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TOWARDS A MORE HUMAN-CENTRED WATER RESOURCE MANAGEMENT: A REVIEW

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Abstract

Inefficient utilization of water in irrigated agriculture and other water management sectors have been reportedly linked to inappropriate water application and/or sharing methods, hydrological uncertainties, and decayed infrastructures. However, a problem that has been affecting the irrigation and other water management sectors which attracted little attention and remaining elusive, is the impact of unlawful human activities. Some of the human activities that have been reported to adversely affect irrigation and other water management sectors include unauthorized water uses, water wastage behavior, and excessive operational losses. Others comprise discharging poorly or untreated wastewater into watercourses, over-application of chemicals, collusions, and other forms of corruption. To change the current water governance for achieving the sustainable development goal number 12, aimed at ensuring sustainable natural resources consumption and production patterns, the impacts of such undesirable human activities need to be assessed and incorporated into water management operational analysis quantitatively.

This paper reviewed and reported two important aspects that need to be considered before putting human-centered water management into practice. 1) Ethical considerations in water use and management which need to be studied, revisited, and revised. 2) Human behavior-induced cases that have occurred and hampered the success of irrigation and other water management sectors. An insightful knowledge was gained from the review that drought condition (the state of water availability) affects water users' level of compliance with rules.

This paper, therefore, identified the impact of human unlawful activities as the missing link that if not quantitatively incorporated could render irrigation and other water management sectors unproductive. For example, a model that simulates water management operation whilst coupling the impact of humans quantitatively would be a valuable tool for prudent decision-making. It is, therefore, strongly recommended to be incorporating the impact of human activities on irrigation and other water management performance analysis quantitatively.

Keywords: Human-centred; Irrigation scheme; Management; Water resource

1. INTRODUCTION

The quest for sustainable natural resource utilization is an essential part of the ongoing 2030 agenda for sustainable development goals (SDGs). It is one of the 169 agreed targets being aimed for monitoring and assessing the level of sustainability with which resources, such as irrigation water, are being managed (Osborn *et al*., 2015; Bartram *et al*., 2018). To change the current water governance regime for achieving the SDGs' goals, an international decade for action was launched (2018–2028) and themed '*water for sustainable development* (UN-Water, 2018). This is in response to concern about how to sustainably utilize the limited water resources in the face of rapid socio-economic development and climate change, particularly in agricultural sectors. However, a problem that has been affecting the water sector, and attracted little attention, while also remaining elusive, is the impact of unlawful human activities (Groenfeldt, 2013; Shanono et al., 2020). Some of the reported activities adversely affecting the water sector include unlawful water abstractions, improper water usage (wastage); poor acceptance of water re-use measures, and excessive operational losses. Others comprise contamination of water bodies by discharging untreated or improperly treated wastewater, over-application of chemicals in agricultural activities, and fraudulent system operation (Plummer & Cross, 2006; Hermann-friede et al., 2014; SABPP, 2013; WWAP, 2017). Although adherence to water ethics in addressing these undesirable human activities thereby achieving water management goals has been stressed (Falkenmark & Folke, 2002; UNESCO, 2011), to date, these issues have not been explicitly addressed.

In water-stressed countries such as South Africa, reservoirs are a major feature of the water resource systems, and reservoir operation is, therefore, an essential aspect of the country's water management. Reservoir operation is a challenging water management task, and when behavior-driven problems arise, it may turn out to be even more complicated. The South African Department of Water and Sanitation (DWS) identifies unlawful water use as one of the major problems affecting the water sector. However, many stakeholders consider the low implementation level of water laws as the main cause of these problems (DWA, 2012). According to Mckenzie *et al*., (2012), the total water loss in South Africa amounts to 31.8 % of which 6.4 % is considered as commercial losses due to unlawful use and meter inaccuracies. The annual total water loss and water loss due to unlawful use are estimated to be 1,366 and 275 million m^3 respectively. Illegal abstraction locations exist, and several of them were identified in the farming areas of the Western Cape Province in 2017 (Philanda, 2017).

Although freshwater is plentiful in some parts of the world, it is scarce in some regions such as Southern Africa (Basson e*t al*., 1994). To address the potentially conflicting water demands in such regions, water managers need to account for all losses, thereby improving the performance of existing reservoirs (Yu *et al*., 2013; Kuria & Vogel, 2014). Such non-structural risk reduction measures have been identified as an imperative option, due to limited sites for constructing new reservoirs (Basson & Van Rooyen, 2001; Ndiritu, 2005; WWAP, 2018). South Africa is a water-stressed country, due to several factors including droughts, socio-economic growth, unlawful water use, and excessive operational losses. It has been predicted by the Department of Water Affairs and Forestry (DWAF) that unless consumption patterns change, by 2025 the country may not be able to sustain its water demand (DWAF, 1997). Studies revealed that the country's demand-supply deficit could reach 17% by 2030 if the demand continues to grow at the current rate (DWS, 2018; Colvin & Muruven, 2017). This agrees with the assertion that water demands are expected to escalate in countries with emerging economic development, such as South Africa (WWAP, 2018). Moreover, South Africa faces the most severe surface water scarcity in Sub-Saharan Africa (Burek *et al*., 2016). As of January 2018, the DWS categorized the flow in 243 (43%) of South Africa's 565 rivers as low or very low, which means the country's overall water crisis is not limited to the Western Cape (Donnenfeld, 2018). Several studies have highlighted the risk of water scarcity in Southern Africa (McMahon *et al*., 2007; Pietersen *et al*., 2008; Wada *et al*., 2016). Hence, in water-stressed countries like South Africa, there is a need to employ all necessary measures that could reduce water demand including human-induced cases thereby increasing its availability.

2. THE ETHICS OF WATER USE AND MANAGEMENT

Human beings are the major agents for changing the state of the natural environment. Thus, the quest for limiting the adverse human effects and sustainable utilization of natural resources such as water necessitates a distinctive ethical explanation (Jennings *et al*., 2009). In the 19th and 20th centuries, issues related to water rights, led to some ethical explanations on the moral philosophy of water management, drawn from ethics theories such as utilitarianism - *actions based on the benefits* and deontology - *duty based on virtuousness* (Kordig, 1974; Wescoat-Jr, 2013). Ethics are codes of conduct governing human behavior with which human actions are judged as either ethical or unethical (Ssonko, 2010; Cameron *et al*., 2004). Globally, ethics-centered approaches such as water conservation campaigns and participation, monitoring compliance, and enforcement, policy dialogues, legal actions, and other demand management measures have been reported to improve water management performance (Liu *et al*., 2009; WGF, 2000, 2016). Conversely, unlawful human activities are reportedly linked to the deterioration of the water sector (Plummer & Cross, 2006; Hermann-friede et al., 2014; SABPP, 2013; WWAP, 2017). The majority of the current water management policies were developed based on utilitarianism (Miller, 2007). To develop robust and sustainable water management policies, human and water systems need to be studied and analyzed in tandem thereby assessing the impact of various anthropogenic activities on water systems, as envisioned in the concept of socio-hydrology (Sivapalan *et al*., 2012; Montanari *et al*., 2013). As expounded in the fields of water and environmental ethics (Groenfeldt, 2010; 2013; Odume & De Wet, 2016), socio-hydrology also seeks to attain sustainable water management by ensuring the needs of both humans and the ecosystem.

It has been reported that the power of technology in modifying the world, could increase peoples' propensity for unlawful activities, making ethics increasingly important in the 21st century (UNESCO, 2013). Ethics are the codes of conduct governing human activities which involves methodizing the concept of right and wrong conduct, as reflected in people's actions (Ssonko, 2010). Applying the concept of ethics can take care of ethical issues from technical, environmental, economic, social, and climate change impacts such as floods and droughts, thereby creating credibility and uniting people through sound leadership. When a society attains these values, the ethical climate is said to have prevailed, and positive responses are always expected from that society. The ethical climate of a given organization is the overall view of the moral atmosphere within that organization (Treviño *et al*., 2006). It is therefore desirable that such ethical/moral atmosphere is created in the management of water especially during poor hydrological conditions (droughts).

Water users have been blamed for aggressive habits toward maximizing usage especially during resource shortfall due to drought, which commonly leads to resource failure (Ostrom *et a*l., 2002). The majority of the water users are known to operate for maximizing production (profit) and can be viewed through the lens of egoism ethical theories – *actions based on self-interest to maximize utility* (Persky, 1995; Monroe, 2001; Miller, 2009). Hence, there is a need to consider human behavior and actions as an integral part of the water management component (Odume & de Wet, 2016; Shanono & Ndiritu, 2020)**.** One of the causes of changing human behavior is the perception of risk which was considered as an inherent part of decision-making (Williams & Noyes, 2007). According to Kinzig et al. (2013), the perceived level of risk by a given society can interrupt and change that society's established norms and values (behavior). Several studies have been conducted on the impact of human activities on water resource systems, or how people respond to hydrological extremes (floods and drought). However, it is only recently that the impacts resulting from the interactions and feedbacks between humans and water have been formalized (Sivapalan *et al*., 2012). For example, in years of drought, farmers' risk perception is expected to intensify which can drive users to disobey the water sharing rules (N.J. Shanono, 2020). This theory of human-drought interaction if further studied could contribute toward answering science question 2 of *Panta Rhei* (McMillan *et al*., 2016; Montanari *et al*., 2013)**.** The question stated that: "*How do changes in hydrological systems interact with, and feedback to both natural, and social sub-systems driven by hydrological processes*?"

3. HUMAN-DROUGHT INTERACTIONS: EXPERIENCE FROM CASE STUDIES

Reservoir yield analysis is a technique for assessing yield potential under the anticipated range of varying conditions such as hydrological and infrastructural constraints, reliability of supply, and operating rules (McMahon *et al*., 2006; Shanono et al., 2015). In conventional reservoir yield analysis, it is typically assumed that yield falls below target draft only in times of drought, but this is not always the case as human activities, such as unlawful water abstractions, can also affect yield significantly. When a water year experienced drought conditions, reservoir operators responded by implementing various adaptive strategies, such as imposing supply restrictions. In restriction periods, some users are expected to comply, whereas other users could decide to abstract water unlawfully (Shanono et al., 2019). Such human-drought relationships could significantly impact reservoir yield performance. Thus, a decrease in reservoir storage is expected to generate concern that can change the state of water users' level of risk perception. Awareness campaigns and law enforcement, in addition to whistleblowing by co-water users, can help reduce these problems.

A case in point is that Di Baldassarre *et al*., (2017) developed a model that simulates and relates the co-evolution of water abstraction from a reservoir and hydrological extremes (floods and droughts). The model revealed how reservoir storage changes due to human activities characterized by massive water withdrawals amid resource shortfall (drought) or less water withdrawal in time of excess water (flood). Other studies have also discovered that the increased severity of drought increases the rate at which water is abstracted, due to the perceived threat to users' quality of life (Elshafei *et al*., 2014; Firoz *et al*., 2017). According to Elshafei *et al*., (2014) whenever the available amount of water decreases, and water users become well aware of the situation, the users' perceived risk increases. Also, the drier and hotter a year is, the higher the evapotranspiration, and thus the higher the crop water requirement becomes (Abbas & Chowdhury, 2016). This will instigate irrigation water users to demand more water, which could enhance their concern over a perceived water shortage. Therefore, it can be ascertained that the hydrological state can change the level of irrigation users' perceived threat to their farming activities, and financial state. Such changes in the users' risk perceptions are also expected to subsequently change their level of compliance with the water allocation rules. Hence, hydrological conditions can affect users' perceived threat, which can generate more concern, and subsequently, change their compliance behavior.

Another case in point, which can be linked to the dynamics of human-drought interaction, is the well-known 2016 water scarcity crisis of the city of Cape Town, South Africa. Water conservation and water demand management (WC-WDM) measures were implemented, and a considerable reduction in consumption was recorded from 2011 to 2014. It was then presumed that no water resource development was needed until 2024 if water users in the city maintained this behavior. However, in 2015, the city's water consumption significantly increased, due to a change in users' behavior with regard to the WC-WDM measures. The situation was also suspected to have been exacerbated by the failure to impose restrictions on time, and over-abstraction by agricultural users due to perceived risk as a result of a prolonged drought condition in that year (Muller, 2017). This reveals that the interplay between humans and drought is highly uncertain but essential to be incorporated into both water management strategies and operations.

Sub-Saharan African countries such as South Africa and many other countries across the globe are water-stressed, due to several factors including droughts, socio-economic growth, unlawful water uses, and excessive operational losses. Studies revealed that South Africa's demand-supply deficit could reach 17% by 2030 if the demand continues to grow at the current rate (DWS, 2018;

Colvin & Muruven, 2017). This agrees with the assertion that water demands are expected to escalate in countries with emerging economic development, due to not only demand dynamics but also drought impacts coupled with unavoidable human behavior (WWAP, 2018). Although some non-structural risk reduction measures like WC-WDM are in place in some countries, there is a need to dynamically consider the impacts of anthropogenic activities relating to water use. To achieve this, the causes and effects of human responses to hydrological extremes (droughts and floods) need to be explored, well-understood, and realistically incorporated into analysis for decision support. It is important to note that the primary cause of this problem is resource shortfall (drought), which is linked to the escalation of water consumption due to users' perceived threat to their quality of life (van Oel *et al*., 2008; Elshafei *et al*., 2014; Firoz *et al*., 2017). Also, ineffective water laws enforcement and other situational factors related to water users, surveillance systems, and other infrastructural constraints contributed immensely to this problem.

Other human factors that directly represent the level of users' moral awareness, understanding, and cooperation, especially in drought periods need to be considered. Moral or ethical awareness is the ability of an individual to identify his deliberate action, and figure out what consequences that action could cause to others, and understand his instinctive feelings (De Cremer *et al*., 2010). Humans' decisive actions, which can have positive or negative impacts, can be categorized as either ethical or unethical respectively (Cameron *et al*., 2004). Ethical decision-making and action is the people's will to adhere to commonly accepted rules, as in allocating valuable resources such as water. Thus, for an individual to make a decision that is ethical or not, depends on whether that individual is morally aware of the consequences (Tenbrunsel & Smith-Crowe, 2008). Such a decision can lead to either moral or immoral practices and depends on an individual's motives (self-interest or fairness), shaped by some inherent factors (Tenbrunsel & Smith-Crowe, 2008; De Cremer *et al*., 2010). These factors comprise culture, awareness or knowledge, religion, social well-being, and other societal value-related attributes known to shape individuals' moral thinking, and actions (Treviño *et al*., 2006). These socio-cultural values are known to influence how new, and innovative policies are received, and adopted by indigenous societies (Akiwumi, 1998). These factors also affect personality characteristics such as trust or distrust, as in accepting and complying with newly introduced natural resources conservation and sharing policies (Rim-Rukeh *et al*., 2013).

4. CONCLUSION

Although considerable studies on the effect of human behavior on water management have been conducted both in research and in practice, its impact on water management is rarely modeled and quantified. Also, the effectiveness of a given water management policy can have impacts on human behavior, it is only recently that research on the interactions, feedbacks, and co-evolution of the coupled human-water systems has been formalized and termed as socio-hydrology. A model that simulates water management operation whilst coupling the impact of humans quantitatively would be a valuable tool for prudent decision-making. Globally, there are different approaches to water management-related studies, such as environmental management, socio-economic, climate change, and policy perspectives. However, the effectiveness with which water is being managed and utilized with due consideration to the impacts of human behavior is missing in the earlier and current literature. Realistic incorporation of the concepts of ethics into irrigation and other water management operation can help in achieving the water management goals. This is in line with the calls to explicitly incorporate ethical issues (social) into the water resources management (hydrology), and the recent call to the socio-hydrologists to broaden the modeling to the level of individuals' intention and action. This paper identified the impact of human unlawful activities as the missing link that if not quantitatively incorporated could render irrigation and other water management sectors unproductive. Thus, it is recommended to be incorporating the impact of human activities on irrigation and other water management performance quantitatively.

References

Abbas, A., & Chowdhury, S. (2016). Effects of Temperature and Growing Seasons on Crop Water Requirement: Implications on Water Savings. *Journal of Applied. Environmental Management*, *20*(2), 424–433. Retrieved from https://www.ajol.info/index.php/jasem/article/download/140444/130194

Akiwumi, F. A. (1998). Water use in an African setting : history, culture, and perception as a barrier to sustainability. In *International Workshop on Barriers to Sustainable Management of Water Quantity and Quality, 12-15 May 1998, Wuhan, China. Organized by the Chinese Hydraulic Engineering Society (CHES) and the International Commission on Water Resource Systems (ICWRS) of t* (pp. 1–19).

Bartram, J., Brocklehurst, C., Bradley, D., Muller, M., & Evans, B. (2018). Policy review of the means of implementation targets and indicators for the sustainable development goal for water and sanitation. *J. Clean Water*, *1*(1), 3. https://doi.org/10.1038/s41545-018-0003-0

Bassi, M. P. (2010). *Ethical Issues of Water Resource Management in a Changing Climate: Equity and Legal Pluralism in Chile. A master degree thesis was presented at the Department of International Studies and the Graduate School of the University of Oregon*.

Basson, M. S., Allen, R. B., Pegram, G. G. S., & van Rooyen, J. A. (1994). *Probabilistic Management of Water Resource and Hydropower Systems*. Water Resources Publication ISBN.

Basson, M. S., & van Rooyen, J. A. (2001). Practical Application of Probabilistic Approaches to the Management of Water Resource Systems. *Journal of Hydrology*, *241*(1–2), 53–61. https://doi.org/10.1016/S0022-1694(00)00367-X

Burek, P., Satoh, Y., Fischer, G., Kahil, M.T., Scherzer, A., Tramberend, S., Nava, L.F., Wada, Y., Eisner, S., Flörke, M., Hanasaki, N., Magnuszewski, P., Cosgrove, B. & Wiberg, D. (2016). *Water Futures and Solution - Fast Track Initiative - International Institute for Applied System Analysis (IIASA) Working Paper. Laxenburg, Austria: WP-16-006*. Retrieved from http://pure.iiasa.ac.at/id/eprint/13008/1/WP-16-006.pdf

Cameron, K., Bright, D., & Caza, A. (2004). Exploring the Relationships Between Organizational Virtuousness and Performance. *American Behavioural Scientist*, *47*(6), 1–24. https://doi.org/10.1177/0002764203260209

Colvin, C., & Muruven, D. (2017). *Scenarios for the Future of Water in South Africa*. *WWF-SA*. Retrieved from http://awsassets.wwf.org.za/downloads/wwf_scenarios_for_the_future_of_water_in_south_africa_v7_6_pf_1.pdf

De Cremer, D., Mayer, D. M., & Schminke, M. (2010). On Understanding Ethical Behavior and Decision Making: A Behavioral Ethics Approach. *Business Ethics Quarterly*, *20*(1), 1–6. https://doi.org/10.1017/S1052150X00002736

Di Baldassarre, G., Martinez, F., Kalantari, Z., & Viglione, A. (2017). Drought and flood in the Anthropocene: feedback mechanisms in reservoir operation. *Earth System Dynamics*, *8*, 225–233. https://doi.org/10.5194/esd-8-225-2017

Donnenfeld, Z. (2018). South Africa is over-exploiting its water system, and the problem is getting harder and costlier to fix. Retrieved July 10, 2018, from http://firstthing.dailymaverick.co.za/article?id=99844#.W0R6MNIzYml

DWA. (2012). *Water Reconciliation Strategy Study for the Large Bulk Water Supply Systems: Greater Bloemfontein Area*. Retrieved from https://www.dwa.gov.za/orange/Docs/Great Bloem Area/Preliminary Reconciliation Strategy.pdf

DWAF. (1997). *(Department of Water Affairs and Forestry) Overview of water resources availability and utilization in South Africa by M.S. Basson, Pretoria, South Africa.*

DWS. (2018). *National Water and Sanitation master plan: Ready for the Future and Ahead of the Curve, vol.1 (version 8.3)* (Vol. 1). Retrieved from http://www.dwa.gov.za/National Water and Sanitation Master Plan/Documents/NWSMP Call to Action v8.3 18 Jan 2018 CORAL version.pdf

Elshafei, Y., Sivapalan, M., Tonts, M., & Hipsey, M. R. (2014). A prototype framework for models of socio-hydrology : identification of key feedback loops and parameterization approach. *Hydrology and Earth System Sciences*, *18*(6), 2141–2166. https://doi.org/10.5194/hess-18-2141-2014

Falkenmark, M., & Folke, C. (2002). The ethics of socio-ecohydrological catchment management: towards hydrosolidarity. *Hydrology and Earth System Sciences Discussions*, *6*(1), 1–10. Retrieved from https://hal.archives-ouvertes.fr/hal-00304643

Firoz, A. B. M., Nauditt, A., Fink, M., & Ribbe, L. (2017). Quantifying human impacts on hydrological drought using a combined modeling approach in a tropical river basin in Central Vietnam. *Hydrology and Earth System Sciences Discussion*, *86*, 1–33.

Groenfeldt, D. (2010). Viewpoint – The Next Nexus? Environmental Ethics, Water Policies, and Climate Change. *Water Alternatives*, *3*(3), 575–586. Retrieved from http://www.water-alternatives.org/index.php/allabs/117-a3-3-7/file

Groenfeldt, D. (2013). *Water Ethics: A values approach to solving the water crisis* (First Edit). Routledge.

Hermann-friede, J., Kropac, M., Achermann, S., Heeb, J., & Feuerstein, L. (2014). *Integrity Management Toolbox for Water Service Providers: Manual for Facilitators - Water Integrity Network (WIN)*. Retrieved from www.waterintegritynetwork.net

Jennings, B., Heltene, P., & Kintzele, K. (2009). Principles of Water Ethics. *Minding Nature*, (August), 25–28. Retrieved from http://www.humansandnature.org/filebin/pdf/minding_nature/August_2009_Principles_of_Water_Ethics.pdf

Kinzig, A. P., Ehrlich, P. R., Alston, L. E. E. J., Arrow, K., Barrett, S., Timothy, G., … Saari, D. (2013). Social Norms and Global Environmental Challenges : Tiie Complex interaction of Behaviors, Values, and Policy. *BioScience*, *63*(3), 164–175. https://doi.org/10.1525/bio.20n.63.3.5

Kordig, C. R. (1974). Structural similarities between utilitarianism and deontology. *The Journal of Value Inquiry*, *8*(1), 52–56. https://doi.org/10.1007/BF00136683

Kuria, F. W., & Vogel, R. M. (2014). A global water supply reservoir yield model with uncertainty analysis. *Environmental Research Letters*, *9*(9), 095006. https://doi.org/10.1088/1748-9326/9/9/095006

Liu, J., Daniel, N., Amarbayasgalan, D., Fu, J., Lei, X., Liu, H., … Tachiyama, K. and Y. Z. (2009). *Water Ethics and Water Resource Management A Report by Ethics and Climate Change in Asia and Pacific (ECCAP) Project, Working Group 14. Water*. Retrieved from http://www.unescobkk.org/fileadmin/user_upload/shs/Energyethics/EETAP14rpt.pdf

McKenzie, R., Siqalaba, Z., & Wegelin, W. (2012). *The State of Non-Revenue Water in South Africa (2012) - WRC Report No. TT 522/12*.

McMahon, T. A., Adeloye, A. J., & Zhou, S. (2006). Understanding performance measures of reservoirs. *Journal of Hydrology*, *324*, 359–382. https://doi.org/10.1016/j.jhydrol.2005.09.030

McMahon, T. A., Vogel, R. M., Pegram, G. G. S., Peel, M. C., & Etkin, D. (2007). Global streamflows - Part 2: Reservoir storage yield performance. *Journal of Hydrology*, *347*(3–4), 260–271. https://doi.org/10.1016/j.jhydrol.2007.09.021

McMillan, H., Montanari, A., Cudennec, C., Savenije, H., Kreibich, H., Krueger, T., … Viglione, A. (2016). Panta Rhei 2013 – 2015 : global perspectives on hydrology, society, and change. *Hydrological Sciences Journal*, *20*(4). https://doi.org/10.1080/02626667.2016.1159308

Miller, C. (2009). The Conditions of Moral Realism. *Journal of Philosophical Research*, *34*, 123–155. https://doi.org/10.5840/jpr_2009_5

Miller, R. W. (2007). Review: Water Resource Economics: The Analysis of Scarcity, Policies and Projects by Ronald C. Griffin. *Electronic Green Journal*, *1*(25), 1–2.

Monroe, K. R. (2001). Paradigm Shift: From Rational Choice to Perspective. *International Political Science*

Review, *22*(2), 151–172. https://doi.org/10.1177/0192512101222002

Montanari, A., Young, G., Savenije, H. H. G., Hughes, D., Wagener, T., Ren, L. L., & Belyaev, V. (2013). " Panta Rhei — Everything Flows ": Change in hydrology and society — The IAHS Scientific Decade 2013 – 2022. *Hydrological Sciences Journal*, *58*(6), 1256–1275. https://doi.org/10.1080/02626667.2013.809088

Montanari, A., Young, G., Savenije, H. H. G., Hughes, D., Wagener, T., Ren, L. L., … Belyaev, V. (2013). "Panta Rhei—Everything Flows": Change in hydrology and society—The IAHS Scientific Decade 2013–2022. *Hydrological Sciences Journal*, *58*(6), 1256–1275. https://doi.org/10.1080/02626667.2013.809088

Muller, M. (2017). *Understanding the origins of Cape Town's water crisis: By Social Science Research Network (SSRN) in Civil Engineering of June 2017*. Retrieved from file:///C:/Users/Wits-User/Downloads/SSRN-id2995937.pdf

Ndiritu, J. G. (2005). Maximizing water supply system yield subject to multiple reliability constraints via simulation-optimization. *Water SA*, *31*(4), 423–434. https://doi.org/10.4314/wsa.v31i4.5133

Odume, O. N., & de Wet, C. (2016). *The Role of Environmental Ethics in Social-Ecological Systems and Water Resource Management*. Retrieved from http://www.wrc.org.za/Knowledge Hub Documents/Research Reports/2342-1-15.pdf

Osborn, D., Cutter, A., & Ullah, F. (2015). *Universal Sustainable Development Goals: Understanding the transformational challenge for developed countries*. *Universal Sustainable Development Goals*. Retrieved from https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=1684&menu=35

Ostrom, E., Dietz, T., Dolsak, N., Stern, P. C., Stonich, S., Weber, E. U., & (Eds). (2002). *The Drama of the Commons*. *National Research Council* (Vol. 43). https://doi.org/10.17226/10287

Persky, J. (1995). Retrospectives: The Ethology of Homo Economicus. *Journal of Economic Perspectives*, *9*(2), 221–231.

Philanda, R. (2017). Water Crisis: Green Scorpions to monitor water theft. *Cape Argus*. Retrieved from https://www.iol.co.za/capeargus/watercrisis-green-scorpions-to-monitor-water-theft-11507146

Pietersen, K., Beekman, H., Abdelkader, A., Ghany, H., Opere, A., Odada, E., … Abdelrehim, A. (2008). Freshwater. In *Chapter 4: FRESHWATER* (pp. 119–154).

Plummer, J., & Cross, P. (2006). *Tackling Corruption in the Water and Sanitation Sector in Africa: Starting the Dialogue*. *Water and Sanitation Program (WSP)*. Retrieved from http://www2.wsp.org/UserFiles/file/712200782528_Tackling_Corruption_in_the_Water_and_Sanitation_Sector_in_Africa.pdf

Rim-Rukeh, A. Irerhievwie, G. Agbozu, I. E. (2013). Traditional beliefs and conservation of natural resources: Evidences from selected communities in Delta State, Nigeria. *International Journal of Biodiversity and Conservation*, *5*(7), 426–432. https://doi.org/10.5897/IJBC2013.0576

SABPP. (2013). *(South Africa Board for People Practices) Ethics, Fraud and Corruption - SABPP Fact Sheet (Number*

2 February 2013). Retrieved from http://www.workinfo.org/images/Attachments/SABPP/SABPP-FACT-SHEET-no-2-FEBRUARY-20132.pdf

Shanono, N.J. (2020). Applying the concept of socio-hydrology to assess the impact of human behavior on water management sectors: A review. *Bayero J.of Eng & Tech*, *15*(2), 105–116. Retrieved from https://www.bayerojet.com/wp-%0Acontent/uploads/journal/published_paper/volume-15/issue-2/bjet_Dtl5F0Qb.pdf

Shanono, N.J., Bello, M. M., Zakari, M. D., Ibrahim, A., Nasidi, N. M., Usman, I. M. T., & Maina, M. M. (2020). A Review of Stakeholders Conflict and Infrastructural Decay in Nigerian Irrigation Schemes. *Nigeria Journal of Engineering Science and Technology Research*, *6*(1), 78–90. Retrieved from http://www.njestr.com.ng/view.php?_folder&_yr=2020&_vl=6&_ish=1

Shanono, N.J., Sabo, A. A., Nasidi, N. M., Zakari, M. D., Mohammed, M., Isma'il, H., & Halilu, A. G. (2015). Hydraulic Infrastructures and Institutional Assessment of Watari Irrigation Project, Kano. *Bayero J.of Eng & Tech*, *10*(2), 44–51. Retrieved from https://www.bayerojet.com/wp-%0Acontent/uploads/journal/published_paper/volume-10/issue-2/bjet_OK3Hjei6.pdf

Shanono, N J, Nasidi, N. M., Maina, M. M., Bello, M. M., Ibrahim, A., Umar, S. I., … Putra, U. (2019). Socio-hydrological study of water users' perceptions on the management of irrigation schemes at Tomas irrigation project, Kano, Nigeria. *Nig J. Eng, Sci & TECH*, *5*(2), 139–145. Retrieved from http://www.njestr.com.ng/view.php?_folder&_yr=2020&_vl=6&_ish=1

Shanono, Nura Jafar, & Ndiritu, J. (2020). A conceptual framework for assessing the impact of human behavior on water resource systems performance. *Algerian Journal of Engineering and Technology*, *03*, 9–16. https://doi.org/http://dx.doi.org/10.5281/zenodo.4400183

Sivapalan, M., Savenije, H. H. G., & Blöschl, G. (2012). Socio-hydrology: A new science of people and water. *Hydrological Processes*, *26*(8), 1270–1276. https://doi.org/10.1002/hyp.8426

Ssonko, D. K. W. (2010). *Ethics, Accountability, Transparency, Integrity, and Professionalism in Public Service: The Case Study of Uganda*. *Enhancing Professionalization of Human Resource Management in the Public Service in Africa*. Retrieved from http://unpan1.un.org/intradoc/groups/public/documents/un-dpadm/unpan038789.pdf

Tenbrunsel, A. E., & Smith-Crowe, K. (2008). Ethical Decision Making: Where We've Been and Where We're Going. *The Academy of Management Annals*, *2*(1), 545–607. https://doi.org/10.1080/19416520802211677

Treviño, L. K., Weaver, G. R., & Reynolds, S. J. (2006). Behavioral Ethics in Organizations: A Review. *Journal of Management*, *32*(6), 951–990. https://doi.org/10.1177/0149206306294258

UN-Water. (2018). International Decade for Action - Water for Sustainable Development 2018-2028. Retrieved March 22, 2018, from http://www.unwater.org/new-decade-water/

UNESCO. (2011). *Water Ethics and Water Resource Management - UNESCO Bangkok Regional Unit for Social and Human Sciences in Asia and the Pacific*. Retrieved from http://unesdoc.unesco.org/images/0019/001922/192256E.pdf

UNESCO. (2013). *Background for a Framework of Ethical Principles and Responsibilities for Climate Change Adaptation - COMEST Report at its 8th Ordinary Session held in Bratislava, Slovakia, from 27 to 29 May 2013*.

van Oel, P. R., Krol, M. S., Hoekstra, A. Y., & de Araújo, J. C. (2008). The impact of upstream water abstractions on reservoir yield: The case of the Orós Reservoir in Brazil. *Hydrological Sciences Journal*, *53*(4), 857–867. https://doi.org/10.1623/hysj.53.4.857

Wada, Y., Flörke, M., Hanasaki, N., Eisner, S., Fischer, G., Tramberend, S., … Vliet, M. T. H. Van. (2016). Modeling global water use for the 21st century: the Water Futures and Solutions (WFaS) initiative and its approaches. *Geoscientific Model Development*, *9*, 175–222. https://doi.org/10.5194/gmd-9-175-2016

Wescoat-Jr, J. L. (2013). Reconstructing the duty of water: a study of emergent norms in socio-hydrology. *Hydrology and Earth System Sciences*, *17*, 4759–4768. https://doi.org/10.5194/hess-17-4759-2013

WGF. (2000). *(Water Governance Facility) Anti-Corruption in the Water Sector: UNDP Water Governance Facility at SIWI Issue Series No. 2*. Retrieved from file:///C:/Users/Wits-User/Downloads/WGF_IssueSheet_no2_Corruption (3).pdf

WGF. (2016). *(Water Governance Facility) Developing Capacities for Water Integrity: Impact Review of Training Courses. WGF Report No. 6, SIWI, Stockholm*. Retrieved from file:///C:/Users/Wits-User/Downloads/WGF-report-no-6-web (1).pdf

Williams, D. J., & Noyes, J. M. (2007). Theoretical Issues in Ergonomics Science How does our perception of risk influence decision-making? Implications for the design of risk information. *Theoretical Issues in Ergonomics Science*, *8*(1), 1–35. https://doi.org/10.1080/14639220500484419

WWAP. (2017). *(United Nations World Water Assessment Programme). The United Nation World Water Development Report 2017. Wastewater: The untapped resource. Paris, UNESCO*. Retrieved from http://iahs.info/uploads/UNESCO/247153e.pdf

WWAP. (2018). *(United Nations World Water Assessment Programme)/UN-Water. 2018. The United Nations World Water Development Report 2018: Nature-Based Solutions for Water. Paris, UNESCO.* Retrieved from http://unesdoc.unesco.org/images/0026/002614/261424e.pdf

Yu, M., Lee, D., Yi, J., & Kwon, T. (2013). Re-evaluation of multi-purpose reservoir yield. *WIT Transactions on Ecology and the Environment*, *175*, 283–292. https://doi.org/10.2495/ECO130241