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Social Perspectives on the Effects of Buffer Zone Anthropogenic Activities on Mashili Reservoir of Shibuyunji District, Central Province, Zambia

Monde Hamatuli[1], Manoah Muchanga[2]

[1]*Forestry Department Kafue, Zambia,*
[2]*University of Zambia, Environmental Education and Management*

Corresponding Author: *Monde Hamatuli, *Forestry Department Kafue, Zambia;*

Email: mondemwale@gmail.com

Abstract: *Buffer zone anthropogenic activities reduce the quality of the environment and threaten the sustainability of water resources. This is because anthropogenic activities tend to alter the aquatic ecosystem and change its ability to offer valuable ecosystem goods and services. The core purpose of this study was to examine the effects of buffer zone anthropogenic activities on Mashili Reservoir in order to establish possible intervention to reduce the effects. The specific objectives were to: investigate the specific buffer zone anthropogenic activities within the catchment; assess impact of buffer zone anthropogenic activities on Mashili reservoir and; explore the possible intervention measures. The research approach adopted in this study was qualitative in nature specifically a single case study research design. Structured interviews and observation methods were used to collect data. The data was analyzed using thematic analysis approach and the data quality control and trustworthiness involved the use of between method data triangulation in order to validate the findings. The study noted that there was lack of awareness on environmental protection of buffer zone resulting into loss of storage capacity for the reservoir, reduced water quality and quantity. The principal buffer zone anthropogenic activities were, deforestation, gardening, brick molding, among others. These accelerated sediment generation, transportation and siltation into the reservoir. The study concluded that, indeed human activities within the buffer zone of the reservoir are detrimental to sustainability of water resources in the reservoir and eventually affect aquatic biodiversity and hits back on the people who cause them. Such anthropogenic activities were due to inadequate environmental and water education among residents and also lack of alternative means of livelihood.*

Keywords: *Social Hydrology, Sediment, Sedimentation, Reservoir, anthropogenic activities, Buffer Zone, Water*

1. BACKGROUND

Buffer zones are designated areas used to protect hydrologically sensitive landscapes including wetlands, wildlife reserves and rivers from external pressures such as those caused and exacerbated by anthropogenic activities (Tagoe and Mantey, 2017). Buffer zones are spaces directly adjacent to water bodies such as lakes, reservoirs, rivers, streams and wetlands. In Zambian context, in accordance with what is provided for in Statutory Instrument No. 1 of 2000, buffer zones are 50m radius from the water boundaries or river banks. These areas have a significant impact on controlling non-point source pollution, sediment generation and bank degradation associated with anthropogenic activities nearby water bodies. Water bodies around the world are known to be the key source of sustainable ecosystems goods and services (Tagoe and Mantey, 2017), however, most water bodies have been and or are being affected by anthropogenic activities along the river and reservoirs banks raising a series of environmental concerns. Most of the environmental impacts associated with catchment degradation are primarily caused by different anthropogenic activities taking place along reservoirs or rivers (Khatri and Tyagi, 2015). Reservoirs are water bodies formed or modified by human activity by

impounding surface runoff or sections of the river channel in order to provide accessible and controllable water resource (Thornton *et al*., 1982). They provide a range of benefits including increased access to water in local communities, improved household food security, diversified livelihood options, female empowerment and enhanced entrepreneurial activities (Saruchera and Lautze, 2019). Livelihood factors such as the need for agricultural land, food, income, employment have all greatly contributed to the degradation and in some cases depletion of forest resources within buffer zones. With the warming temperature, changes in precipitation and runoff, sedimentation becomes rampant affecting water supply and quality. Sedimentation, pollution, climate change, deforestation and landscape changes are some of the key drivers of reduction in water resources and decreased ground water recharge (Muchanga, 2020, Muchanga *et al*., 2019; Polite 2010; Sichingabula, 1997).

One of the most serious threats to water resources is the degradation of ecosystems which often takes place through changes to landscapes such as clearance of forests, the conversion of natural landscapes to farmland, and urbanization (Sichingabula, 2000). There is a positive correlation between vegetation within the catchment in general and availability of surface water resources (Muchanga, 2020), hence, if trees are conserved, water will also be conserved. For example, Chongwe River, Magoye River, Makoye and Chongwe Dams have been drying up due to such human activities (Muchanga, 2020, Sakeyo, 2008). Where water is scarce, reservoirs are mainly used to conserve available water for use during water stressful periods. When excess surface water proves to be problem, a reservoir can be used for flood control to prevent downstream areas from being inundated during periods of heavy upstream rainfall (Saruchera and Lautze, 2019). Reservoirs provide a range of benefits including increased access to water in local communities, improved household food security, diversified livelihood options and adaption to climate change (Sakeyo, 2008), hence, when they are silted up or damaged, not only is aquatic life affected, but also livelihood. In Zambia, Sichingabula (1997) has documented that small dams are losing storage capacity due to human-propelled sedimentation. He argues that human activities and lack of soil conservation practices in catchment areas contribute to soil erosion and silting up of reservoirs in the Southern Province and Zambia as a whole. Additionally, land degradation as a result of deforestation in different parts of Zambia is said to be a major problem accelerating soil erosion such that mobilized soil particles end up in water bodies. It is argued that many of the dams constructed in the 1950s and 1960s are today silted up and need to be dredged (Sichingabula, 1997). This hypothesis was partly validated by Muchanga (2020, 2017) who found large scale catchment-wide generation of sediment and deposition into reservoirs. This implies that if sedimentation is not checked, the usefulness of reservoirs in future will be much lower than at present. Some of these activities are not only depleting the water resource, but are also polluting it thereby rendering the resource inadequate with some water sources drying up especially during the dry season. Other related case studies from Zambian context have been documented regarding the problem of sedimentation on water resources in small dams and rivers and how the phenomenon reduces adaptive capacity to climate change and even COVID-19 because studies have shown high demand for water resources during the pandemic (Mtonga and Muchanga, 2021; Sichingabula, 2018). It was against this background that this study was conducted to understand the effects of buffer zone anthropogenic activities on Mashili Reservoir. The main gap in all reviewed study was lack of critical perspective on social perspective on sedimentation and reservoirs management.

2. METHODS AND TOOLS

Mashili Reservoir is located in Shibuyunji District at 580796.00 East and 8308374.00 South 63Km west of Lusaka Central Business District. Mumbwa District is on its North, Mazabuka District on its south and Chilanga on its East. The elevation is 998 meters above sea level. The maximum monthly temperature ranges between 24˚C and 34˚C whereas the minimum monthly temperature oscillates between 11˚C and 20˚C (Figure 1a). Figure 1b shows the physical location of the study area.

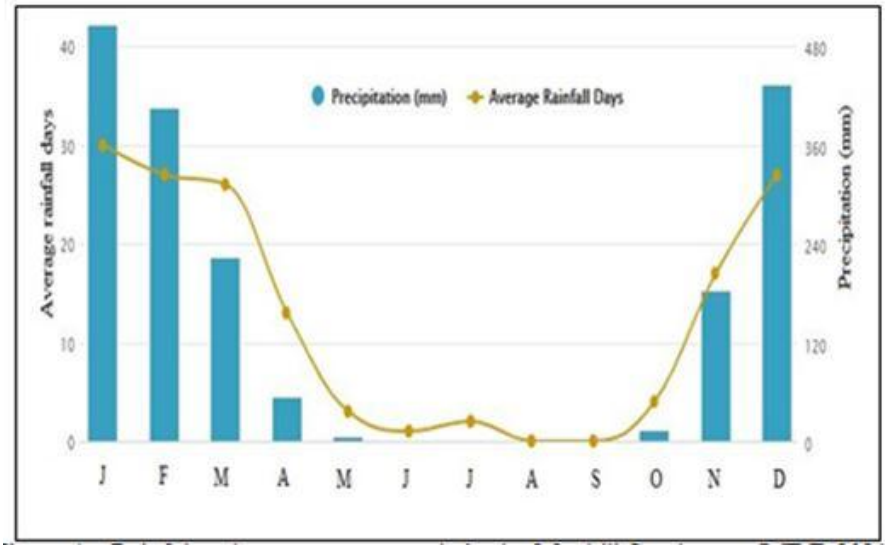

Figure 1a. *Rainfal and temperature trends in the mashili Catchment (MDZ, 2021)*

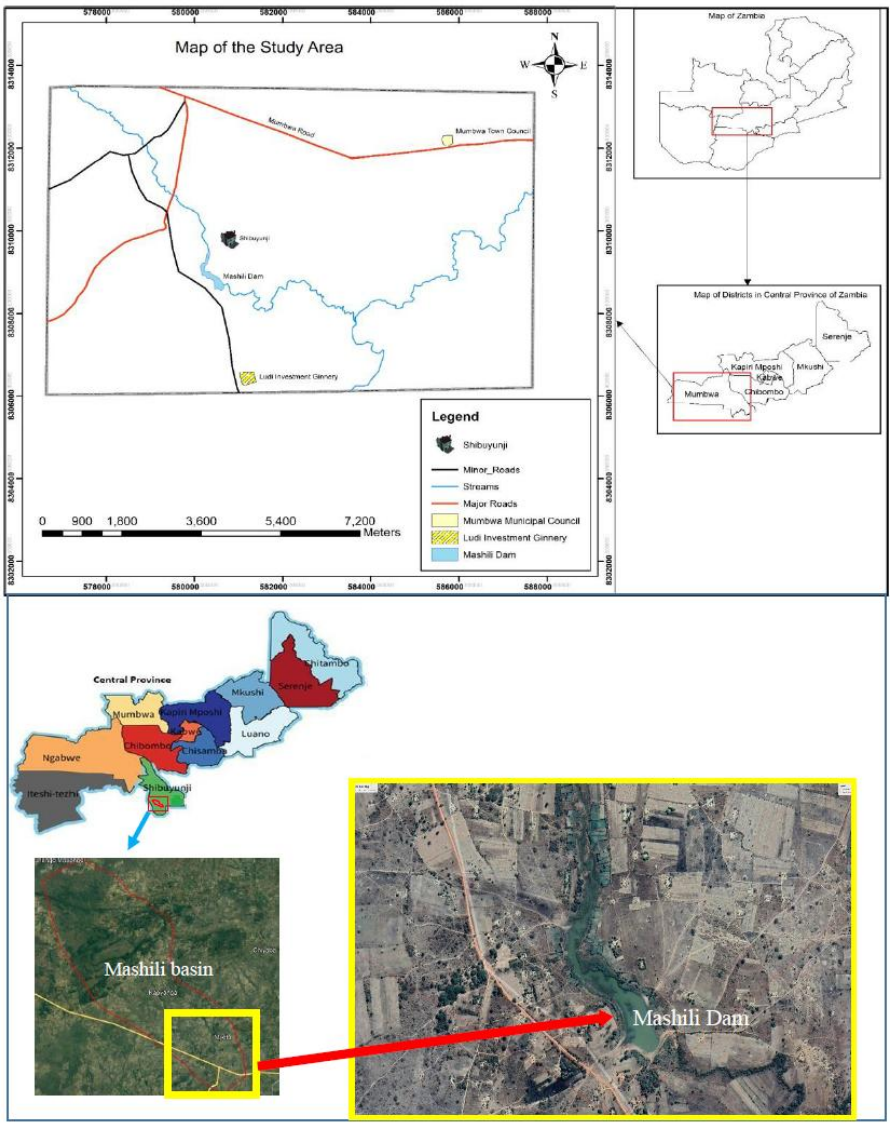

Figure 1b. *Map of Shibuyunji District showing general and specific location of Mashili Reservoir*

The remote sensed satellite imagery impression of the study area clearly shows that the area is highly inundated with a lot of human activities within and beyond the 50m buffer zone. The District where

Mashili Reservoir is located has a total population of 52,860 of which 26,333 are females and 26,527 are males. The common drivers of the district's economy are, charcoal burning, small scale mining as well as crop and pastoral farming. Majority of communities depend on agriculture related activities for domestic and economic sustenance (Central Statistical Office (CSO) 2010). The major crops cultivated include maize, cotton, soya beans, groundnuts, cowpeas, sunflower, sweet potatoes, and vegetable crops. The fisheries and livestock industry also provides significant potential for ranching and processing of meat and fish (CSO, 2010).

The research approach adopted in this study was qualitative in nature (Welman *et al.*, 2005). Specifically a single case study was adopted, this design is well documented by Yin (2009) and Bryman (2008). The study considered a target population of residents in Shibuyunji community. These residents included local farmers, school teachers, area counsellor and local traditional leaders. The sample size was 40 participants. The study used a non-probability sampling design specifically purposive sampling (Bryman, 2008). Hence, not everyone had an equal chance of being selected to participate in a study of this nature because it targeted those who had full knowledge of anthropogenic activities within the buffer zone (Knobel and Lankshear, 2004). Data was collected directly from the participants through interviews (Kothari, 2004 and Saunders, 2006). The semi-structured interview method was relevant for the study because it inspired both the researcher and the participants to interact on a one on one basis in order to explore the effects of buffer zone anthropogenic activities on the Mashili Reservoir. Oberservation was also employed to visually confirm activities that were cited by the participants. In cases where the researcher was not clear, this method assisted in making follow-up questions. The study employed a thematic analysis approach and descriptive statistics in analyzing nominal data. In order to ensure data quality control and trustworthiness in the study, the researcher employed triangulation, which facilitated validation of data through cross verification from more than two sources (Korn and Graubard, 2004). The methodological decisions were ontologically and epistemically informed by critical realism (Korn and Graubard, 2004, Bhaskar, 2018). Studies that are located within critical realism uphold both transitive and intransitive realities about phenomenon and Muchanga (2020a) argues that every methodological decision must always be directly or indirectly be informed by philosophical a stance.

3. RESULTS

Anthropogenic activities in the buffer zone and their drivers

Deforestation was the main anthropogenic activity cited to have been contributing to siltation of the Mashili Reservoir. Participants of the study were probed on what they thought about the magnitude and extremity of deforestation around the reservoir catchment, the following were the responses (Figure 2).

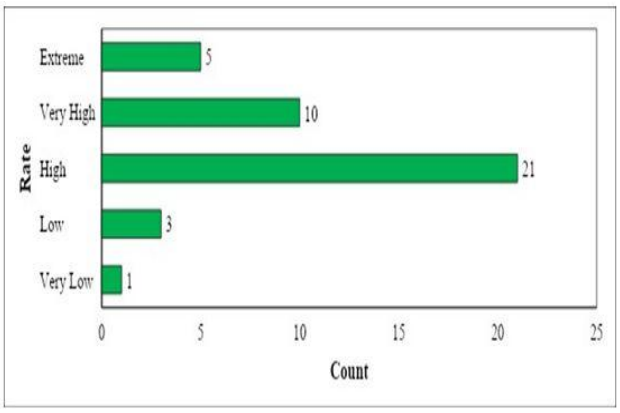

Figure 2. *Responses on the magnitude and severity of deforestation*

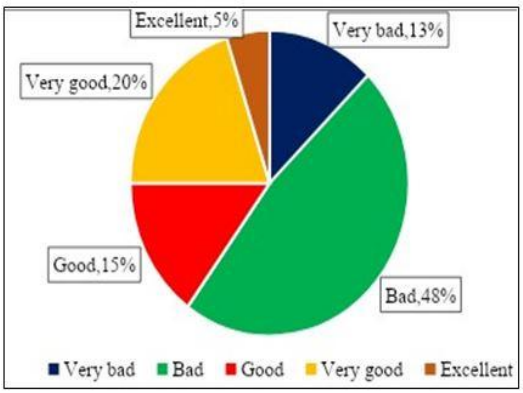

Figure 3. *Ranking of the attitude of local community towards*

The responses from the participants confirmed that severity and magnitude of deforestation was within high to extreme levels in the buffer zone. Gardening and agriculture in general were the most prevalent human activities within the reservoir's buffer zone. Beyond gardening, there were also several brick molding activities and some soil quarrying activities that contributed to the siltation of the reservoir.

Livestock watering was also a notable accelerator of the problem of siltation especially around water access points. The study further sought some responses from the study participants on the attitude of community members on protection of local resources especially within the buffer zone. As presented in Figure 3, the attitude by community members on protection of the buffer zone was predominantly bad to very bad representing about 60% of the participants. Notwithstanding that, some participants still felt that the people's attitude was ranging from good to excellent, but this was inherently nullified by the fact that the reservoir and its buffer zone were already getting degraded.

The study also found that there was lack of legal authority to curb unsustainable landuse that contributed to shrinking of the pristine of the buffer zone. The findings also showed that, lack of implementation of provisions of the SI No.1 of 2000 and the Water Resources Management Act No. 21 of 2011 that is, keeping all human activities away from the 50m buffer zone contributed to uncontrolled human activities' prevalence in the undesignated area. Diverting of water from the reservoir was also one of the major areas of concern as this created sediment heaps that were transported into the reservoir through surface runoff. The study further revealed that such anthropogenic activities were punctuated by poor water governance capacity at local level.

Effects of Buffer Zone Anthropogenic Activities on Mashili Reservoir

The study found that buffer zone activities had increased soil erosion, increased pollution risks, and destruction of ecosystem, hence, affecting biodiversity because nearby ecological niches were observed to be unstable and offering reduced functions. The most emphasized impacts were as presented in Figure 4.

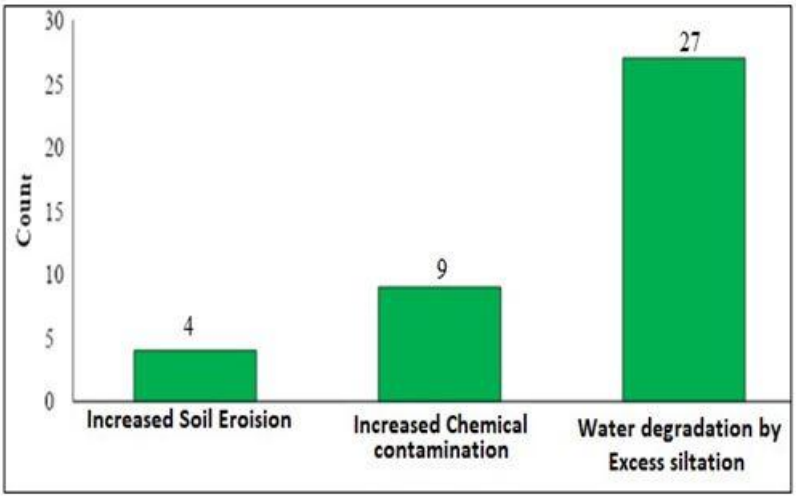

Figure 4. *Impacts of Buffer Zone Anthropogenic Activities*

Participants lamented that aquatic ecosystem destruction was one of the major consequences of increased soil erosion and excess sediment deposition.

Intervention Measures to reduce the effects of Buffer Zone Anthropogenic Activities

Participants suggested conducting sensitization and awareness campaigns so as to help educate the community on what buffer zones were and their importance towards sustainable management of water in the reservoirs and rivers at large. Information was also obtained on whether there should be local laws guiding people on how to responsibly use water resources and ensure sustainability of reservoir, the following were the responses (Table 1). The responses in Table 1 point to weak community structures and lack of formidable Water Users Associations (WUAs) to safeguard the available water resource infrastructure.

Table 1. *Responses on developing local laws to safeguard Mashili Reservoir*

Responses	Frequency	Percentage
No	2	5
Yes	33	83
Not sure	5	12
Total	**40**	**100**

4. DISCUSSION

Buffer zone protection is a critical element in the management of surface water resources. However, this was not the case in the Mashili Catchment where anthropogenic activities had caused damage to the buffer zone and eventually the aquatic system. As buffer zone areas get converted to crop and grazing lands, more soil is loosened such that during the rainy season, large scale erosion takes its toll leading to large scale sedimentation in reservoirs. Human settlements built in the buffer zone area disturbs riparian soils and interferes with lacustrine biodiversity and habitat. Human activities could also lead to impairment of stream water quality as stream temperatures increase and fertilizer/manure is deposited into streams, introducing organic matter, nutrients and pathogenic organisms thereby compromising the quality of water resource and also recolonization of aquatic macrophytes and microphytes. Cutting of woody vegetation was earlier noted by Sichingabula (1997) to have a weakening influence of the banks sometimes leading to breaking of dams because as noticed in the Mashili Basin, deforestation weaken and sometimes even degrades the banks, and once the banks are degraded, gully erosion become rampant and eventually siltation.

Deforestation due to charcoal burning as a means of livelihood in the buffer zone was classified to be severe to extreme, which means that perhaps people did not have the right form of literacy around the importance of protecting buffer zones. Namafe and Muchanga (2017) assert that as the world and Zambia in particular reposition for attainment of SDGs such as SDG 6 and SDG 14 in a localized way, environmental literacy becomes indispensable in order to ensure informed participation of all citizens in addressing pressing ecological issues such as sedimentation and to build resilience towards climate change (Jonathan 2016; Muchanga 2012; Hassan, 2012; Chen and Lin, 2011). The need for environmental literacy is premised on the findings that the attitude of community members towards protection of the buffer zone was poor in most cases. Hence, having environmental knowledge and skills would influence how humanity perceives the environment. A study by Jameson (2008) asserts that, in places where environmental literacy is embraced, such environmental challenges as loss of reservoir capacity due to sedimentation are almost reduced by half unlike in areas where environmental literacy is not embraced. Almost all participants recognized the importance of environmental literacy as an intervention strategy as also provided for in the National Policy on Environment.

Zambia has a substantive water resource management act of 2011 that provides guidelines on how water resources and ecosystems must be governed. Notwithstanding that, lack of effective controls and authority was found to be contributing to rapid loss of ecosystem change. Gavin (2017) states that, regulation of utilization of resources is a strong principle to attaining sustainable development. However, this has not been the case in many contexts and particularly in the Mashili Basin resulting into weak enforcement of regulations for riverine ecosystem conservation. The consequence of lack of adequate ecosystem regulation has contributed to severe environmental degradation with almost a zero chance of regeneration capacity or perhaps that, it may take a very long time to stabilize or regain pristinity. Through a Citizen Science lens, the study noted that landuse/cover was a major influencing aspect that contributed to the increasing rate of soil erosion. It was cited as causing harm to the environment by disturbing the supply of water, reducing the storage capacity and availability of water in the area.

Study conducted by Sharma *et al.* (2011) on the effect of landuse/cover change on erosion process from 1989-2004 illustrated that landuse change can severely damage the once lucrative aquatic ecosystems. Hence, it was no strange phenomenon to find this as one of the principal drivers of change in the Mashili Catchment. Landuse/cover change destroys the pristinity of ecosystem and causes loss in the biodiversity of natural habitats. Other than loss of reservoir productivity, many species could also be lost due to landuse change. When species are lost, the ecosystem is greatly affected and there could be more consequences on humanity that punctuated such changes as was the case in Mashili Catchment where both the stream and reservoir ecosystems were severely affected. In his earlier study in the Magoye Catchment, Muchanga (2020) noted a significant relationship between landuse change and siltation in water bodies and his caution resonates with the one which the current study proposes, thus, stopping by law, all deleterious anthropogenic activities especially in ecologically sensitive areas.

5. CONCLUSION AND RECOMMENDATIONS

Premised on the findings of the study, the study concluded that Mashili Reservoir was under threat getting fully silted up and losing its aquatic biodiversity because of persistent anthropogenic activities within not only the reservoir buffer zone, but also the entire catchment. Water security is threatened as the reservoir gets widely inundated with sediment. As noted in other studies, deforestation and agricultural activities were the principal drivers of changes and degradation of riverine environments of the Mashili Catchment. This could be attributed to little or no literacy about water resources management at community level and lack of coordinated implementation of laws that protect buffer zones. The study recommends community-based water and environmental education to be implemented so as to raise conscious among community members on the importance of waters resources protection so as to build adaptive capacity amidst climate change. In line with critical realist philosophy, this paper ontologically acknowledges the provisionality of emerged reality based on the methodological choices, so worth considering is doing further studies in this catchment using quantitative methods so as to determine the bathymetry, storage capacities and useful life of the reservoir as well as spatial temporal analysis of water quality. Clear understanding of these variables would enhance evidence for decision making towards protection of the catchment for sustainable life under water and also sustainable access to clean water resources for both humanity and aquatic organisms as the country moves towards achieving water-related SDGs by 2030 and beyond.

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AUTHORS' BIOGRAPHY

Monde Hamatuli, holds a Bachelor's Degree in Environmental Education, She is a qualified Forest Scientist and currently works for the Forest Department under the Government of the Republic of Zambia. Her research interest is Environmental Education, Water and Forestry.

Manoah Muchanga, is a Doctor of Philosophy in Fluvial Geomorphology. He is currently a researcher and lecturer at the university of Zambia. His research interest is in Water and Sediment; Water Education, Environment and Learning, Climate Change; Social Hydrology.

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