www.ijramr.com

ISSN: 2350-0743

International Journal of Recent Advances in Multidisciplinary Research
*Vol. 06, Issue 12, pp. 5400-5411, December, 2019*

# RESEARCH ARTICLE

## COMMUNITY PERCEPTIONS ON THE EFFECT OF LAND DEGRADATION TO WATER RECOURSES AT BOLAHLA- MPHOSONG IN LERIBE DISTRICT

**Mphonyane H. Ntlele (MSc)[1,*], Makoala V. Marake (PhD)[1], Francis T. Mugabe (PhD)[2], Sebolelo F. Molete (PhD)[1], Botle E. Mapeshoane(PhD)[1], Tumelo Nkheloane (MSc)[1] , Joseph Patrick Mensah (MSc)[1] and Tebello A. Sekhobe (MSc)[1]**

[1]Department of Soil Science and Resource Conservation, National University of Lesotho, P. O Roma 180, Maseru, Lesotho
[2]Zimbabwe Open University, P. O. Box MP 1119 Mount Pleasant, Harare, Zimbabwe

**ARTICLE INFO**

***Article History:***
Received 19th September, 2019
Received in revised form
30th October, 2019
Accepted 05th November, 2019
Published online 30th December, 2019

***Keywords:***
Water Resources Degradation, Community Perceptions, Management and Crop Production.

**ABSTRACT**

In Lesotho, the alpine wetlands and sponges are the sources of drinking water for humans and livestock and environmentally critical for sustainable perennial flow of our streams. However, these environments are some of the most threatened ecosystems in Lesotho. Both ground and surface water are exposed to increasing and unprecedented threats from anthropogenic stressors that degrade water quality, reduce water quantity and availability. The net effects are compounded by the climate change impacts creating extreme precipitation conditions of drought and floods, both of which collude to destroy habitat and harm aquatic life. Climate change is the compounding factor, the effects of which are exacerbated by anthropogenic activities which cause land degradation. Since the knowledge, attitudes and practices of the people to a large extend influence how they manage the environment, the purpose of the study was to assess the land users' perceptions on their water quality, availability and distribution. A structured open-ended questionnaire was used to illicit information from focus group discussions with community groups and interviews with key informants. The questions were based on LADA framework of Driving Forces, Pressures, State, Impacts and Responses (DPSIR), which sought to assess the state (S) of the water resources, the driving forces and pressure factors (DP) bearing on water resources, the impacts (I) impacts of the anthropogenic factors on the ecosystem as well as to the households and then the response (R) surface of the community and policy makers. The status of the water resources were found to have decreased due to lack of proper management of the resources, high population caused water shortage and infrastructures decrease water sources as result, the water becomes low both in quality and quantity and their crop production decreased. In respone, the community had started making dams and covering their wells. However, no policies were made regarding water resources management.

## INTRODUCTION

Land and soil degradation is a widespread problem, especially in dry land areas of developing countries (Cerretelli *et al*., 2018). Land degradation takes different forms depending on the causal agents of pollution, overexploitation of natural resources, deforestation, global warming, unsustainable agricultural practices, habitat destruction and loss of biodiversity (Majara 2005; Garda *et al*., 2017). Land degradation is caused by a variety of complex interrelated processes leading to three major land degradation types: soil, vegetation and water resources degradation (FAO 2016). In contrast, water resources degradation entails surface water depletion and fragmentation, pollution and depletion of surface and ground water resources (Garda *et al*., 2017) and alterations in the hydrological regime leading to reduced productivity of the aquatic systetem in terms of fish and other useful aquatic species and products. However, groundwater is less vulnerable to pollution than surface water because of the natural filtering ability of soils and rocks through which contaminated surface water percolates into the aquifers. That notwithstanding, recalcitrant chemicals reaching the ground water are extremely difficult to remove (Abdi *et al*., 2013). Water resources degradation affects the quantity, availability and quality of drinking water by humans, livestock and wildlife (FAO 2016). The quality of the global water resources is in a transient state (Burrow, 1991; AWRA 2012; Hoekstra 2016) because it is either degraded, being degraded or is at risk of degradation. Freshwater supply is also affected by socioeconomic development, lack of sanitation and waste treatment facilities especially in high populated areas of developing countries (Peters *et al*., 2000). Water scarcity (Gibbs *et al*., 2002) is a result of pressures emanating from population growth,

***Corresponding author:*** **Mphonyane H. Ntlele (MSc),**
Department of Soil Science and Resource Conservation, National University of Lesotho, P. O Roma 180, Maseru, Lesotho.

environmental change and a state of degradation and skewed distribution and access to water resources (Appelgren, 1996; Gibbs *et al*., 2002; Rocchi *et al*., 2016). These pressures degrade the state of the environment, which then impacts upon human health and ecosystems, causing the society to make various policy responses such as regulations, information and taxes (Borja *et al* 2006; FAO 2016). Mining and irrigation in some instances also influence salinity of water resources and reduce the quality of water (Water and Forestry 2004). In Lesotho, overgrazing of the rangelands on the fragile soils on steep slopes is causing serious sedimentation of rivers and water supply reservoirs as well as reduced recharge of water supply aquifers. In the urban industrial centers of Maseru and Maputsoe, untreated effluence produced by the textile factories is pumped directly into fresh water systems. Climate change induced drought is already precipitating serious water shortages to supply industries and metropolitan centers in Lesotho (Gibbs *et al*., 2002) especially the industrial area of Maseru and Maputsoe metropolitan area.

Water is a shared resource with multiple functions, uses, and merits (Ballester and Mott Lacroix, 2016). It is of course central to all economic activity and essential for human life hence it is a national priority. It is thus important to ensure that water resources management supports the provision of water services, potable water and safe sanitation to all people and is the key medium that links global warming to changes in human and physical systems (Buang *et al*., 2014). Hence, water needs to be secured to sustain biodiversity and natural ecosystems, including wetlands, which are the basis for rural livelihoods and for tourism (SADAC, 2006). Water resources assessment (WRA) focuses on measuring, collecting and analyzing relevant parameters on the quantity and quality of water resources for the purposes of a better development and management of water resources. WRA tools aim at evaluating water resources in relation to a reference frame, or evaluate the dynamics of the water resource in relation to human impacts or demand (WMO, 2012) at catchment or sub-catchment level and relies on a full understanding of water flows and storages in the unit under consideration (GWP 2013).

It is thus imperative to study and analyze the relationship between the state of water resources, the anthropogenic and environmental pressures impacting on the water resources, the driving forces for the various environmental degradation vectors on water resources, the impacts on ecosystem services and on people's livelihood and the possible responses from land users, policy makers and other stakeholders using people's perceptions as an assessment lens (Noga *et al*., 2013). The LADA Local assessment methodology aims to deliver an understanding, not only of the state and nature of change in the land resources (soil, water and biological resources) and ecosystems, but also of the drivers of and impacts of land degradation and sustainable land management, the impacts they have on ecosystem services and livelihoods, also the effects of recent response measures adopted by land users and other actors. The purpose of the study is, therefore to determine people's perception on water resources degradation and their management using LADA methodologies.

## MATERIALS AND METHODS

**Location:** The study was located in the Mphosong-Bolahla catchment from the confluence of Bolahla and Mphosong River to the northeastern escarpment (Fig. 1) in the foothills of the Leribe district. The overall catchment was divided into three sub-catchments of Bolahla (18.0 ha), Senyokotho (10.4 ha) and Mphosong (14.2 ha) for a total area of approximately 42.6 ha in size.

**Climate and Biophysical Characteristics of the Study Site:** The Mphosong-Bolahla catchment is located in the foothills of the northern district of Lesotho between 1,840 m and 3,090 m above sea level. The lowest average minimum monthly temperature in Lesotho was recorded in July (-0.3$^0$ C) and the highest in January (13.4$^0$ C). The lowest temperature range (-1.09 to 14.83$^0$C) was recorded in June (BOS 2017). The amount of rainfall in Lesotho has been increasing throughout the years, where the highest increase was observed from 2009 (762 mm) to 2010 (865 mm) constituting 13.5 percent. However, since 2012, the district has experienced a sudden decrease of 35.0 percent of the average national annual rainfall (BOS, 2014) leading to minimum annual rainfall of 516 mm while the maximum rainfall was 785 mm in 2012.

Farmers in the area mainly practice subsistence mixed farming of livestock (cattle, horses, sheep and goats) and field crops (maize, beans, wheat and sorghum) with a variety of vegetables and fruit trees (mainly peaches) in the fields and backyard gardens of the homesteads. Leribe is a prime agricultural land with high production except in drought years e.g. 2015/16 cropping season when farmers experienced high crop failures and most of their lands fallow due to drought (BOS 2017). For instance in the 2016/2017 growing season, the planted area of maize was 33, 629 ha and beans in an area of 5,790 ha far higher than other districts. Some cottage industries of dried fruits are practiced by women in the study area and a bakery at Ha Senyokotho village. The geomorphologic character of the landscape is characterized by dendritic drainage pattern with three main streams draining the whole catchment and converging into the Mphosong River. Thus the natural water resources like wells springs and wetlands are distributed within the catchment.

**Characterization of Study Area:** The key stakeholders, relevant projects and NGOs operating in the area were identified and documented in terms of their operational interventions and role in the local watershed management. Thereafter, a reconnaissance field visit with selected land users was conducted. This was done to help the team familiarize themselves with the study area, land uses and the extent and severity of degradation.

**Community Focus Group Discussions (FGD):** Community FGDs were conducted in all three sub catchments with average attendance of 20 community elders selected on the basis of their knowledge of the village territory, history and land uses, especially water resources in the catchment. The groups were composed of land users, local authorities (village chiefs and members of community council) and various working professionals (teachers, retired civil servants), community based organizations and community task teams (e.g. water committee). Land users, key stakeholders and local people walked systematically along a defined transect across the project area to explore the water resources in an area, by visual observation, asking and listening. That is where the resources to be assessed fully were marked on the map. The assessment was conducted during key informant interviews and field measurements respectively.

**Key Informant Interviews:** A structured open ended questionnaire was administered to select key informants and land users who are knowledgeable of the study area. Based on consultations with the local authorities in each catchment the sample size of key informants in the sub-catchment were determined using the Slovin's formula1960:

$n = \frac{N}{1+e^2}$ where n = sample size, N = the number of key informants and "e" = error margin

A minimum of five key informants were interviewed per village with each sub-catchment. Overall 78 land users were interviewed across three (3) sub catchments of Bolahla (27), Ha Senyokotho (26) and Mphosong (25) respectively. The purpose of the interviews was to verify the discussion done during the focus group discussions. The interview focused on changes in water resources quality, quantity, and availability and sought to reflect the status and trends (S) of the water resources in terms of water quality, quantity and the hydrological regime, change in demand or pressures on water resources (P) and related drivers (D), the impacts (I) of changes in water quality and availability on productivity, livelihoods and the environment, some actual and possible policy or management responses (R) to conserve and / or manage water resources.

## RESULTS AND DISCUSSION

**Water Supply Assessment at Community Level:** The water resources found in the area included wells and springs, wetlands, rivers, reservoirs and taps. However, the majority of households rely mostly on wells and rivers for livestock watering and potted water especially in the Mphosong sub catchment. The water supply situation in the study area is below national benchmarks. For instance, national statistics indicate that 58.0 percent of urban households and 65.4 percent of peri-urban households have access to potable water supply in the homestead as the source of drinking water. In contrast, 55.5 percent in rural communities use public tap/standpipe as the main source of drinking water (BOS, 2018). Thus, overall, about a third (35.3%) of the households in Lesotho used public tap/standpipe as their main source of drinking water compared to only 27.5 percent who use private portable water source within the homesteads. Thus the analysis of water supply situation in the study area is corroborated by national statistics (BOS 2018) because few people in this rural study areas have access to piped water. The study found that the main source of water for domestic and livestock in Mphosong-Bolahla catchment is wells, springs, wetlands and community reservoirs.

**Community Assessment of Water Resources Degradation:** Analysis of the land users' perception on degrading and managing the water resources was analyzed to reveal the water supply situation in the study area.

**People's Perceptions on Water Accessibility:** For purposes of this study, accessibility measures the perception of people on the ease with which they can reach the water sources assessed in terms of remoteness of the area or proximity to the village. Respondents were thus asked to evaluate the accessibility of water supply in their jurisdiction relative to the previous 10 years in terms of the perceived changes in accessibility based on their perception of changes in distances travelled to reach water resources compared to the previous 10 years. Thus affirmative (yes) response means that people are still able to reach water sources or in the case of changing distance they perceive a change in the distance travelled to reach present day water sources (Fig. 2). Both accessibility and quality are assumed to be an indicator of changes in distance to water sources due to, among other factors, climate change induced drought effects or impacts of pollution on water quality.

Community perceptions on the accessibility of water resources varied across the sub-catchments. A greater proportion of households (78, 76 and 62 percent in Bolahla, Mphosong and Senyokotho respectively) reported that water sources were accessible. However, overall the results show a concern that distances to the water sources are getting longer (Senyokotho = 68 percent; Mphosong = 60 percent) with the exception of Bolahla where a majority of the respondents (78%) did not perceive any change (Fig. 2). In effect, the key informants revealed that the water sources within the catchment stood the test of the 2015 drought such that people from other sub-catchments would come to Bolahla to fetch water. This case of Bolahla notwithstanding the results show that there is a growing concern *albeit* some exceptions, that people now travel longer distances to reach water sources compared to the reference period. Key informant sources also observed that even the public standpipes run out of water more frequently now compared to the previous 10 years.

This emergent situation was attributed to lowering of water tables due to the increasing frequency and intensity of drought episodes. Other studies (Alsdorf *et al*., 2007, Tulbure and Broich, 2013, Zou *et al*., 2017) also confirm the direct relationship between surface water discharges, fluctuation of water tables and precipitation. This study also revealed increased awareness of climate change impacts on water sources in terms of the intensity and frequency of climate change induced drought referenced against the memories of 2015 growing season.

The perception of increasing distances to water sources was also linked to climate change. This notion is also corroborated by other studies which indicate that climate change and increased climate variability strongly impact surface water resources directly (Aherne *et al*., 2006, Ferguson and Maxwell, 2012, Tulbure *et al*., 2016; Poudel *et al*., 2017). Moreover, land users mentioned that when it was extremely hot, some of the water resources are negatively affected. This is attributed to evapotranspiration because high temperatures tend to increase evaporation of water creating longer drought spells which in turn reduce water volume and the extent of water bodies. Other studies (Haryani 2016; Zou *et al*., 2017) also found that temperature had statistically significant negative effects on the annual average water body area, year-long water body area and number. The observations in the study area are also consistent with the findings of other researchers in Lesotho (Rocchi *et al*., 2016) and elsewhere (Appelgren, 1996) in terms of uneven distribution of water under changing climate regimes.

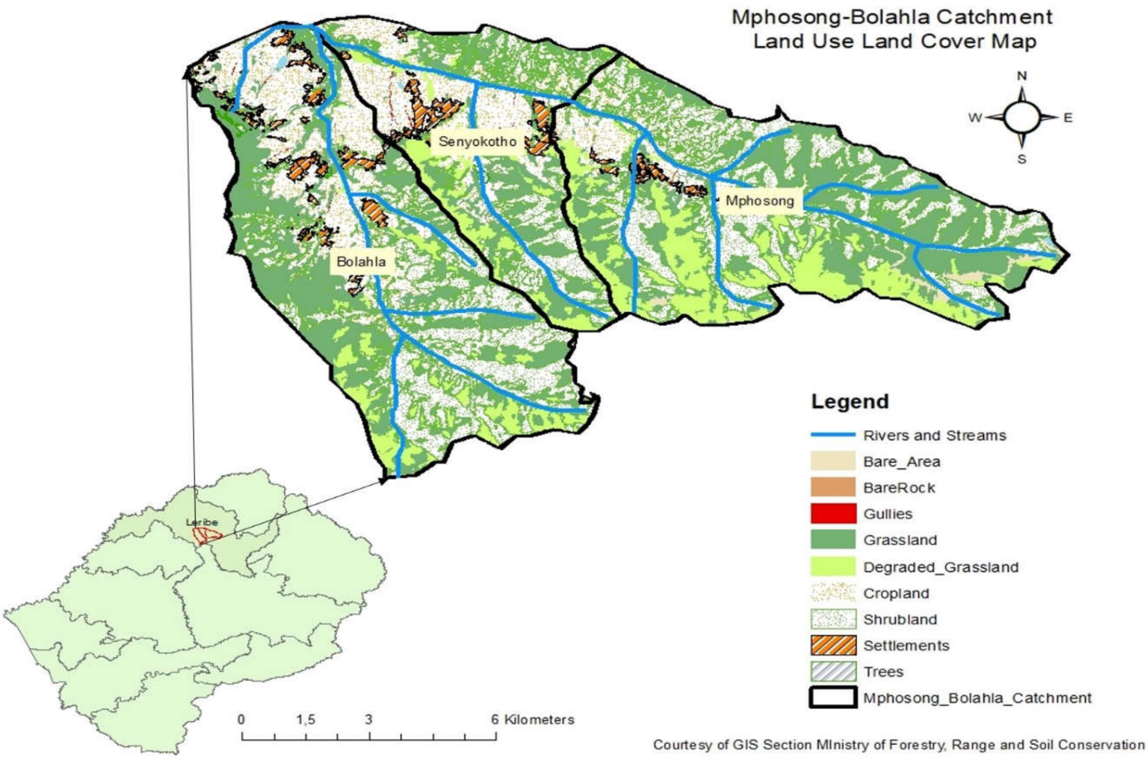


**Fig 1.Map of Bolahla-Mphosong catchment**

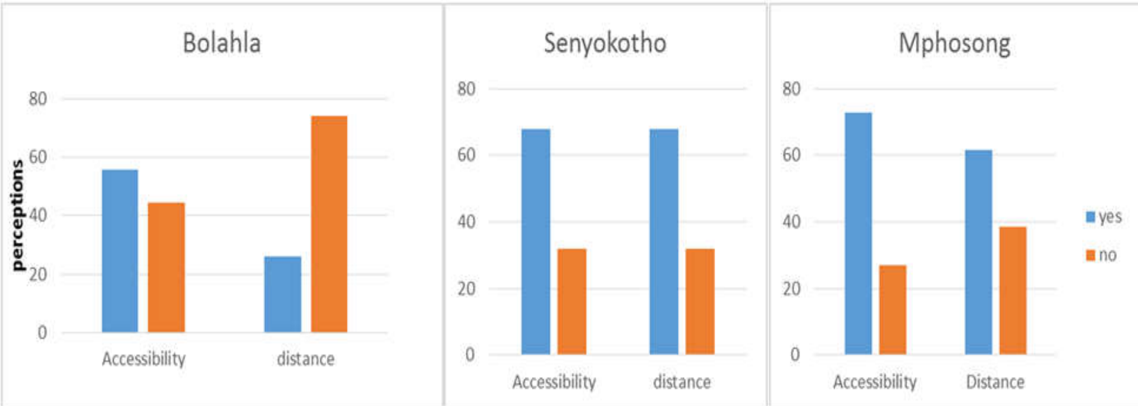


**Fig. 2. Perceptions on accessibility and Distance to Water Sources**

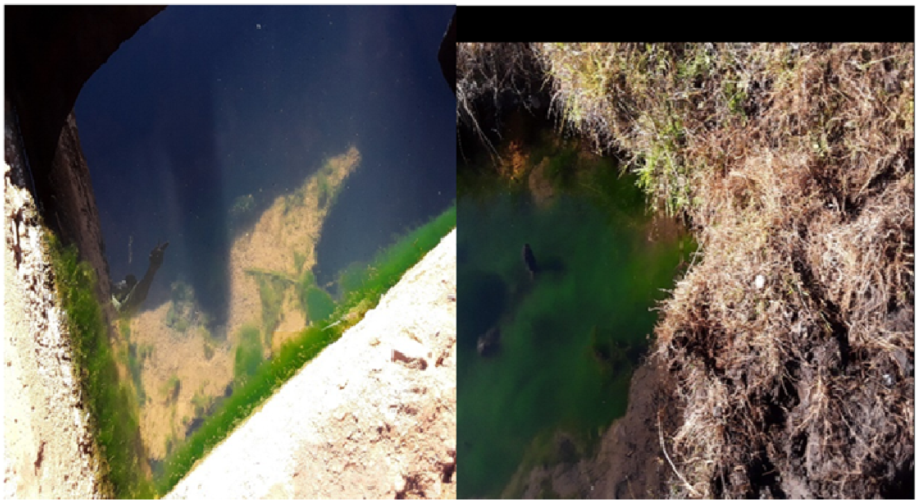

**Fig. 3. Algal growth in two community wells at Ha Mahloane (Left) and at Ha Nkoane (Right)**

Fig. 4. Sedimentation in a community reservoir at Ha Mahloane, Bolahla

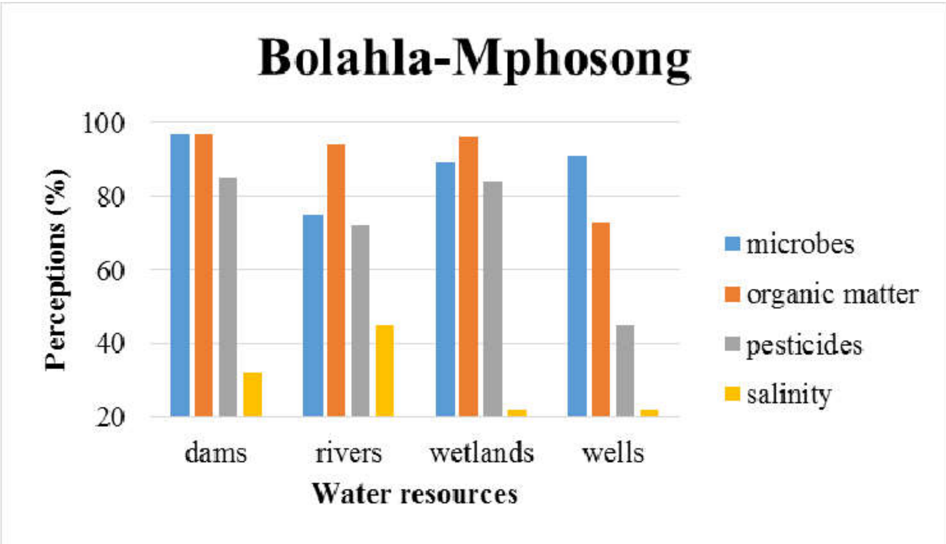


Fig. 5. Perceptions of changes in water quality

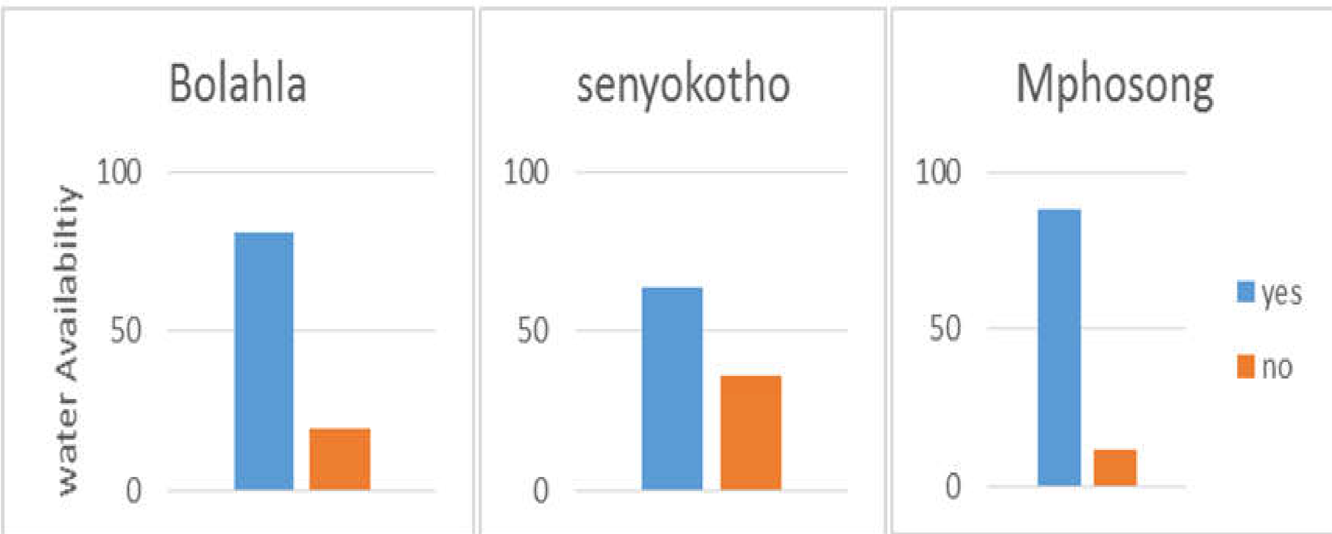


Fig. 6. Perception of water availability

**Table 1.Water quality changes in water resources**

| | Sub-Catchment | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bolahla | | | | Senyokotho | | | | Mphosong | | | |
| Factors | Dams | Rivers | Wetlands | Wells | Dams | Rivers | Wetlands | Wells | Dam | Rivers | Wetlands | Wells |
| Pathogens | + | + | + | + | + | + | + | + | + | + | + | + |
| Organic Matter | + | + | + | + | + | + | + | + | + | + | + | + |
| Pesticides | + | + | + | + | + | + | + | + | + | - | + | - |
| Salinity | C | - | + | C | - | - | + | - | - | - | C | - |

Legend: Increasing (+); Decreasing (-); Remaining constant (C)

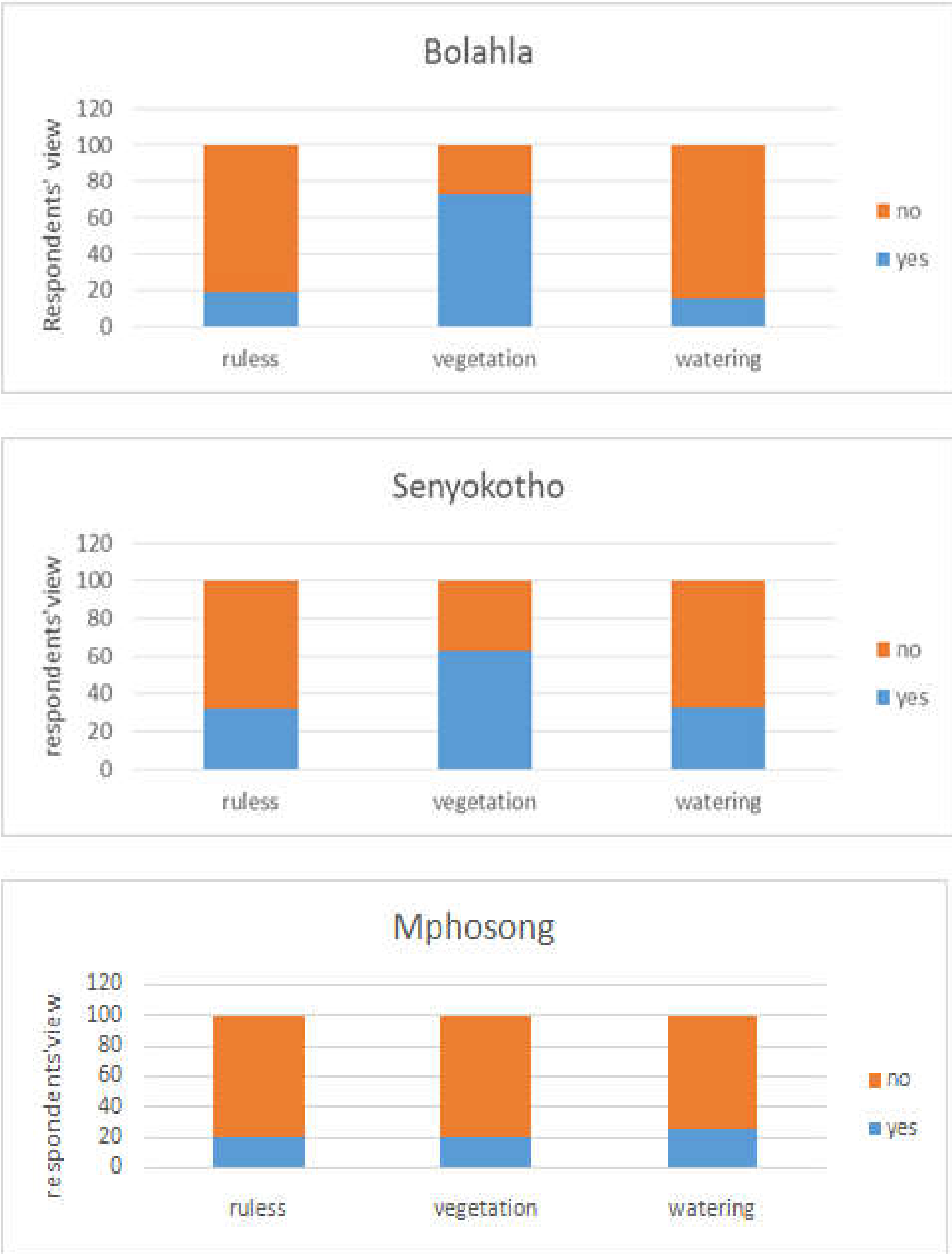


**Fig. 7. People's perception on the management and usage of Livestock watering areas**

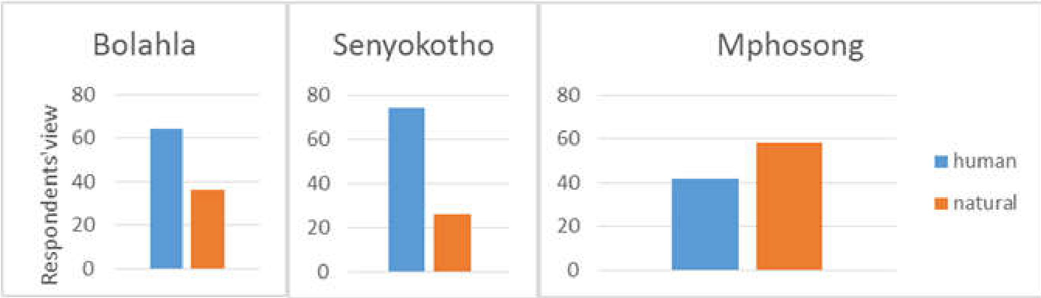


Fig. 8. Human or natural caused wetland degradation

Fig. 9. Observed wetland degradation at Ha Mahloane (left) and at ha Nkoane (right)

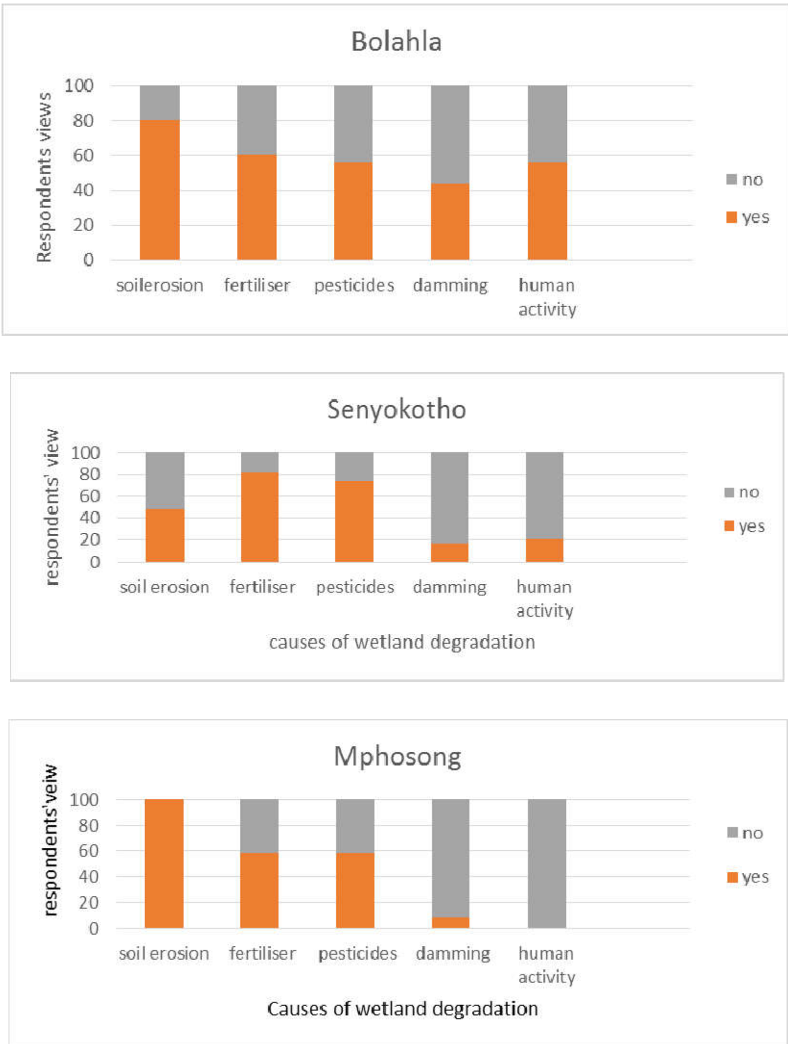


Fig. 10. Causes of wetland degradation

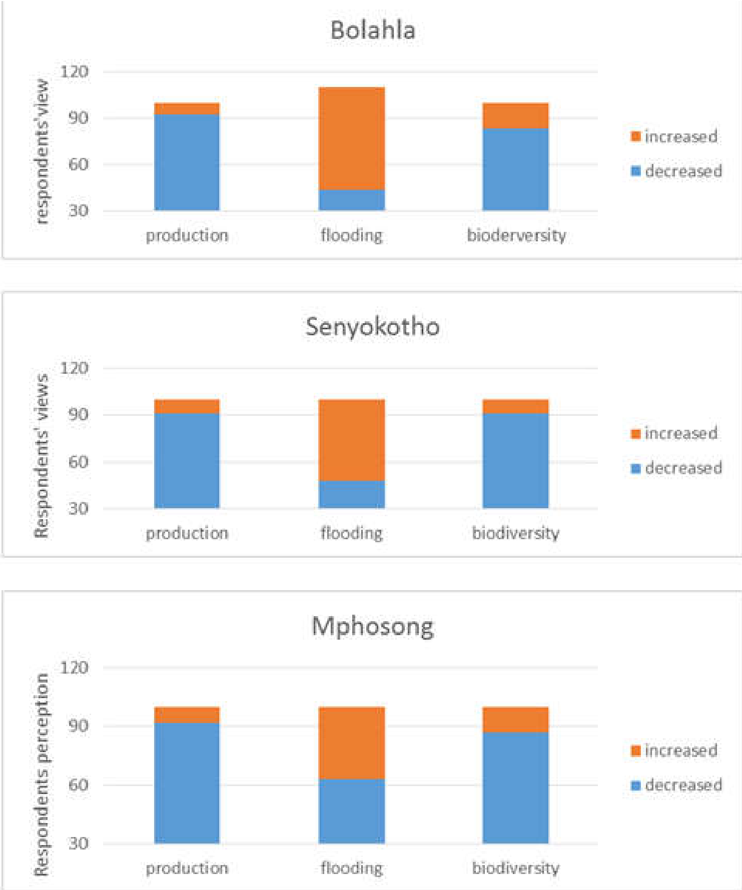


**Fig. 11. Community perceptions of wetland status in the study area**

**Community Perceptions on Water Resources Degradation:** In order to assess the extent and severity to which water resources have been degraded and the resultant impact on water quality, various water sources were discussed to assess the direction of change over the last 10 years. Land users were also asked to assess the availability of water in the catchment area in order to make a qualitative assessment of the degree of water resources degradation focusing on the causes and changes in water quality and availability. In addition, people were asked to describe the signs and causes of water quality degradation. They were able to differentiate fresh clean water from potentially polluted water. According to the informants free flowing water is clean, fresh and free of pathogens or insects and pathogenic microorganisms. Polluted water was characterized as stagnant, containing waste material and infested by insects. The presence of algal growth in the fresh water was also associated with degradation of water resources especially in the domestic water springs and streams below the homesteads or croplands (Fig. 3).

Decline in water quality and symptoms therein were generally acknowledged across the study catchment. For example, at Ha Senyokotho, a majority of respondents (80%) reported presence of polluted water bodies, streams and small reservoirs while in the Bolahla sub-catchment, water pollutions was associated with high deposits of organic matter in reservoirs by a significant majority of respondents (84%). A similar proportion of respondents (85%) in the Bolahla sub-catchment reported other algal growth which they associated with agrochemical pollutants from the croplands. Siltation of community reservoirs used for livestock watering and small irrigation activities was also recognized as a cause of the degradation of water resources (Fig. 4).

These community observations are corroborated by other studies (Alam et al., 2018) that water environment in the rural water bodies generally fluctuates both seasonally and diurnally leading to seasonal variations in pollution levels. In similar studies, human interference in water bodies is also reported as a cause of change in the functioning of most of fragile ecosystems (Wanganeo et al., 2018). As such, sediment contamination cause the impairment to water bodies because suspended sediment directly impact aquatic organisms and increases the cost of water treatment in stream channels and reservoirs (Ayandiran et al., 2018). This was the case with Ha Mahloane community reservoir (Fig. 4) where the community was expected to dredge the sediments in the dam. However they could not manage due to high sediment load and laborious nature of work. Communities at Mphosong associated pollution with high organic matter buildup and this is substantiated by research observations that surface water and sediments were grossly polluted by organics and heavy metals (Ayandiran *et al*., 2018). The presence of pollutants especially organics, algal growth in stagnant waters and insects in the water are associated poor water quality and presence of pathogens and /or pathogenic conditions in the water especially in the springs (Fig. 5). During the transect walk with informants, only visual observations were made and we did not sample the types of pathogens to determine whether they are pollution tolerant or sensitive since every microbe plays a different roles in water (Li *et al*.,2017). For example, Aquatic protozoa are important energy transfer mediators from Nano-planktonic to higher trophic levels in an ecosystem such as a wetland. Mainly protozoans (ciliates and flagellates) and algae were located in the water resources.

Therefore, this study is corroborated by other findings that the protozoans (Flagellates and ciliates) were dominating especially in the wells (Li *et al*., 2017). The protozoa are sensitive to living environment and are rapidly responsive to environmental changes. They have been used as indicators for water quality and the health status of an aquatic ecosystem. Most of the wells and wetlands were situated down slope of the cropping lands creating the probability that these could be polluted with agrochemicals from runoff water flowing into the water sources. Looking at the foothills, the area is steep hence during heavy rainfall agrochemical are washed off by sheet erosion and surface runoff and pollute the environment. Cropping management in the study area involves use of compound nitrogen (N), phosphorus (P) and potassium (K) fertilizers. Thus unknown amounts of N, given its high leaching potential and mobility (Souza *et al*., 2018) are washed into downslope water bodies and streams with a high potential to cause eutrophication. In addition, P also can be lost in runoff water to aquatic ecosystems where it can contribute to algal blooms and thereby degrade water quality (Savci, 2012; Nash *et al*., 2015). Although we could not quantify the use of fertilizers in the study area beyond the qualitative estimates by informants, the use of fertilizer is reportedly high in the Leribe district (BOS, 2017).

Therefore, due to the type of fertilizers used and the location of the study site, most water resources would be prone to agrochemical pollutants (pesticides and fertilizer) due to high runoff rates. The respondents in both the FGDs and key informant interviews were asked to estimate the trends of different pollutants into different water sources in each sub-catchment (Table 1). The perceptions of the community are that water quality decreased in the various water sources with a few exceptions in the salinity which declined in other water sources and was constant in others (Table 1). The overall results shows that the indicators of water quality are indicative of degrading water resources. Salinity declined in most water resources especially in the rivers. This might be because of the rainfall that the signs of salinity (whitish deposit) around the river had been washed away. This was even recognized through visual observations with the key informants. There is a definite decline in perceived water quality in the catchment to the buildup of pollutants in water resources. These results are in conformity with studies which also found that water quality deteriorated over time with increase in nutrients loading and ***E. coli*** entering water bodies (Namugize *et al*., 2018).

**Community Perceptions on Water Availability:** For purposes of this study, water availability refers to the quantity of water to be obtained or used in the study area. Despite the declining trends of water quality factors, there is a definite perception that water is available to meet domestic use in the study catchment (Fig. 6). There was an overall perception that water was available across the catchment. However, the strongest perception of water availability was recorded at Mphosong and Bolahla sub-catchments with over 80 percent of the respondents indicating good availability of water. The highest perception of limited water supply was recorded at Senyokotho sub-catchment where only 60 percent of the respondents indicating that water was not available. However, in Lesotho the water availability is seasonal with the rainy season starting from October to February after which the surface water resources availability declines towards the winter (Maliehe *et al*., 2017). This is normally true in lowlands only because in the foothills and mountains the water availability remains high even in winter due to precipitation in the form of snow.

**Community Perceptions of the Grazing Gradients from Water Resources:** For assessing the extent and severity of grazing gradients (systematic change in vegetation cover) in watering points, the respondents were asked to give information on the rules regarding livestock control, change in vegetation cover, soil and water conservation measures around the watering points and the effectiveness of those measures. There were no rules in controlling livestock watering in all sub-catchments. However, there was observable changes in vegetation cover except in the Mphosong sub-catchment where the vegetation around the water resources had not degraded. There were forests and bushes around them and there are no soil and water conservation measures around the watering points (Fig. 7).

The respondents in the study area kept more than one livestock species consisting of goats which are mainly browsers and sheep and cattle which are mainly grazers. The rivers and streams were found to be the place where livestock drink and the vegetation around the area had changed i.e. the vegetation cover around the water source was degraded due to regular animal trampling. High intensity of trampling along the routes deteriorates soil organic matter and porosity, thus decreases soil stability and thereby increases runoff and sediment production (Stavi *et al*., 2008, Stavi *et al*., 2011, Sarah and Zonana, 2015). Land Use and Land Cover (LULC) changes affect geomorphology, soil properties, hydrological processes and water quality at global, regional and local scales (Bowden *et al* 2015; Wan *et al*., 2014) as well as the ecological integrity of aquatic ecosystems (Miserendino *et al*., 2011). Therefore the results in Mphosong sub-catchment on the vegetation cover around the watering points was found to be in agreement with Namugize *et al*., (2018) who reported that vegetation has greatly changed in Umngeli catchment in South Africa due to clearing of natural vegetation and that trampling of the routes by flocks of sheep and goats affects the redistribution of water and, consequently, shrub size (Sarah *et al*., 2018).

Perceptions on Degradation and Management of Wetland: *To assess degradation and management of wetlands, the key informants were asked to give information on the main type of wetland degradation, productivity, downstream flooding and biodiversity in the wetland and their responses were analyzed (Fig.* ***8****).* Then, the main cause of degradation in wetlands was found to be anthropogenic activities with the exception of Mphosong sub-catchment where respondents claimed that the quality of wetlands is a function of precipitation and now that the precipitation was scarce they said the wetlands had degraded. They believed that humans had no power on wetlands, one key informants showed that back in their youth, they used wetlands as an indicator of coming rainfall, the wetlands would be wet on the surface but nowadays *"lefatše le tsofetse"* i.e. the land is old hence its productivity has declined hence why the natural factors appeared to be the main cause of wetlands degradation. The overall assessment of communities on degradation of wetlands as a combination of human and natural factors is supported by the research observations that wetland degradation is caused by both natural stressors and human activities (Wang *et al*., 2012).

According to the respondents the main reason for the degradation was anthropogenic activity especially agriculture.

The results in this catchment align with other research works (Wang *et al*., 2012; Jiang *et al*., 2015) indicating that that increased urbanization, infrastructure and agricultural activities are the reasons for wetland degradation (Fig. 9) which shows animal trampling and animal route especially at Ha Nkoane cutting across the middle of wetland. In contrast, respondents in the third sub catchment believed that natural threats were the main cause of wetland degradation. For instance, climate strongly affects the change of wetlands, mainly through the change of air temperature and precipitation. Other researchers (Melly *et al*., 2017) also found that precipitation and wetlands area have a positive correlation. That is, precipitation turns to increase the water content of soil and expand the area of the wetlands. The respondents were also asked to rank the other causes of wetland degradation. Soil erosion was thought to be the leading cause of wetland degradation especially in Bolahla and Mphosong sub catchments while agrochemical pollution resulting from sheet erosion and runoff was ranked high in the Senyokotho sub-catchment. Therefore, soil erosion was regarded as the main cause of wetland degradation in the whole catchment followed by agrochemical pollution and lastly human activities in the proximity of the wetlands (Fig. 10).

Soil erosion was found to be the main cause of wetland degradation and this was attributed to overgrazing and livestock trampling resulting in the degradation of vegetation leading to high rates of soil erosion. Other community opinions also attributed the spade of wetlands degradation in the catchment to lack of awareness on wetlands' protection. These findings align with the other studies (Meng *et al*., 2017) that due to the lack of awareness of wetland protection and the rapid economic development and urbanization, wetlands have been destroyed. Businge (2017) also found that wetland degradation in western Uganda may also be influenced by other factors including poverty, population increase, and institutional failure. The wetlands were regarded as the free land in the study area as said by the key informants and the findings of this study are consistent with Businge ( 2017) who also observed that most people regarded the wetlands as an open commons. Thus the productivity of wetlands decreased significantly in all sub- catchments while flooding downstream increased in the Bolahla and Senyokotho sub-catchment but decreased in the Mphosong sub-catchment. In addition, biodiversity has decreased in all the wetlands (Fig. 11). The most common drivers of wetland degradation such as draining, overexploitation, burning and conversion to other land uses are corroborated by other studies in Uganda (Namaalwa *et al*., 2013, Bosma *et al*., 2017).

In this study, biodiversity in the wetlands was found to have decreased. In similar studies (Matšela *et al*., 2015; Jiang *et al*., 2017) it was observed that wetland degradation caused reduction of wetland area, water pollution, environmental degradation, and biodiversity loss among other issues.

**Conclusion**

The water resources that were found in the catchment were the rivers, wetlands, wells, springs and small community reservoirs. These water resources were found to be evenly distributed in the catchment. Drinking water for domestic purposes was mostly sourced from the wells and springs while for livestock watering communities resorted to rivers and sometimes community reservoirs. In general, the proximal areas to the watering points were found to be degraded and devoid of vegetation but the quality of vegetation increased with distance from the watering points into the distal rangeland. While overall assessment indicates availability and accessible water to meet demands for domestic and livestock requirements, the water resources are gradually but increasingly invaded by pollution mainly due to anthropogenic activities. In fact, the main cause of degradation in the wetlands was attributed to human activities which cause soil erosion and pollution of water bodies and wetlands by agrochemicals. The perfect example is the reservoir at Phororong River where the wetland in that area vanished as community people constructed the dam besides the wetlands. As a results of wetland degradation, the production capacity of wetlands was poor, the flooding was found to be high and the biodiversity declining or outright lost.

There is urgent need to raise awareness in the communities across the Mphosong-Bolahla catchment area on the importance of conservation and sustainable use of natural resources in their area. In the light of climate change pressures and shocks on water resources, it is imperative to build capacity of communities for water harvesting, conservation and efficient use. While agrochemical pollution is perhaps not a very significant problem as yet, it is likely to grow with time as communities adopt a variety of agrochemical uses such as herbicides and increased fertilizer use. Thus conservation agriculture is recommended as a major strategy to deal with high rates of runoff and erosion of top soil leading to land degradation, siltation of reservoirs and water ways, and pollution of water bodies by agrochemicals, domestic chemicals such as laundry detergents and poor waste management. Finally the organizations working in the catchment need to work together with the farmers in mitigating water resources degradation.

**Acknowledgement**

This research project was sponsored by The Food and Agriculture Organization of the United Nations and the Ministry of Forestry, Range and Soil conservation in Lesotho under the auspices of project: TF.FRLES.TF5G110015355.

## REFERENCES

Alam, A. H. M. B., Unami, K., and Fujihara, M. 2018. Holistic water quality dynamics in rural artificial shallow water bodies. Journal of environmental management, 223, 676-684.

Alsdorf, D.E., Rodriguez, E., Lettenmaier, D.P., 2007. Measuring surface water from space. Rev. Geophys. 45 (2):1-24http://dx.doi.org/10.1029/2006RG000197

Appelgren, B. 1996. A management approach to national water scarcity; water policy. Proceedings of the International Conference. Cranfield University

AWRA 2012, Case studying integrated water Resources management: from Local stewardship to national Vision

Ayandiran, T. A., Fawole, O. O., and Dahunsi, S. O. 2018. Water quality assessment of Bitumen polluted Oluwa River, South-Western Nigeria. Water Resources and Industry, 19, 13-24

Ballester and Mott Lacroix, 2016.A. Ballester, K.E. Mott Lacroix Public participation in water planning in the Ebro River Basin (Spain) and Tucson Basin (US, Arizona):

impact on water policy and adaptive capacity building Water, 8 (2016), p. 273

Borja, Á. I., Galparsoro, O., Solaun, I., Muxika, E. M., Tello, A., Uriarte, and Valencia, V. 2006. The European Water Framework Directive and the DPSIR, a methodological approach to assess the risk of failing to achieve good ecological status. Estuarine, Coastal and Shelf Science, 66(1), 84-96

BOS, 2014, 2013 Energy, Air and Climate Change Report. Lesotho

BOS, 2017, 2016/2017 Agricultural Production survey Crops. Lesotho

BOS, 2018, 2016 Environment Report. Lesotho

Bosma C. K., Glenk, and Novo P 2017. How do individuals and groups perceive wetland functioning? Fuzzy cognitive mapping of wetland perceptions in Uganda. Land Use Policy 60, 181-196

Buang A. 2014, women and liveability- best practices of empowerment from Lesotho

Burrow C. 1991. Land degradation: breakdown of terrestrial environments. New York: Cambridge University press

Businge Z. 2017. Drivers of wetland degradation in western Uganda and Iceland, and how they are addressed in current policies and legal frameworks, Kigumba-Kiryandongo, Uganda

Cerretelli, S. L., Poggio, A., Gimona, G., Yakob, S., Boke, M., Habte, and Black, H. 2018. Spatial assessment of land degradation through key ecosystem services: The role of globally available data. Science of the Total Environment, 628, 539-555

FAO 2016, Land degradation assessment in dry lands, Rome

Garda, C. H., Castleden, and Conrad, C. 2017. Monitoring, Restoration, and Source Water Protection: Canadian Community-Based Environmental Organizations' Efforts towards Improving Aquatic Ecosystem Health. Water, 9(3), 212.

Gibbs, A., and Tim, G. 2002. A water supply and pollution crisis in Lesotho' Textile factories: the problem of footloose investment.

Global water Partnership (GWP). 2013. Support to Global Water Partnership – Water and Drought Management. Department for Green Growth, GRV – Ministry of Foreign Affairs, Copenhagen

Hoekstra, A. Y. 2016. A critique on the water-scarcity weighted water footprint in LCA. Ecological indicators, 66, 564-573

Jiang, L. K., Nielsen, O. B., Andersen, and Bauer-Gottwein, P. 2017. CryoSat-2 radar altimetry for monitoring freshwater resources of China. Remote Sensing of Environment, 200, 125-139.

Jiang, W. J., Lv, C., Wang, Chen, Z., and Liu, Y. 2017. Marsh wetland degradation risk assessment and change analysis: A case study in the Zoige Plateau, China. Ecological Indicators, 82, 316-326.

Majara N. 2005. Land degradation in Lesotho, University of Stellenbosch

Maliehe, M., and Mulungu, D. M. 2017. Assessment of water availability for competing uses using SWAT and WEAP in South Phuthiatsana catchment, Lesotho. Physics and Chemistry of the Earth, Parts A/B/C, 100, 305-316

Meng, W. M., He, B., Hu, X., Mo, H., Li, B., Liu, and Wang, Z. 2017. Status of wetlands in China: A review of extent, degradation, issues and recommendations for improvement. Ocean and Coastal Management, 146, 50-M.L.

Miserendino M.L. R., Casaux, M., Archangelsky, C.Y., Di rinzio, C. Brand, A.M. Kutschker. 2011. Assessing land-use effects on water quality, in-stream habitat, riparian ecosystems and biodiversity in Patagonian northwest streams Sci. Total Environ., 409 (3) (2011), pp. 612-624

Namaalwa, S. A., Funk, G. S., Ajie, and Kaggwa, R. C. 2013. A characterization of the drivers, pressures, ecosystem functions and services of Namatala wetland, Uganda. Environmental science and policy, 34, 44-57

Namugize, J. N. G., Jewitt, and Graham, M. 2018. Effects of land use and land cover changes on water quality in the uMngeni river catchment, South Africa. Physics and Chemistry of the Earth, Parts A/B/C

Nash, D. M., Watkins, M., Heaven, M. W., Hannah, M., Robertson, F., and McDowell, R. 2015. Effects of cultivation on soil and soil water under different fertilizer regimes. Soil and Tillage Research, 145, 37-46.

Ngoma, D. H., and Wang, Y. 2018. Hhaynu micro hydropower scheme: mbulu–tanzania Comparative River Flow Velocity and Discharge Measurement Methods. Flow Measurement and Instrumentation.

Noga, J., and Wolbring, G. 2013. Perceptions of water ownership, water management, and the responsibility of providing clean water. Water, 5(4), 1865-1889

Peters, N. E., and Meybeck, M. 2000. Water quality degradation effects on freshwater availability: impacts of human activities. Water International, 25(2), 185-193

Rocchi A., Pietro, D. 2016, Lesotho: rural development and migration

SADAC, 2006, Regional water policy. South African Development community, Infrastructure and service Directorate, SADAC secretariat: Gaborone

Sarah, P. E., Sachs, H., Zhevelev, A. G., Fragin, and Shaked-Weiss, A. 2018. Trampling routes modified size distribution of Sarcopoterium spinosum in semiarid rangelands. CATENA, 160, 90-94

Sarah, P., and Zonana, M. 2015. Livestock redistribute runoff and sediments in semi-arid rangeland areas. Solid Earth, 6(2), 433-443

Savci, S. 2012. Investigation of effect of chemical fertilizers on environment. Apcbee Procedia, 1, 287-292

Stavi, I. E. D., Ungar, H., Lavee, and Sarah, P. 2011. Soil aggregate fraction 1–5 mm: an indicator for soil quality in rangelands. Journal of Arid Environments, 75(11), 1050-1055

Stavi, I. E. D., Ungar, H., Lavee, and Sarah, P. 2008. Grazing-induced spatial variability of soil bulk density and content of moisture, organic carbon and calcium carbonate in a semi-arid rangeland. Catena, 75(3), 288-296.

Tulbure, M.G. M., Broich, 2013. Spatiotemporal dynamic of surface water bodies using Landsat time-series data from 1999 to 2011. ISPRS J. Photogramm. Remote Sens. 79:44–52. http://dx.doi.org/10.1016/j.isprsjprs.2013.01.010.

Tulbure, M.G. M., Broich, S.V., Stehman, Kommareddy, A., 2016. Surface water extent dynamics from three decades of seasonally continuous Landsat time series at subcontinental scale in a semi-arid region. Remote Sens. Environ. 178:142–157. http://dx.doi.org/10.1016/j.rse.2016.02.034

Wan, R., S., Cai, H., Li, G., Yang, Li, Z., and Nie, X. (2014). Inferring land use and land cover impact on stream water quality using a Bayesian hierarchical modeling approach in the Xitiaoxi River Watershed, China. Journal of environmental management, 133, 1-11

Wang, M., S., Qi, and Zhang, X. 2012. Wetland loss and degradation in the Yellow River Delta, Shandong Province of China. Environmental Earth Sciences, 67(1), 185-188

Wanganeo, A. R. R. N. R. K. N., Wanganeo, Srivastava, and Kumar, P. 2018. Variations in physico-chemical characteristics of water bodies placed at different geographical coordinates in Antarctica. Polar Science

World Meteorological Organization (WMO), 2012, Technical material for water resources assessment

Zou, Z. J., Dong, M. A., Menarguez, Xiao, X., Qin, Y., Doughty, R. B., and Hambright, K. D. (2017). Continued decrease of open surface water body area in Oklahoma during 1984–2015. Science of the Total Environment, 595, 451-460

*******