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AND SAFE WATER: A CASE OF ULUGURU FOREST CATCHMENT AREAS
MOROGORO, TANZANIA**

Prosper I. Massawe, Adili Mvena, Daniel Nyoki and Enock L. Chambile

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EFFECTS OF ANTHROPOGENIC ACTIVITIES ON AVAILABILITY OF CLEAN AND SAFE WATER: A CASE OF ULUGURU FOREST CATCHMENT AREAS MOROGORO, TANZANIA

Prosper I. Massawe^{1*}, Adili Mvena¹, Daniel Nyoki² and Enock L. Chambile³

*Corresponding author email: massawep17@gmail.com

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ABSTRACT

Forests offer a range of options for water provision, depending on their type, age, species of the trees, and amount of watershed under forest, soil, climate, location and prevailing human agricultural activities in Sub Saharan Africa (SSA). For example, the Uluguru forest catchment areas in Tanzania is the major source of river flows supplying water to major urban centers of Morogoro, Pwani and Dar es Salaam regions. The forest provides fuels, maintenance of humid climate suitable for agriculture, secure stable and good water supply and the main source of water for the urban and industrial uses in Tanzania's most populous city Dar es Salaam through the Ruvu River. The Catchment forest reserves are part of the life of the people living in the Uluguru slopes. The need to optimize the availability of clean and safe water use while minimizing environmental risks in Uluguru forest water catchment areas and sub-Saharan Africa (SSA) at large is behind schedule. The challenges related to managing Uluguru forest water catchment areas in Tanzania can be associated with a lack of awareness and unestimated values of the catchment function of the forest into monetary terms. However, as most of the economic activities depend on water from this forest, the value must be billions of dollars over the years. This jeopardized the loss of the forest cover, woodlands and other trees from the mountain. As results, the apparently clean and safe water is not protected and the springs are subject to sources of pollution and contamination. Water intakes are similarly contaminated due to farming and logging activities. Limited research has been conducted to improve availability of clean and safe water along the Uluguru forest catchment areas but the adoption remains low, mainly because farming is generally practiced by resource-poor smallholder farmers. This research gap must be addressed through putting supportive environmental policies operationalised, innovation platforms involving key stakeholders to realize the function of forest water catchment areas and address efficient use of existence of natural resources into the sustainable manner.

¹Tanzania Agricultural Research Institute (TARI) – Selian, P.O. Box 6024, Arusha, Tanzania.

²Department of Agriculture, Tanga Regional Commissioner's Office, P.O. Box 5095, Tanga, Tanzania.

³Department of Geography and Environmental Studies, Sokoine University of Agriculture, P.O. Box 3038, Morogoro, Tanzania.

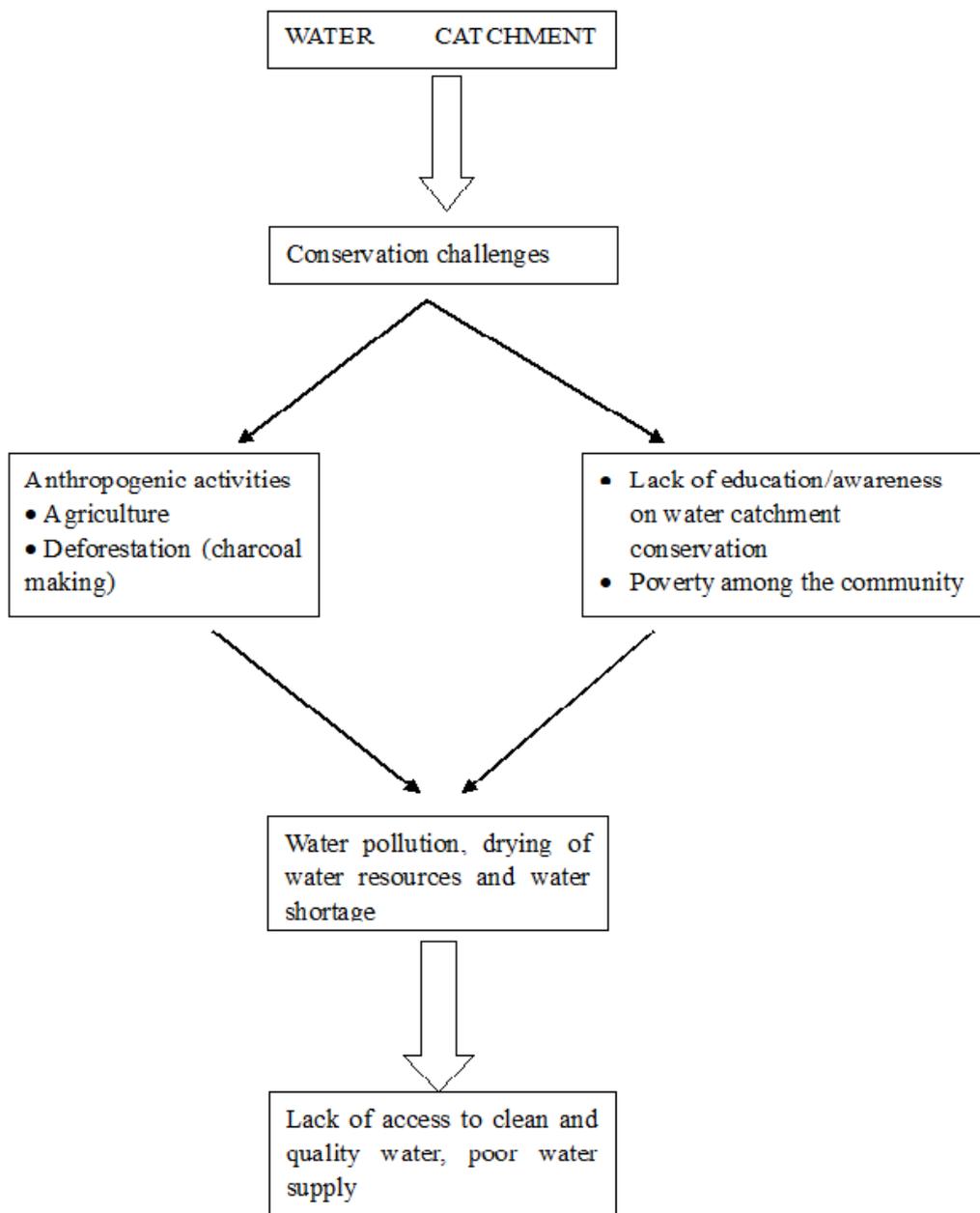
Therefore, this review paper aims to discuss an overview of forest worldwide, access to clean and quality water, water catchment conservation in relation to clean and quality of water, anthropogenic activities that lead to the degradation of water catchment areas and impacts of water catchment degradation. This will help to suggest appropriate management strategies for restoration of Uluguru forest catchment areas.

INTRODUCTION

Most of the environmental impacts associated with water catchment degradation are primarily caused by different human activities that are taking place along the catchment areas (Khatri and Tyagi, 2015). Human activities leading to the environmental impacts include agricultural activities which are associated with deforestation leading to increased surface runoff and decreased groundwater recharge (Peters and Meybeck, 2000). Pesticide and herbicide applications on crops contribute to chemical deposits in the soil, which are carried through runoff and leaching into rivers, lakes and groundwater (Cerejeira *et al.*, 2003; Guzzella *et al.*, 2006). These environmental impacts bring about adverse effects to the living organisms and the environment in general. Among the influences includes water pollution, water shortage which lead to a lack of access to clean and quality water caused by drying water sources such as rivers, wells etc. Most mountains receive large amounts of rainfall, and they are the most important water catchment areas. For example, recent researches reveal that Uluguru Mountain is of high benefit to the people living in Morogoro Municipality and the surrounding areas. Access to clean water is a severe problem in some areas despite the fact that water is relatively abundant (Chang, 2003). Springs and water intakes are subject to sources of pollution and contamination due to farming and logging activities which eventually impair access to clean and safe water. Water from the rivers is considered unsafe due to the community living around the mountains practicing activities that threaten the efficiency of these catchment areas to produce clean and quality water, hence resulting to the problem of shortage of clean and quality water (Chang, 2003). The community around Uluguru mountains do practice various anthropogenic activities that are very dangerous to the catchment, and these include cutting trees from Uluguru mountain forests which is mostly done by charcoal makers as the source of fuel and agricultural activities associated with poor farming practices that do not follow good farming techniques termed as unsustainable agriculture. Because of the importance of mountains water catchment area to provide its service efficiently to the demanding communities, there is a need of assessing as to why the community living around the mountains continues to practice anthropogenic activities that are not beneficial to the catchment without considering its importance to the demanding community. Therefore, this review paper aimed in identifying human activities that contribute to drying up of water sources and that distort the quality of water, the measures taken by local people towards conserving water sources and knowing how people understand the impacts of water catchment degradation. This will provide the basis for understanding the environmental impacts of mountains water catchment forest reserve areas that will be of more importance to the management team of the catchment area, the existing measures taken by local people towards conserving water sources and knowing how people understand the impacts of water catchment degradation.

CONCEPTUAL FRAMEWORK

Conservation challenges on water catchment areas are directly linked to the environmental degradation arising from the invasion of water sources/catchment areas. Environmental degradation resulting from illegal human activities related to agriculture and livestock keeping, settlement along the slopes of mountains, on top of mountain ranges, in the river valley and around water sources (Elmqvist *et al.*, 2010). Environmental degradation due to deforestation and massive tree cutting for firewood, charcoal and house construction. Studies show that there is a lack of detailed information and data on the importance of catchment areas but there is a considerable concern that entire aquatic ecosystems are now under threat (Hymas, 2000).



AN OVERVIEW OF FOREST WORLDWIDE

A forest is a biotic community predominated by trees and woody vegetation that are significantly taller, greater, thicker, and deeper than other vegetation types and generally covers a large area (Chang, 2003). Forests cover approximately 26.2% of the world, with 45.7% of Latin America and the Caribbean being covered, 35% of East Asia and the Pacific, and 35% of the European Union. Canada and the United States (U.S.) combined account only for 6.8% of the world's forests while Africa has even less 5.7% (Forest Types of the World, 2013). Forests are essential for water and water is necessary for life. Forests serve as our natural water collection, filtration, and delivery systems by collecting rain and snow and delivering it into streams, wet meadows, and aquifers throughout the year (World Bank, 2005). Water flows from forests into rivers that supply our reservoirs, agricultural canals, and water tables. Forests also are keys to flood control, absorbing and holding vast amounts of water in major rain events such as those increasingly seen with climate change, releasing it far more slowly, and cleanly, that would have happened otherwise (Forest Types of the World, 2013). At the local level, particularly in semiarid regions forests and forest resources play an important role in supplementing and diversifying farm incomes. Limited or uncertain tenure rights in much of Tanzania's woodlands and forests in the past have resulted in extractive use for short-term gain.

Since the introduction of community-based forest management (CBFM) via the Tanzania Forest Act of 2002, communities now have the rights to manage, protect, and use these areas for sustainable forest management and economic development. The contribution of forests to local livelihoods and the Tanzanian national economy as a whole is significant but is mostly unrecorded and consequently unrecognized. The difficulty of examining forestry in the context of economic growth arises because no markets exist for ecosystem services. Many transactions related to forest products and services fall within the informal sector or are undertaken illegally, hence not recorded. Official gross domestic product (GDP) figures on which the analysis of economic growth is made, do not reflect the "true" economic importance of the forest sector to the national economy (World Bank, 2005). Despite years of catchment experiments, the precise interactions between different tree species and ages, different soil types and management regimes are still often poorly understood, making accurate predictions difficult (Stolton and Dudley, 2007). The availability and quality of water is strongly influenced by forests, however, in many regions of the world, water is more threatened by overuse, misuse, pollution and deforestation. (Calder *et al.*, 2007). Existence of some forests are less able to control some contaminants (for example, the human parasite *Giardia lamblia*), in most cases the presence of forests can substantially reduce the need for treatment for drinking-water and thus radically reduce costs of supplying water (Stolton and Dudley, 2007). Climate change is also altering forest's role in regulating water flows and influencing the availability of water resources (Bergkamp *et al.*, 2003). Therefore the establishment of the relationship between forests and water is a critical issue that must be accorded high priority in forest catchment areas.

ANTHROPOGENIC ACTIVITIES AND THEIR INFLUENCE ON WATER AVAILABILITY

Environmental impacts that are occurring at the catchment scale are the results of various human activities that affect the distribution, quantity, and chemical quality of water resources (Liyange and Yamada, 2017). The range in social activities that affect the interaction of groundwater and surface water is broad. Agriculture has been the cause of significant modification of landscapes throughout the world. Tillage of land changes the infiltration and runoff characteristics of the land surface, which

affects recharge to groundwater, delivery of water and sediment to surface water bodies, and evapotranspiration (Akyildiz and Stuntebeck, 2006). All of these processes, either directly or indirectly affect the interaction of ground water and surface water (USGS, 2016). Several methods have been developed to alleviate the negative effect of agriculture on water. For example, tillage practices have been modified to maximize retention of water in soils and to minimize erosion of soil from the land into surface-water bodies. Contour farming has significant effect on reducing the effect of agriculture on water bodies' contamination. Deforestation tends to decrease evapotranspiration, increase storm runoff and soil erosion, and decrease infiltration to ground water and base flow of streams and therefore, programs on conservation of forests have been streamlined to protect water from contamination and drying up (USGS, 2016). Evidence seems to suggest that cloud forests (Bruijnzeel, 1990) and some older natural forests (such as old *Eucalyptus* forests) can increase net water flow. From the viewpoint of water-resource quality and management, the increase in storm runoff and soil erosion and the decrease in base flow of streams are generally viewed as undesirable, (Bogena *et al.*, 2009).

Therefore, it is important for the forest conservationists to agree on the amounts of pollutants in surface waters which are significantly influenced by anthropogenic inputs associated with land cover, land use and point sources.

ACCESS TO CLEAN AND QUALITY WATER

Usually, water quality and quantity are all affected by a multitude of different aspects about the natural environment because the potential for conservation land to affect water quality and quantity issues is very wide and complex (Arain, 2011). For example, restoring or improving vegetation could affect both the quality of water and the rate at which it flows through the watershed, not only that but also affect soil condition which, in turn, has additional effects on water quality and flow (McAlpine and Wotton, 2009). Therefore, it is important to understand and become aware that water catchment area in everyday actions may impact the local surface water and groundwater to secure the best water quality possible within water supply catchments areas (Qin *et al.*, 2014). The application of chemicals by the manufacturer's recommendations, reducing the flow of fertilizers, soil nutrients and agricultural inputs into waterways can offset the problems of water quality. Also by avoiding overgrazing and utilizing reticulated water supplies, maintain vegetations such as trees, shrubs and groundcovers along river. Furthermore, we can limit stock access to waterway and vegetation alongside catchments areas and riversides (Central Highlands Water, 2017). Therefore the primary motivations through societal management of water quality have to be strengthening to protected forests for their water resources and quality issues.

CHALLENGES ON AVAILABILITY OF CLEAN AND SAFE WATER

The problem of improving water quality is a growing global concern; the main drivers of poor water quality are economics, poor water management, agricultural practices and urban development (Ludwig *et al.*, 2005). Water is a key natural resource which is vital for the survival of all ecosystems on the planet (Renewable Resources Coalition, 2016). However, less than 1% of the earth's water resources are accessible to humans as fresh water, in the form of either surface or groundwater (Krchnak *et al.*, 2002, UNESCO, 2006). Although there is currently sufficient water for essential activities (Blanco *et al.*, 2009) including drinking, irrigation, and domestic and industrial use on a global scale, the spatial distribution of water suggests that, in many cases, it is not available where it is required. Because of the unequal distribution of freshwater resources, billions of people around the

globe live in water-stressed and water-limited environments (Human Development Report, 2006). Therefore it is crucial to preserve water resources although in practice it is continually degraded and depleted owing to inappropriately targeted funding initiatives leading to poor water management, redundant and outdated agricultural practices and urban development (Rosegrant *et al.*, 2002; Verhoeven *et al.*, 2006).

WATER CATCHMENT CONSERVATION ABOUT CLEAN AND QUALITY OF WATER

People have settled historically in areas rich with natural resources, and today, most of the world's population lives downstream of forested watersheds (Reid, 2001). Societies have created strong cultural links with forests, and it is widely assumed that forests help to maintain a constant supply of good quality water (Stolton and Dudley, 2007). A meta-study conducted for the World Wide Fund for Nature (WWF) on the role of forest protection in drinking-water provision identified a strong linkage between human settlement and availability of clean and quality water (Dudley and Stolton, 2003). This involved a survey of more than 100 of the world's most populous cities revealed a clear link exists between forests and the quality of water coming out of a catchment (Stolton and Dudley, 2007).

Most of the literatures are mostly suggesting that ecosystems with intact groundcover and root systems generally improve water quality within a catchment (Bradshaw *et al.*, 2007; Lowrance *et al.*, 1997). This implies that vegetation, microbes, and soils are capable of removing pollutants from overland flow and from groundwater by just physically trapping water and sediments, adhering to contaminants, also reducing water speed to enhance infiltration, biochemically transforming nutrients and pollutants, absorbing water and nutrients from the root zone, stabilizing soils and eroding banks, and diluting contaminated water (Rey, 2003; Ludwig *et al.*, 2005; Brauman *et al.*, 2007). Therefore a comprehensive risk assessment and risk management approach which is effective and consistently for ensuring the safety of a drinking water that encompasses all steps in water supply from catchment to consumer is essential.

IMPACTS OF WATER CATCHMENT DEGRADATION

Problems associated with water quality are commonly attributed to nutrient, chemical and pathogen loadings into an aquatic system as a result of point source and non-point source activities (EPA, 2009). Surface and groundwater contamination in a catchment is mainly attributed to outdated farm management practices (Bradshaw *et al.*, 2007). These include excessive use of fertilizers for high product yields, traditional irrigation practices, use of pesticides and herbicides and poorly managed animal farming operations (Moss, 2008; EPA, 2009). Other sources include deforestation, atmospheric deposits by rainfall and untreated sewage waste. Farm management practices may result in nutrient, chemical, pathogen and sediment fluxes with main nutrient issues being due to excess phosphorus and nitrogen losses (Hunter and Walton, 2008). Therefore, integrated, predictive management with alternatives for and improvement of the multiple uses must be implemented at the level of community to decentralise management and provide opportunities for different stakeholders to win-win benefits

CONCLUSIONS

Uluguru mountain is globally and nationally recognized for being a significant source of water for Morogoro, Pwani, and Dar es Salaam regions in Tanzania. Challenges such as deforestation, cultivating along river banks and climate change which contribute to drying up of water sources do exist. Most farmers in Uluguru mountain tend to apply both pesticides and fertilizer in their farming practices and this signify the contribution to water catchment pollution, especially rivers that receive runoff water from different forest catchment areas. The physical science study should be undertaken to develop the baseline data for biophysical parameters for further environmental monitoring. The public awareness on conservation has to be enhanced because the impacts to local people as the results of water catchment degradation in Uluguru forest reserve is not enough to the extent that they can relate what they observe on the environment as the adverse effects of what they are practicing on their daily life. One way to encourage more active protection of water quality and quantity through ecosystem protection is to raise awareness about the benefits of conservation and to reward those that maintain healthy ecosystems. This will help to compensate protected areas, communities, indigenous peoples and private landowners for maintaining forests water catchment areas.

Conflict of interests

The authors declare no conflict of interest.

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