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## Understanding Water Systems Resilience Problems in Tanzania

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### Abstract

The world's biggest devastation is currently due to disasters; their consequences range from deaths and physical damages of infrastructures to environmental, ecological and economic losses. Water systems are critical infrastructures and are recurrently affected by the impacts of disasters. In Tanzania, these events play a part in infrastructures failures; the country has experienced 266 different disasters contributing to 13,288 deaths, 57,556 injuries, and damages valued at 465.79 million USD for the period from 1900 to 2016. Water systems, in particular, are a subject of exposure to disasters, their resilience has been tested and has shown different responses. Of concern is the El Nino episodes of 1992-1993 and 1997-1998 which had significant impacts nationwide regarding economic losses, power blackout and rationing, widespread water-related diseases, infrastructure destructions and others. As such, different studies have investigated water-related issues, but little is known about their resilience to disasters. This paper uses literature to examine the problems and improvement measures of water systems resilience at a global scale and the case of Tanzania. The findings show that aging infrastructures, systems interdependency, unbalanced investment, limited community involvement, rapid population growth and urbanization, regular changes of the water ministry and others affect the resilience of water systems. On the other hand, acceleration of assets replacement, preparedness, installation of alternative power supply, community involvement, policies and plans enforcement, and balanced investment and others would improve their resilience. However, further studies are required to measure the resilience across all dimensions systematically.

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## 1. Introduction

The National Science Challenge defines resilience as “The ability to absorb the effects of a disruptive event, minimize adverse impacts, respond effectively post-event, maintain or recover functionality, and adapt in a way that allows for learning and thriving, while mitigating the adverse impacts of future events” [1]. This concept has come into prominence to prepare for the increasing threats of terrorism, natural disasters and other crisis [2]. Natural disasters, for example, are devastating threats due to their unpredictability nature, and the large number of deaths, destructions and economic losses caused in a very short time of occurrence. In recent years, the impact of climate change has been reported to intensify the frequency and magnitude of natural disasters. Flood, for example, is influenced by climate change, every year, many flood hazards are reported all over the world, Africa without exclusion. Systems such as roads, telecommunications, and water to mention a few are vulnerable to floods, and this has led to the need for resilience.

Water systems, in particular, are among lifeline infrastructures because they provide essential services that support the life of the communities [3]. They comprise of catchments/water sources, water treatment infrastructures, distribution infrastructures, raw water transmission pipes, electronic facilities and other cyber systems [4]. These systems have a downstream and upstream interdependency with sectors such as transportation, industrial, agriculture, power, fire, and others. Their direct relation to the community and the managing organizations make them considered as social-ecological-technical systems comprising of natural, physical, organizational, and social systems [5]. This composition gives a serious opportunity for threats [6]. Examples of of disasters that had direct impacts on water systems include the 2003 North American power grid blackout, 2008 snowstorm in China, The 2004 Tsunami in Asia, 3000 flooded septic tanks in 2000 in Chokwi and Xia-Xia cities of Mozambique, the 2007 Bangladesh flood event, and the 2011 Christchurch earthquake.

Tanzania, for the period from 1900 to 2016 has been hit by different disasters in the form of 25 epidemics, 41 floods, 11 earthquakes, 10 droughts, and about 179 technological events which caused 13,288 casualties, 57,556 injuries, and damages valued at 465.79 million USD [7]. Few examples are in the form of floods which include the 2015 floods in Shinyanga [8], and the El Nino episodes of 1992-1993 and 1997-1998. These caused economic losses, nationwide power blackout and rationing, food shortage and increased prices, severe losses of livestock and crops, widespread water-related diseases, infrastructural, settlements, livelihoods and other property destructions [9, 10].

Studies on climate change in Tanzania indicate that there will be an increase in extreme weather in the form of floods, droughts, cyclones, and tropical storms [11]. Although water-related issues have been examined, little is known about the resilience of the water systems in the face of disasters. It is the purpose of this paper to review problems related to the resilience of water systems and the improvement measures at a global scale and the case of Tanzania. The findings of this article could be useful for informing decision makers about the water resilience problems and actions that may be taken to improve the water systems resilience.

## 2. Background of water systems in Tanzania

In Tanzania, water systems play a crucial role in public health, environment, agriculture, industries, and the economy as a whole. Initially, water systems were limited to shallow wells, rivers, lakes, springs, and natural impoundments, where people used to walk for some distances to fetch water. In 1891 the colonial government invested in developing a piped water system in Dar Es Salaam the major city of Tanzania [12], this system was administered by a cost-sharing approach. The approach was then replaced following a "free water for all" declaration of the first President of Tanzania [13]. They further state that the 1970s economic crisis affected the "free water for all" policy; thus the government adopted back the cost sharing system in the mid-1980s, which was finally replaced by an emphasis on full cost recovery and private sector involvement following the National Water Policy adoption in 1991.

Water resource in Tanzania is in the form of rivers, lakes, and groundwater, this resource is governed and managed by the water policy of 2002 and the Water Resources Management Act 2009. The latter is preceded by the Act no. 10 of 1981, which divided water resources management into nine water basins throughout the country [14]. On the other hand, water infrastructures are managed by water authorities at the regional, district and township levels, which are governed by the Water and Sanitation Act 2009. The bodies mentioned above are all under the Ministry of Water and Irrigation. The Energy and Water Utilities Regulatory Authority became active in 2006 after being established under

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