qualitative Research Methods: A Data Collector's Field Guide.* North Carolina: Family Health International.

Marks, S. J. & Davis, J., 2012. Does User Participation Lead to Sense of Ownership for Rural Water Systems? Evidence from Kenya. *Elsevier Ltd..*

Martin, D. & Schouten, J., 2013. *Sustainable Marketing: Pearson New International Edition.* Kindle Edition ed. s.l.:Pearson Education Limited.

Meah, K., Fletcher, S. & Ula, S., 2008. Solar photovoltaic water pumping for remote locations. *Renewable and Sustainable Energy Reviews,* Volume 12, p. 472–487.

Merriam, S. B., 1998. *Case study research in education: A qualitative approach.* San Francisco: Jossey-Bass.

Miller , R. L., 2000. *Researching Life Stories and Family Histories. Introducing Qualitative Methods.* 1st ed. London: Sage Publications.

Miller, B., 2018. *CNN.* [Online]
Available at: https://edition.cnn.com/2018/11/29/world/climate-change-wmo-2018-report-wxc/index.html
[Accessed 8 December 2018].

Miller, B., 2018. *CNN.* [Online]
Available at: https://edition.cnn.com/2018/12/11/world/climate-change-arctic-report-card-2018-wxc/index.html
[Accessed 11 December 2018].

Miller, B. & Croft, J., 2018. *CNN.* [Online]
Available at: https://edition.cnn.com/2018/10/07/world/climate-change-new-ipcc-report-wxc/index.html
[Accessed 8 December 2018].

Milne , M. J. & Gray, R., 2012. W(h)ither Ecology? The Triple Bottom Line, the Global Reporting Initiative, and Corporate Sustainability Reporting. *Springer Science+Business Media Dordrecht.*

Mokeddem, A. et al., 2011. Performance of a directly-coupled PV water pumping system. *Energy Conversion and Management ,* Volume 52, p. 3089–3095.

Mooney, C., 2018. *The Washington Post.* [Online]
Available at: https://www.washingtonpost.com/news/energy-environment/wp/2018/06/01/trump-withdrew-from-the-paris-climate-plan-a-year-ago-heres-what-has-changed/?noredirect=on&utm_term=.db5aec196082
[Accessed 28 December 2018].

MOPIC & UNDP, 2016. *E-Consultation: Somalia 2016 - Towards an Inclusive Somalia National Development Plan 2017-2019,* s.l.: MOPIC & UNDP.

Moula, M. E. et al., 2013. Researching social acceptability of renewable energy technologies in Finland. *International Journal of Sustainable Built Environment,* Volume 2, p. 89–98.

Naseem, Z. & Imran, S., 2016. Assessing the Viability of Solar Water Pumps Economically, Socially and Environmentally in Soan Valley, Punjab. *Internataional Journal of Environmental and Ecological Engineering,* 10(6).

Odeh , I., 2014. Production Economic feasibility of large scale PV water pumping applications utilizing real field data for a case study in Jordan. *Int. Journal of Renewable Energy Development,* 3(2), pp. 107-117.

Omcon Consulting Group, 2006. *Feasibility Assessment for the Replacement of Diesel Water Pumps with Solar Water Pumps,* Namibia: Omcon Consulting Group.

Painuly, J. P. & Fenhann, J. V., 2002. *Implementation of Renewable Energy Technologies - Opportunities and Barriers,* Denmark: UNEP Collaborating Centre on Energy and Environment, Riso National Laboratory.

Parajuli, R., Pokharel, G. R. & Østergaard, P. A., 2014. A comparison of diesel, biodiesel and solar PV-based water pumping systems in the context of rural Nepal. *International Journal of Sustainable Energy,* 33(3), p. 536–553.

Petersen, G. & Gadain, H., 2012. *Climate Change Impacts on Water Resources of Somaliland and Puntland. Technical Report No W-21,* Nairobi, Kenya: FAO-SWALIM.

Picheta, R., 2018. *CNN.* [Online]
Available at: https://edition.cnn.com/2018/10/29/health/wwf-wildlife-population-report-intl/index.html
[Accessed 30 October 2018].

REHMAN, S. & SAHIN, A. Z., 2015. Performance Comparison of Diesel and Solar Photovoltaic Power Systems for Water Pumping in Saudi Arabia. *International Journal of Green Energy ,* Volume 12, p. 702–713.

Romero , M. & Jones, V., 2018. *Ocasio-Cortez understands the promise of a 'Green New Deal'.* [Online]
Available at: https://edition.cnn.com/2018/12/10/opinions/green-new-deal-ocasio-cortez-climate-change-romero-jones/index.html?utm_source=Fareed%27s+Global+Briefing&utm_campaign=329bc86907-EMAIL_CAMPAIGN_2018_12_12_08_11&utm_medium=email&utm_term=0_6f2e93382a-329bc86907
[Accessed 13 December 2018].

Rotberg, R. I., 2004. Failed States, Collapsed States, Weak States: Causes and Indicators. In: R. I. Rotberg, ed. *When States Fail: Causes and Consequences.* s.l.:Princeton University Press, pp. 1-25.

Sahin, A. . Z. & Rehman, S., 2012. Economical Feasibility of Utilizing Photovoltaics for Water Pumping in Saudi Arabia. *International Journal of Photoenergy,* Volume 2012.

Saunders, M., Lewis, P. & Thornhill, A., 2009. *Research methods for business students.* 5th ed. Harlow: Pearson Eduction.

Searchinger, T. et al., 2018. *Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050,* Washington, DC: World Resources Institute.

Shawki, N., 2018. Global Basic Rights, Positive Duties, Extraterritorial Obligations, and Mediating Institutions: Do the Sustainable Development goals deepen the institutionalisation of a global responsibility to end poverty?. *Social Alternatives,* 37(1).

Shouman, R. E., Shenawy, E. E. & Badr, M., 2016. Economics Analysis of Diesel and Solar Water Pumping with Case Study Water Pumping for Irrigation in Egypt. *International Journal of Applied Engineering Research,* 11(2), pp. 950-954.

SIDRA & UNDP, 2018. *Localizing the Sustainable Development Goals (SDGs) & SDG7 in Puntland,* Garowe, Somalia: SIDRA & UNDP.

Sontake, V. C. & Kalamkar, V. R., 2016. Solar photovoltaic waterpumping system-A comprehensive review. *Renewable and Sustainable Energy Reviews,* Volume 59, p. 1038–1067.

Starman, A. B., 2013. The case study as a type of Qualitative Research. *JOURNAL OF CONTEMPORARY EDUCATIONAL STUDIES,* p. 28–43.

The United Nations Population Fund (UNFPA), 2014. *Population Estimation Survey 2014 for the 18 Pre-war Regions of Somalia,* Nairobi: The United Nations Population Fund (UNFPA).

Thomas, R., Brocklesby, R., Coleman, A. & Cuchhadia, 2016. Triple bottom line: Sustainability in amblyopia care. *Macmillan Publishers Limited.*

Trivedi , A., 2018. *World Resources Institute.* [Online]
Available at: https://www.wri.org/blog/2018/10/women-are-secret-weapon-better-water-management
[Accessed 11 December 2018].

Trivedi, A., 2018. *World Resources Institute.* [Online]
Available at: https://www.wri.org/blog/2018/10/women-are-secret-weapon-better-watermanagement
[Accessed 11 December 2018].

Turner, D. W., III, 2010. Qualitative interview design: A practical guide for novice. *The Qualitative Report,* 15(3), pp. 754-760.

UNDP, 2011. *Fast Facts.* s.l.:UNDP.

UNICEF, 2018. *UNICEF Somalia WASH Strategy Note 2018-2020,* s.l.: UNICEF.

UNICEF, August 2016. *Strategy for Water, Sanitation and Hygiene 2016-2030.* New York: Programme Division.

United Nations Development Group , 2016. *The Sustainable Development Goals are Coming to Life: Stories of Country Implementation and UN Support,* United States of America: United Nations Development Group.

United Nations, 1991. *Solar-powered Water Pumping in Asia and the Pacific,* New York: United Nations.

United Nations, 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development.* New York, United Nations.

United Nations, 2018. *The Sustainable Development Goals Report 2018,* New York: United Nations.

United Nations, 2018. *World Economic and Social Survey 2018: Frontier technologies for sustainable development,* New York: United Nations.

Waite, R., Hanson, C., Searchinger, T. & Ranganathan, J., 2018. *This is how to sustainably feed 10 billion people by 2050.* [Online]
Available at: https://www.weforum.org/agenda/2018/12/how-to-sustainably-feed-10-billion-people-by-2050-in-21-charts
[Accessed 11 December 2018].

Waring, T. & Wainwright, D., 2008. Issues and Challenges in the Use of Template Analysis: Two Comparative Case Studies. *Electronic Journal of Business Research Methods,* 6(1), pp. 85-94.

WHO and UNICEF, 2017. *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baseline,* Switzerland: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF).

Woodbridge, M., 2015. *From MDGs to SDGs: What are the Sustainable Development Goals?.* Bonn: ICLEI World Secretariat.

World Bank Group, 2015. *Somalia Economic Update: Transition amid Risks with a Special Focus on Intergovernmental Fiscal Relations,* Nairobi: World Bank Group.

World Bank, 2018. *Atlas of Sustainable Development Goals 2018: From World Development Indicators,* Washington, DC: World Bank.

World Bank, 2018. *Solar Pumping: The Basics,* Washington, DC: World Bank.

World Economic Forum , 2018. *Harnessing the Fourth Industrial Revolution for Water,* Geneva: World Economic Forum.

World Economic Forum, 2018. *World Economic Forum.* [Online]
Available at: https://www.weforum.org/agenda/2018/12/how-to-sustainably-feed-10-billion-people-by-2050-in-21-charts
[Accessed 11 Decemeber 2018].

World Economic Forum, 2018. *World Economic Forum.* [Online]
Available at: https://www.weforum.org/agenda/2018/11/what-were-eating-is-killing-us-global-nutrition-report
[Accessed 11 December 2018].

World Economic Forum, 2018. *World Economic Forum.* [Online]
Available at: https://www.weforum.org/agenda/2018/11/we-must-rethink-our-food-system-from-planet-to-plate
[Accessed 11 December 2018].

World Meteorological Organization (WMO), 2018. *World Meteorological Organization.* [Online]
Available at: https://public.wmo.int/en/media/press-release/wmo-climate-statement-past-4-years-warmest-record
[Accessed 8 December 2018].

World Resources Institute, 2018. *World Resources Institute.* [Online]
Available at: https://www.wri.org/our-work/topics/climate
[Accessed 11 December 2018].

Wright, H., Huq , S. & Reeves, J., 2015. *Impact of climate change on Least Developed Countries: are the SDGs possible?.* s.l.:The International Institute for Environment and Development (IIED).

WWAP (United Nations World Water Assessment Programme)/UN-Water, 2018. *The United Nations World Water Development Report 2018: Nature-Based Solutions for Water,* Paris: UNESCO.

WWAP (United Nations World Water Assessment Programme), 2016. *The United Nations World Water Development Report 2016: Water and Jobs,* Paris: UNESCO.

Yeboah, F. K. & Jayne, T. S., 2017. *From Theory to Practice: Exploring Sustainable Solutions to Africa's Developmental Challenges.* s.l.:African Journal of Food, Agriculture, Nutrition & Development.

Yin, R. K., 2014. *Case study research: Design and methods.* 5th ed. Thousand Oaks, CA: SAGE.

Zainal, Z., 2007. Case study as a research method. *Jurnal Kemanusiaan,* Issue 9, pp. 1-9.

Acknowledgments

I would like to give my appreciation and thanks to many people and the Lord who helped make my dissertation possible:

The Almighty God

****

For He has provided me the strength and required resources throughout the thesis process and during my courses at the University Cumbria,

Dr. Peter Redding

****

For supervising my paper and providing constructive and vital guidance and feedback throughout the writing process of my MBA thesis,

Student care & my tutors at Robert Kennedy College and University of Cumbria

****

For providing tireless support to my various queries and accessible online learning environment,

My wife (Martha Hailemariam) and the kids

****

For providing tireless encouragement during my difficult times and their own time so that I pursue with my study,

The interview participants

****

For generously sharing their experiences, attitudes and views on the subject matter.