Capacity Building to achieve Sustainable Water Management System in Arid and Semi-Arid Lands (ASALs)

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Abstract

Arid and Semi-Arid Lands (ASALs) comprise of more than 40% of the earth's land surface and supports 20% of the total human population. Droughts, or periods of unusually low rainfall, are part of the expected pattern of precipitation in these regions. Over the past decade, the effects of climate change have become more pronounced, leading to reoccurring cycles of drought in ASALs. The 2011 drought in the Horn of Africa was considered to be the worst in past 60 years which affected 13.5 million people. Such events had far reaching adverse impacts on human health, food security, economic activity, physical infrastructure, natural resources, environment, and national and global security. In order to improve the situation and mitigate the effects, government and NGOs continue their efforts for capacity building through water interventions and training programs. But these initiatives are often short term and uncoordinated. Therefore, there is a need for a holistic framework for capacity building to achieve a sustainable water management system in ASALs. This paper outlines a framework for capacity building that aims to integrate indigenous water management systems with strategies required to overcome current issues. Main focus of this paper is to illustrate three types of capacities (economic, social and environmental) at three levels (individual, organizational and system) to achieve a sustainable water management system and to present a framework that involves five defined phases of capacity building. These five phases are preparation, assessment, planning, implementation and evaluation. This framework would assist in achieving reliability of long-term water availability and enhance self-reliance over time.

Keyword: Capacity, Capacity building, Water management, Arid and Semi-Arid Lands, Indigenous knowledge.

1. Introduction

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Arid and Semi-Arid Lands (ASALs) are characterized by low and erratic precipitation which results in low and unpredictable crop and livestock production. Typically, arid areas are defined as those receiving less than 200 mm of winter rainfall or less than 400 mm of summer rainfall annually (UN Economic and Social Council 2007). Conversely, semi-arid areas are defined as those receiving between 200–500 mm of winter rainfall or between 400–600 mm of summer rainfall (UN Economic and Social Council 2007).The annual rainfall varies between 50-100% in the arid zones of the world with averages of up to 350 mm. In the semi-arid zones, annual rainfall varies between 20- 50% with averages of up to 700 mm (UN Economic and Social Council 2007). In Africa, ASALs (excluding deserts or hyper-arid lands) comprise of more than 40% of the land surface (UN Economic and Social Council 2007). Figure-1 shows a large portion of land area in Africa is currently under water stress and water scarcity (FAO 2008). According to the Falkenmark Water Stress Indicator, a country or region is said to experience "water stress" when annual water supplies drop below 1,700 m^3 per person per year. At levels between 1,700 and 1,000 m^3 per person per year, periodic or limited water shortages can be expected. When water supplies drop below 1,000 m^3 per person per year, the country faces "water scarcity".

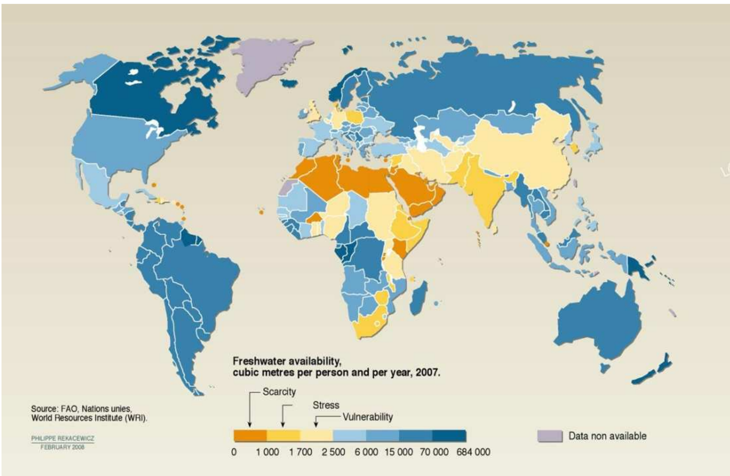

Figure 1. Freshwater availability around the globe (FAO 2008)

Most of the countries in Figure-1 which are under water stress and scarcity have “traditional‟ or “indigenous‟ approaches that have been used for managing water scarcity. They are based on lifestyle adaptations that minimized consumption and maximized beneficial local use (Arab Water Council 2008).The natives of these regions have several indigenous coping mechanisms to overcome the effects of drought in these areas. But studies conducted by UNEP in 2008 mentioned a steep decline in use of such knowledge in past few decades. A 2008 report by Arab Water Council also mentioned the dominance of indigenous knowledge up to the 1970s and increase in usage of modern water management practices after 1970. Though these technological innovations help for a short period of time, they significantly alter water management behaviors and create social, economic and environmental disruptions in these ASALs. Deep tube wells allow continual, unsustainable drawdown of aquifers as well as access to fossil water, wherever available. Pumps allow faster abstraction from canals and rivers than previously possible, disrupting historical patterns of consumption. Some of the challenges causing these disruptions are short term planning and lack of a framework to build capacity (UNESCO-IICBA 2006). This paper aims towards identifying methods for building capacity to achieve sustainable water management system in ASALs of Africa.

2. Background

There are various definitions of "capacity" and "capacity building". Sometimes the terms are used in an ambiguous manner or without being defined (UNDP 2008, UNEP 2002). Hence, it is necessary to have a common and clear understanding of basic concepts. UNISDR (2009) defines capacity as, combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals. UNDP (2005) defines capacity building as sustainable creation, retention, and utilization of capacity in order to reduce poverty, enhance self-reliance, and improve people's lives. The term capacity building evolved from past terms such as institutional building and organizational development lead within UN systems for action and thinking (UNDP 2008). In the 1950s and 1960‟s these terms referred to community development that focused on enhancing the technological and self-help capacities of individuals in rural areas (UNDP 2008). In the 1970s, following a series of reports on international development, an emphasis was put on building capacity for technical skills in rural areas, and also in the administrative sectors of developing countries where training was the most important activity (UNDP 2008). For a long period of time capacity building was referred to training individuals. In the 1980s the concept of institutional development started expanding even more. In the year 2000, UNDP with its partner strategic GEF Secretariat, launched the Capacity Development Initiative (CDI), which involved extensive process to identify countries' priority issues in capacity development needs on global environmental issues. Then the three levels of capacity building were developed by UNDP as individual level, organizational level and system level (UNDP 2008). Individual level focused on attitudes and behaviors-imparting knowledge and developing skills of an individual entity while maximizing the benefits of participation, knowledge exchange and ownership (UNDP 2008). Organizational level focused on the overall organizational performance and functioning capabilities, as well as the ability of an organization to adapt to change (UNDP 2008). System level emphasized on the overall policy framework in which individuals and organizations operate and interact with the external environment (UNDP 2008).

In 2005, a German Donor Agency GTZ (Deutsche Gesellschaftfür Technische Zusammenarbeit) introduced the concept of five phases of capacity building cycle. These five phases were: preparation, analysis, planning, implementation and evaluation. Phase I is the preparatory phase of the capacity building cycle which addresses the agreement on objectives, the establishment of the work process at the individual, organizational and system levels. Phase II identifies existing capacity gaps in view of particular goal which has to be achieved. It determines capacities which need to be built, acquired or utilized. Phase III transforms identified capacity needs into time dependent capacity building strategies. Phase IV is implementation of activities that requires sound planning of measures and identification of capacity building service providers to deliver specific services. Phase V is the final phase that evaluates the impact of capacity building (GTZ 2005).

Capacity building has evolved a lot in past decades but the 2005 report by World Bank Operations Evaluation Department, mentioned that capacity building was still not a well-defined practice in ASALs of Africa. Herold's 2009 report on water crisis in Africa mentioned that capacity building for water management has several challenges in almost all the ASALs in Africa. Various challenges mentioned in his report were:

- Immediate needs are addressed instead of long term planning. Capacity building caters to immediate water needs that creates mismatch between water supply and water demand grows in few years. Also as mentioned in the UNEP 2002 report, water demand calculations conducted in past took care of the immediate needs of water demand or need in near future thus if there is a drastic change in the future demand, the availability of water is not enough to cater the community.
- Absence of a capacity building framework. Different policies related to water securities and usage are not defined in usual water management programs and absence of these capacities lead to theft of water and over exploitation of water resources (UNESCO-IICBA 2006. Most of the communities in ASALs of Africa are poor and live a nomadic life, traveling with their livestock in search of water and pasture (FAO 2008). There is no legal administration regarding water security policies in those regions (UNEP 2002). Thus water theft arises purely from failure to define water rights, enforce monitoring, lack of interpretation of readily available information that is collected at great cost and enforce compliance.
- Several agencies understand capacity building as a post disaster need assessment programs whereas some believe that capacity building is limited to training people and organizations living in different communities (World Bank OED 2005).
- Decline in indigenous knowledge and its application is one of the biggest capacity building challenges in rural areas of ASALs of Africa (UNEP 2008, Arab Water Council 2008). Capacity building needs a lot of community interaction and involvement, indigenous skills, customs and social norms help the better involvement of pastoral communities in ASALs.
- Capacity building is always performed to achieve agreed goals but often the goals are not clearly defined.
- Unavailability of local authority and legal framework. Capacity building is a long term process and thus it is important to understand the different capacities which need to be developed in order to achieve the goal.

Thus these challenges clearly define the necessity of a capacity building framework for an agreed goal, i.e., to achieve sustainable water management system in ASALs of Africa. There is a need to revive indigenous water management practices with strategies to overcome these challenges. This can be done by using the capacity building framework and understanding the underlying importance of indigenous knowledge for efficient use of resources and the ability to deliver social, cultural and economic needs of the community. This would increase reliability of long-term water availability in ASALs of Africa and have a potential impact on social, economic and environmental condition of such regions. This paper presents a capacity building framework to achieve sustainable water management system in ASALs of Africa.

3. Research Methodology

Research methodology can be divided in three tasks. (i) Various indigenous water management practices in ASALs around the globe were identified from existing literature as well as the evolution of capacity building was identified. (ii) Second task focused on developing the entire capacity building framework which includes feasibility study of the various indigenous water management practices, selection of a practice to define the goal of capacity building, five phases of capacity building and development of a system dynamic model for a long term projection and sustainable retention of water. (iii) Third task included application of the framework, results and analysis. This paper illustrates the development of the framework whereas application of this framework is subject of another paper.

4. Development of the framework

A generic flowchart of the framework is shown in Figure-2.

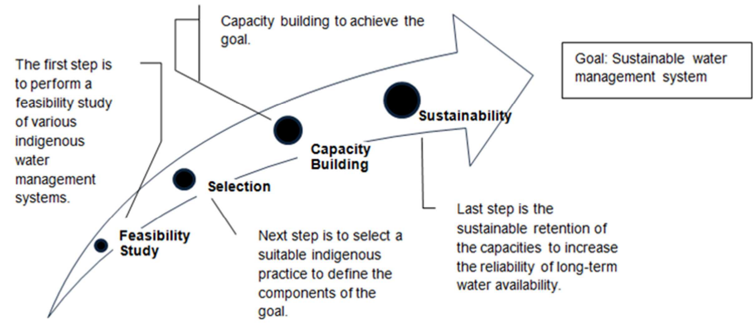

Figure 2. A generic flowchart of the capacity building framework (Sinha 2012)

4.1. Goal: Sustainable water management system

A Sustainable water management system in this research is defined as a system that utilizes rain water harvesting technique to store water using a selected indigenous water management practice. This system addresses the current issues of water management in ASALs of Africa in terms of water security and water usage policies, financial constraints related to construction and maintenance of the system, and legal framework to implement those policies. A capacity matrix is proposed in this research to be utilized during the first four phases of capacity building.

4.2. Feasibility study

Table 1 shows feasibility study of some of the indigenous water management practices selected to be studied for this research based on their cost of construction, water contamination and loss of water due to evaporation. 2004 SASOL report mentions that these three parameters are important technical criteria before selecting any water intervention in ASALs.

Table 1. Feasibility Study of various indigenous water management practices

	Definition	**Cost (USD/m^3)**	**Contamination**	**Evaporation loss**
Roof catchment Systems (UNEP/SEI 2009)	Rooftop catchment systems collect rainwater from the roofs of houses, schools, etc., using gutters and downpipes and then store it in containers that range from simple pots to large ferrocement tanks. It is practiced around the globe.	7-15 depending on the type of construction material for container	Low contamination. Very close to portable drinking water	Evaporation loss of water is low in a covered container
Ponds and Pans (Gomes 2006)	Ponds and pans are like a hole dug in the ground, which can be square, rectangular or round. Very common practice in ASALs of Africa and Asia	30-130 depending on the type of construction material and design of pond	In absence of a silt trap, water in ponds and pans have high contamination	Evaporation loss of water is high
Underground Tanks (UNEP/SE 2009, Gomes 2006)	Some communities in ASAls of Africa, Asia and Middle East also direct runoff water into an underground tank or cisterns dug into the ground.	10-150 depending on the type of construction material and design of tank	Contamination is low in a covered underground tank	Evaporation loss is low in covered underground tank
Johad (Hemispheres 2007)	Johads are simple mud and rubble barriers built across the contour of a slope to arrest rainwater. It is primarily used in ASALs of India.	1-4 depending on the design	Relatively high water contamination	Evaporation loss is high
Sand dam (www.sandam.org, last visited Nov 2012)	A sand storage dam(Or sand dam) is a small dam build on and into the riverbed of a seasonal sand river. Practiced primarily in Ethiopia and Kenya	0.8- 2 depending on construction material	Low water contamination due to sand that acts as a filter	Evaporation loss is almost negligible

4.3. Selection

As evident from table 1, among all the practices, sand dam is the least expensive water management practice which stores water within the sandy riverbed causing low contamination as well as almost negligible water loss due to evaporation. Thus in this research, sand dam is selected as the water storage component of the sustainable water management system.

4.4. Capacity Building

It is understood from the evolution of capacity building that it occurs at three different levels (individual, organization and system). But capacity building initiatives still lack a framework that differentiates in various types of capacities such as social capacity, economic capacity and environmental capacity. Hence a capacity matrix is proposed in this paper which includes not only the levels of capacity but segregates them as social, economic and environmental capacity. UNISDR (2009) defines capacity as, combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve the agreed goals. Following the same definition in this research; social capacities are defined as those strengths, attributes and resources which are defined under social parameters related to health, education, resource management, population etc. Economic capacities are those strengths, attributes and resources related to funds and financing and Environmental capacities are those strengths, attributes and resources available within a community, related to environment e.g. river, topography, environment protection policy, environment protection activity etc.

Capacity building is a five phase (preparation, analysis, planning, implementation and evaluation) cyclic activity. In this research the proposed matrix is utilized in the first four phases of capacity building and for the last phase which is the evaluation phase a system dynamic model is proposed to show the water projection as a result of this sustainable water management system.

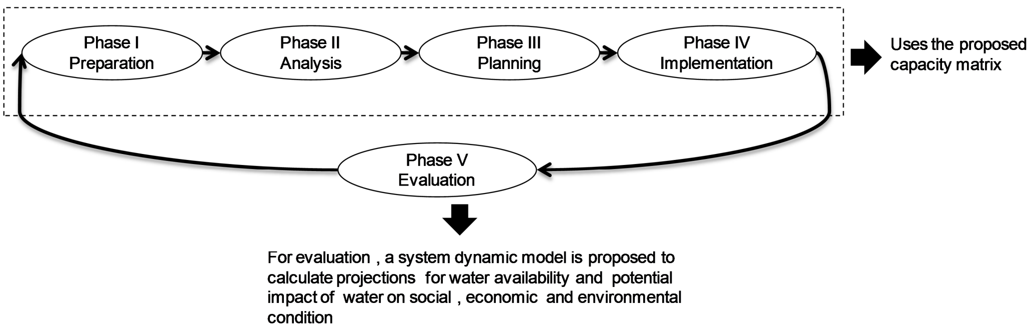

Figure 3. Capacity building phases

4.4.1. Phase I Preparation

The preparatory phase of the capacity building cycle addresses the agreement on objectives and the establishment of the capacities required to achieve the objective at the individual, organizational and system levels depending on different capacity types. The objective of this phase is to prepare for and set in motion a structured process of discussing each capacity required at each level to achieve the goal. In this research, the agreed objective of capacity building is sustainable water management system which includes construction of sand dam and other capacities including policies and resources. Table 2 demonstrates the preparation of the capacities using the proposed capacity matrix.

Table 2. Preparation phase capacity matrix

	Social Capacity	**Economic Capacity**	**Environmental Capacity**
System level	Water security policies	Government funds	Topography Sandy Riverbed
Organizational level	Local committee, NGOs, Materials	Committee funds	Environment protection agencies
Individual level	Labors, Skill	Livelihood	Environment protection activities

4.4.2. Phase II Analysis

Second phase of the capacity building cycle is the analysis phase which identifies capacity needs of a community based on a simple scale developed in this research. It identifies the capacities which are available, unavailable or have a limited availability. Unavailability shows that the respective capacity is not available and needs to be created or acquired in order to achieve the goal. Limited availability shows that the capacity is available but needs improvement to achieve the goal. Availability shows that these capacities are available within a community to achieve the goal. Thus for all the capacities mentioned in preparation phase to achieve the goal, capacity need assessment is conducted in analysis phase, using the mentioned scale.

4.4.3. Phase III Planning

The planning phase transforms the identified capacity building needs into time dependent capacity development strategies. Short term and long term capacity building action plan is accompanied by a list of activities in implementation phase to provide strategic direction for capacity building process in the future. Short term action plan focuses on those capacities in each capacity type which need to be either improved or acquired or created in a few months before or during the construction of sand dam, e.g., improvement of individual skill (social capacity at individual level) and selection of a riverbed (an environmental capacity at system level) are some of the capacity building activities which fall under a short term action plan. Long term action plan includes the rest of the limited available and not available capacities, which cannot be developed immediately and needs to be developed over a year or more to achieve the goal, e.g., water security, financing opportunities and environmental protection policies (all three capacity types at system level).

4.4.4. Phase IV Implementation

Once the capacities are divided under short term and long term action plan, implementation schemas are prepared accordingly. The implementation of capacity building activities requires sound planning of measures and the identification of capacity building service providers to deliver specific services. The implementation of capacity building hence includes several types of activities geared towards each type of capacity at different levels. A continuous monitoring of accomplishments ensures that the capacity building process stays on track and that improved governance related products and services are made available to regional beneficiaries.

4.4.5. Phase V Evaluation

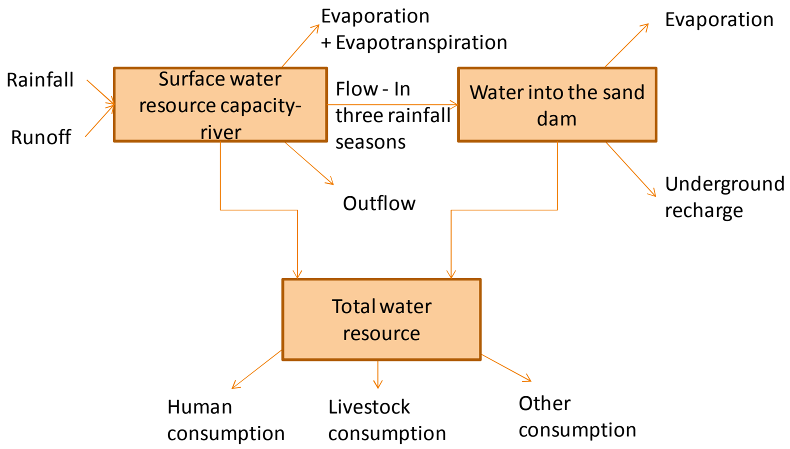

Figure 4. Schematic diagram to show causal relationship for part 1

The final phase of the capacity building process deals with the evaluation of overall outcomes and impacts obtained from capacity building and the goal achieved for the community. Following the implementation of planned capacity building measures, the outcomes and impacts need to be evaluated pertaining to the achieved goal and the impact on social, economic and environmental condition from a sustainable water management system. Thus a system dynamics model is proposed in this research. A system dynamics model helps in understanding the behavior of a complex system over time. Since water management in this research comprises of a complex set of physical and social systems hence system dynamics is used to develop a model to understand water demand and supply after the construction of sand dam. The model also helps in understanding the potential impact of water on social, economic and environmental conditions in ASALs of Africa. The model has two parts:

First part calculates the total water accumulated from surface water of the river bed and the water that is stored in sand dams after its construction. Before developing the model, present water yield, water demand and total number of sand dams required to be built in a community needs to be calculated.

Three main parameters of the first part are surface water capacity of river, water into sand dam and total water available. The schematic diagram shown in Figure-4 depicts the inflows and the outflows of the three main parameters. Total water resource is the water consumed from surface of the river and from water in the sand dam. This water is consumed by humans, livestock and other facilities like hospitals, schools etc. Water on the surface of the river bed is received directly from rainfall and indirectly from runoffs and this water is lost through evaporation, evapotranspiration, overflow and a portion that goes into the sand dam. Similarly water into the sand dam comes from river surface and the outflow is either for underground recharge or a minimal evaporation loss.

Second part calculates the growth in human and livestock population due to direct impact of water availability. The causal loop for human population and livestock population is shown in Figure-5.

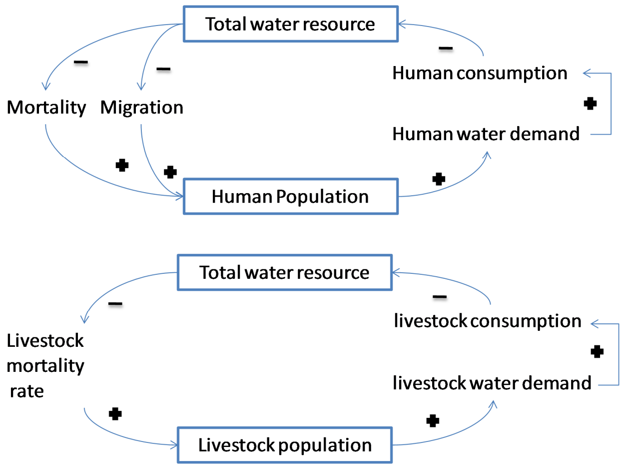

Figure 5. Schematic diagram to show causal relationship for part 2

In Figure-5, first two loops show that increase in total water resource decreases mortality rate and migration rate of human which increases the population which in turn increases the water demand, further increasing the water consumption which reduces the total water resource. The lower loop shows that increase in total water resource decreases livestock mortality rate which increases the livestock population which in turn increases the livestock water demand, increasing their water consumption which reduces the total water resource.

5. Results

The model was run to show a projection for 10 years for a hypothetical case where the total water demand from livestock, human and other facilities for a community was assumed to be 30,000 m^3/month (based on the literature review of ASALs in Africa) with an annual rainfall of 200 mm, mean annual rainfall of 2240 mm, evaporation runoff coefficient 70%. For the sand dam, available data saturation of sand dam is 45% of the volume of sand and total extracted water from sand dam was 35% (www.sanddam.org, last visited Nov 2012). The initial water in the riverbed was assumed to be zero as sand dams are built on perennial rivers and total number of sand dam was assumed to be 34.

The result (Figure-6) for this hypothetical case initially shows a decrease in total water resource (as the sand dam becomes fully functional in 20 months (Nissen-Petersen, 2006)), but after that it shows an increase in water availability which starts declining after end of 5th year, primarily because of the growth in water demand but even after 10 years with growth in population and other consumption, water is available; whereas during the past decade several regions in ASALs of Africa got water only during the rainy seasons.

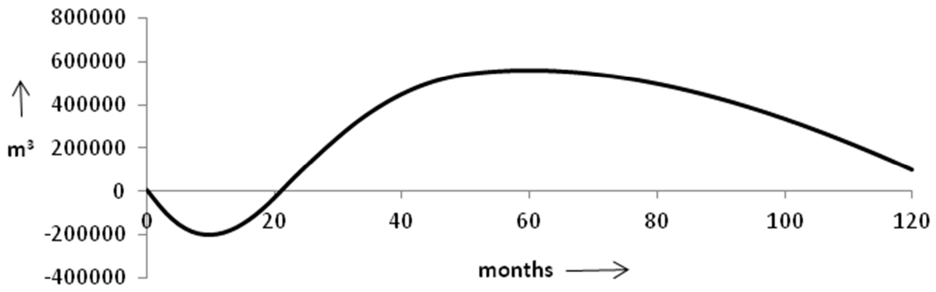

Figure 6. Results for total water resource (m^3) for next 10 years

6. Discussions and Conclusion

Indigenous knowledge for disaster management has helped various communities in Africa to survive in harmony with their environment but a decline in such knowledge is making these communities vulnerable to events like drought. The main aim of this paper was to develop a framework for capacity building to achieve sustainable water management system in ASALs of Africa. This sustainable water management system includes reviving an indigenous water management practice of ASALs of Africa such as sand dams and developing planned strategies for using the water efficiently for long term through capacity building framework. Capacity matrix proposed in this paper highlights different types of capacity along with the three levels of capacity which helps in understanding the importance of social, economic and environmental capacities. This matrix is used in preparation phase, analysis phase, planning phase and implementation phase of capacity building. For the evaluation phase of capacity building cycle a system dynamics model is developed that shows increase in reliability of water availability, using a hypothetical case for the base run of the model.

This framework would mainly assist government agencies and NGOs in their water management interventions in Kenya, Ethiopia and other ASALs in Africa with similar kind of disaster events and climatic conditions. This research helps in understanding capacities in form of a complex matrix which can be used for achieving agreed goals of a community and is not limited to water management. The system dynamics model proposed in this research helps in understanding the continuous relationship between the demand and supply of water in any region and potential impacts of water availability.

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