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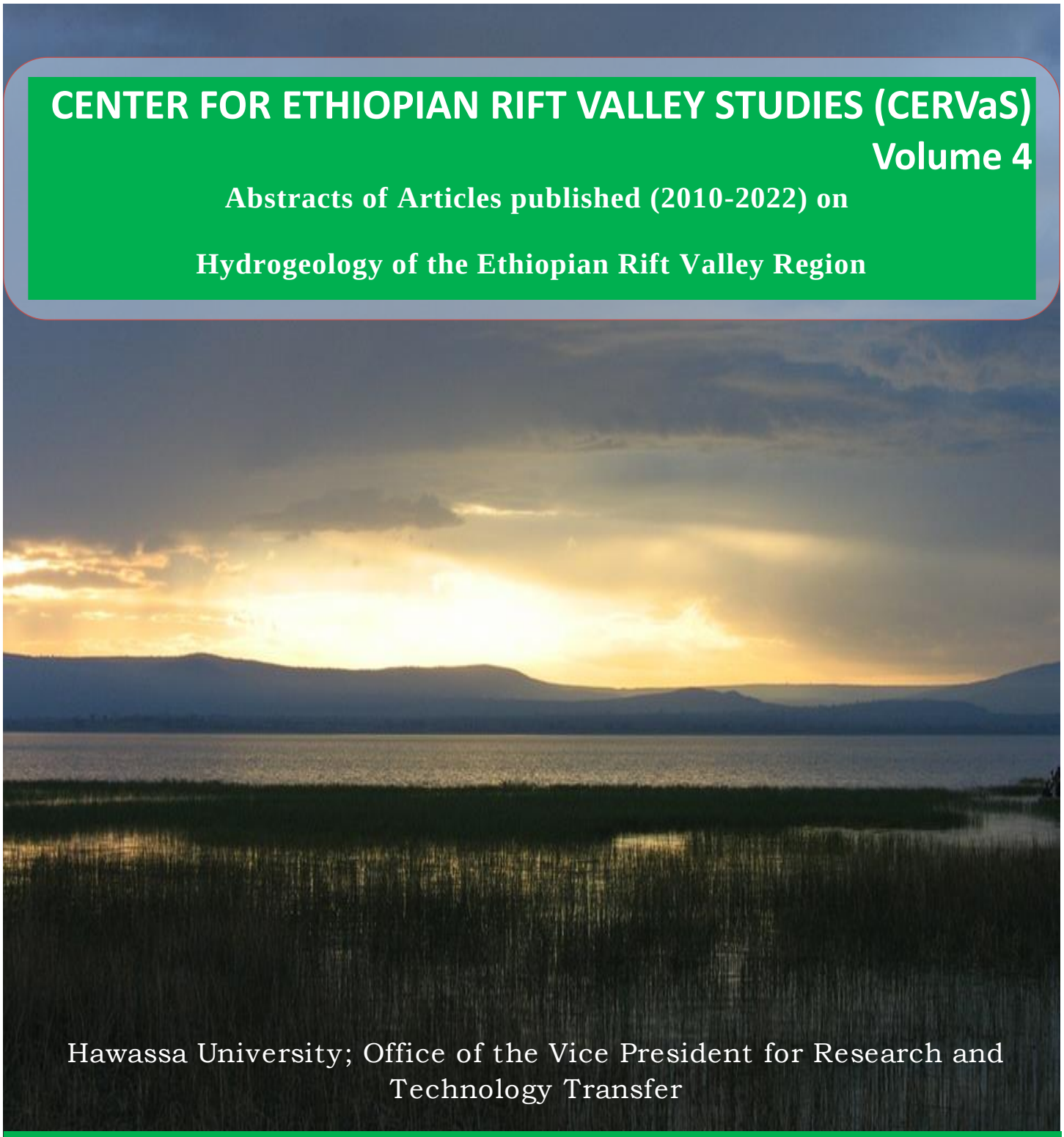

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AHP based analysis of groundwater potential in the western escarpment of the Ethiopian rift valley

Hamza Abrar Abiyot Legesse Kura Engida Esayas Dube and Dereje Likisa Beyene

ABSTRACT

This study investigated groundwater potential in the Western escarpment of the Ethiopian Rift valley, taking Dijo catchment as a case study, an area that is known for its critical shortage of water. Different thematic layers were used to determine the groundwater potential of the catchment. PCI Geomatica and Rockwork were used to automatically extract lineament and lineament orientation, respectively. Weights of parameters were computed using the analytical hierarchy process (AHP). Rank was assigned to each feature class for each thematic map according to their characteristics and interrelationship with groundwater. Once the mapping was done, validation of the estimated result was done. Accordingly, the result indicates that there is a matching between the analysis results and samples taken from boreholes with an accuracy result of 79.2%. The results revealed that nearly half of the catchment was found to have high-to-very-high groundwater potential while the remaining exhibiting limited potential for groundwater. Despite the highpotential, there is a critical shortage of water. This is partly attributed to poor planning and limited capacity in identifying water resource potential. Thus, we suggest that efforts should be made to exploit the available water resources thereby to solve the societal problem.

KEYWORDS: Groundwater potential PCI geomatica Dijo catchmentmain rift valley

Abrar, H., Legesse Kura, A., Esayas Dube, E., & Likisa Beyene, D. (2021). AHP based analysis of groundwater potential in the western escarpment of the Ethiopian rift valley. *Geology, Ecology, and Landscapes*, 1-14.

Alleviating Water Scarcity in the Central Rift Valley Lakes through an Inter-Basin Water Transfer, Ethiopia

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ABSTRACT

Demand for fresh water, as one of the major natural resources, is increasing rapidly with increasing development and environmental degradation. The continued abstraction of water from Lake Ziway and its main feeder rivers Meki and Katar for irrigation indicates that the water demand may soon exceed the supply. To illustrate disparities in spatial distribution of water resources, the Upper Awash sub-basin, which shares a water-divide with the CRVL sub-basin, has large flow volumes particularly in the rainy season and suffers with seasonal flooding. The rationale behind regaining the water in CRVL relies on this non-uniform spatial distribution of fresh water, calling for a balance between water surplus and deficit regions. For this reason, Inter Basin Water Transfer (IBWT) is suggested as a viable option to augment utilizable water resources of the Upper Awash sub-basin to reduce the significant pressure on the water supply of the rapidly developing urban and irrigation areas in the CRVL sub-basin. A water evaluation and planning (WEAP) model was used to quantify the amount of surplus water in the donor basin, when examining the hydrological dynamics of the basins. Furthermore, optimal flow diversion scenarios were generated by maintaining two baseline scenario constraints. The estimated surplus water in the rainy season is expected to contribute 18 million cubic meters (mcm), 88 mcm and 192 mcm in months June, July and August respectively under average conditions. The optimal amount of diverted water could potentially stabilize the environmental degradation of Lake Ziway and Lake Abijata by compensating for development-driven abstraction and surface water evaporation respectively.

Keywords: Inter Basin Water Transfer, WEAP, Lake Ziway, Upper Awash Sub-Basin, CRVL

Berhanu, B., & Bisrat, E. (2020). Alleviating Water Scarcity in the Central Rift Valley Lakes through an Inter-Basin Water Transfer, Ethiopia. *Natural Resources*, *11*(12), 554.

Aluto-Langano Geothermal Field, Ethiopia: Complete Image Of Underlying Magmatic-Hydrothermal System Revealed By Revised Interpretation Of Magnetotelluric Data

Samrock, Friedemann; Grayver, Alexander V.; Cherkose, Biruk; Kuvshinov, Alexey, V; Saar, Martin O.

ABSTRACT

Aluto-Langano in the Main Ethiopian Rift Valley is currently the only producing geothermal field in Ethiopia and probably the best studied prospect in the Ethiopian Rift. Geoscientific exploration began in 1973 and led to the siting of an exploration well LA3 on top of the volcanic complex. The well was drilled in 1983 to a depth of 2144m and encountered temperatures of 320°C. Since 1990 Aluto has produced electricity, albeit with interruptions. Currently it is undergoing a major expansion phase with the plan to generate about 70MWe from eight new wells, until now two of them have been drilled successfully. Geophysical exploration at Aluto involved magnetotelluric (MT) soundings, which helped delineate the clay cap atop of the hydrothermal reservoir. However, until now geophysical studies did not succeed in imaging the proposed magmatic heat source that would drive the observed hydrothermal convection. For this study, we inverted 165 of a total of 208 MT stations that were measured over the entire volcanic complex in three independent surveys by the Geological Survey of Ethiopia and ETH Zurich, Switzerland. For the inversion, we used a novel 3-D inverse solver that employs adaptive finite element techniques, which allowed us to accurately model topography and account for varying lateral and vertical resolution. We inverted MT phase tensors. This transfer function is free of galvanic distortions that have long been recognized as an obstacle in MT inversion. Our recovered model shows, for the first time, the entire magmatic-hydrothermal system under the geothermal field. The up-flow of melt is structurally controlled by extensional rift faults and sourced by a lower crustal basaltic mush reservoir. Productive wells were all drilled into a weak fault zone below the clay cap. The productive reservoir is underlain by an electrically conductive upper-crustal feature, which we interpret as a highly crystalline rhyolitic mush zone, acting as the main heat source. Our results demonstrate the importance of a dense MT site distribution and

state-of-the-art inversion tools in order to obtain reliable and complete subsurface models of high enthalpy systems below volcanic geothermal prospects.

Samrock, F., Grayver, A. V., Cherkose, B., Kuvshinov, A., & Saar, M. O. (2020). Aluto-Langano geothermal field, Ethiopia: complete image of underlying magmatic-hydrothermal system revealed by revised interpretation of magnetotelluric data. In *World Geothermal Congress (WGC 2020+ 1)* (p. 11054). ETH Zurich.

Understanding the groundwater dynamics in the Southern Rift Valley Lakes Basin (Ethiopia): Multivariate statistical analysis method, oxygen (δ 18O) and deuterium (δ 2H)

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ABSTRACT

Multivariate statistical analysis is very important to classify waters of different hydrochemical groups. Statistical techniques, such as cluster analysis, can provide a powerful tool for analyzing water chemistry data. This method is used to test water quality data and determine if samples can be grouped into distinct populations that may be significant in the geologic context, as well as from a statistical point of view. Multivariate statistical analysis method is applied to the geochemical data in combination with δ 18O and δ 2H isotopes with the objective to understand the dynamics of groundwater using hierarchical clustering and isotope analyses. The geochemical and isotope data of the central and southern rift valley lakes have been collected and analyzed from different works. Isotope analysis shows that most springs and boreholes are recharged by July and August rainfalls. The different hydrochemical groups that resulted from the multivariate analysis are described and correlated with the geology of the area and whether it has any interaction with a system or not.

Keywords:Physical, hydrochemical and isotopic characteristics of springs in Beijing, China, compared to historical properties

Water–Rock Interaction and Lake Hydrochemistry in the Main Ethiopian Rift

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ABSTRACT

This study investigates the halogen budget of the Main Ethiopian Rift (MER) lithologies and water, and on the basis of new laboratory experiments gives insights on the water–rock interaction processes which ultimately mobilize fluoride in the environment. The halogen composition, and in particular, the chloride content of MER lakes is also taken into consideration to evaluate compositional variation occurred during the last 80 years that have to be mainly related evaporative effects. The evaporation trends are also investigated on the basis of new analyses of stable isotopes of oxygen and hydrogen that are compared with those available in the literature since the 1970s. In such complex scenario, although the average annual temperature increased ~1 °C in 30 years, we did not observe systematic trends valid for all the investigated lakes. The record defined for the last 30 years by δ18O–δD denote fluctuations of the climatic parameters with extreme evaporation preceding the year 2005, then declining to more “normal” conditions. The relation between the observed climatic parameters and the water isotopic composition suggests that the study lakes quickly respond to the environmental changes, possibly within one (or two) year(s). We therefore suggest to continue the data acquisition of climatic and hydrochemical parameters in order to implement the existing hydro-archive that could be useful to point out possible environmental changes.

Keywords: Ethiopian lakes, Hydro-archive, Geochemistry, Stable isotopes

Belete, A. et al. (2015). Water–Rock Interaction and Lake Hydrochemistry in the Main Ethiopian Rift. In: Billi, P. (eds) Landscapes and Landforms of Ethiopia. World Geomorphological Landscapes. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-8026-1_1

Genesis of the East African Rift System

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ABSTRACT

The East African Rift System (EARS) started in Late Oligocene to Early Miocene time and gradually propagated southwards from the Afar Depression, beginning in the Middle Miocene. The hot, low-density mantle material of the Afar Plume heated the overlying lithosphere, causing thinning, regional doming, and the earliest basaltic volcanism in southern Ethiopia. In Ethiopia, the Afar Depression, the Main Ethiopian Rift, and the broadly rifted zone of southwestern Ethiopia represent the northern segment of the EARS. In the Kenyan sector of the EARS, uplift and doming also gave rise to the Kenya Dome. The radial flow patterns of the initial phonolites provide evidence for doming. Another important observation is that the rift geometry was greatly influenced by pre-existing structures of the underlying Mozambique Mobile Belt. Rifting proceeded through alternating episodes of volcanism and tectonics. Crossing into Tanzania, the influence of the neighbouring Tanzania Craton becomes evident. Here, the rift is expressed only in the northern part, splaying out in diverging half-graben valleys that are outside the Kenya Dome. Large boundary faults and opposing flexural margins, producing mobile asymmetrical full and half-graben basins that are individually linked along the rift axis, mark the Western Rift Valley. These basins are frequently occupied by elongate and narrow lakes (largely freshwater) separated by accommodation zones and containing significant hydrocarbon resources especially in the Albertine Graben. Small to large lakes existed in the EARS during the Plio–Pleistocene. Lakes in the Western Rift are large and deep, whereas those in the Kenya, Main Ethiopian, and Afar Rifts are generally small and shallow. Geological records indicate that the lakes sensitively

responded to orbital forcing as well as to local, regional, and global climatic, environmental, and tectonic changes, resulting in fluctuating lake sizes and even desiccation.

Keywords: Rift Zone; Rift Basin; East Africa Rift System; Main Ethiopian Rift; Kenya Rift

WoldeGabriel, Giday, Daniel Olago, Edwin Dindi, and Mike Owor. "Genesis of the East African Rift System." In *Soda Lakes of East Africa*, 25–59. Springer, 2016.

Geochemistry and water quality assessment of central Main Ethiopian Rift natural waters with emphasis on source and occurrence of fluoride and arsenic

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ABSTRACT

Drinking water supply for the Main Ethiopian Rift (MER) area principally relies on groundwater wells and springs and is characterized by natural source of elevated fluoride concentration. New analyses reveal that the F− geochemical anomaly is associated with other potentially toxic elements such as As, U, Mo and B. Particularly, 35% of the 23 investigated groundwater wells and 70% of the 14 hot springs (and geothermal wells) show arsenic concentrations above the recommended limit of 10 μg/L (WHO, 2006). Arsenic in groundwater wells has a positive correlation with Na+ (R2 = 0.63) and alkalinity (; R2 = 0.70) as well as with trace elements such as U (R2 = 0.70), Mo (R2 = 0.79) and V (R2 = 0.68). PHREEQC speciation modelling indicates that Fe oxides and hydroxides are stable in water systems, suggesting their role as potential adsorbents that could influence the mobility of arsenic.Chemical analyses of leachates from MER rhyolitic rocks and their weathered and re-worked fluvio-lacustrine sediments were performed to evaluate their contribution as a source of the mentioned geochemical anomalies. These leachates were obtained from a 1-year leaching experiment on powdered rocks and sediments mixed with distilled water (10 g:50 ml). They contain as much as 220 μg/L of As, 7.6 mg/L of F−, 181 μg/L of Mo, 64 μg/L of U and 254 μg/L of V suggesting that the local sediments represent the main source and reservoir of toxic elements. These elements, originally present in the glassy portion of the MER rhyolitic rocks were progressively concentrated in weathered and re-deposited products. Therefore, together with the renowned F− problem, the

possible presence of further geochemical anomalies have to be considered in water quality issues and future work has to investigate their possible health impact on the population of MER and other sectors of the East African Rift.

Rango, Tewodros, Gianluca Bianchini, Luigi Beccaluva, and Renzo Tassinari. “Geochemistry and Water Quality Assessment of Central Main Ethiopian Rift Natural Waters with Emphasis on Source and Occurrence of Fluoride and Arsenic.” *Journal of African Earth Sciences* 57, no. 5 (2010): 479–91.

Geothermal potential and origin of natural thermal fluids in the northern Lake Abaya area, Main Ethiopian Rift, East Africa

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ABSTRACT

In this study, the occurrence, chemical composition, origin and geothermal significance of thermal springs and fumaroles naturally discharging in the area located north of the Lake Abaya (western margin of the Main Ethiopian Rift, East Africa) are reviewed in relation with recent tectonics. All thermal springs showed a dominantly Na-HCO3 composition, consistent with observations dating from at least 1972, and most of them displayed a narrow range of δD and δ18O isotopic compositions for water similar to regional meteoric origins. These observations suggest that water-rock interaction processes occur in all aquifers and dominate the contributions of water that actively circulate within thermal fluids, and also suggest a similar elevation of groundwater recharge throughout the study area. Most of the thermal springs are dominated by a CO2-rich gas phase and discharge along the active faults bordering the western edge of the Main Ethiopian Rift valley. The δ13C values of CO2 and the 3He/4He isotopic ratios are consistent with the presence of mantle-derived fluids similar to what is observed in many other areas along

the kinematically active African Rift, especially within Ethiopia. The application of geothermometric techniques in the liquid and the gas phases suggests the presence of a deep reservoir in which the fluids equilibrated at a maximum temperature of approximately 180 °C. Additionally, the presence of fumaroles at boiling temperatures and water/mud boiling pools in several places suggests that the geothermal reservoir is positioned at a relatively shallow depth and likely located in the western side of the study area. The analysis of data collected throughout time reveals that the waters of Lake Abaya have experienced an increase in salinity of 20% paralleled contemporaneously with a decrease in pH and δ18O and δD of water in the last 40 years; these changes do not appear to be related to climate change-induced increases in temperature or evaporation at the global scale.

Minissale, A, G Corti, F Tassi, TH Darrah, O Vaselli, D Montanari, G Montegrossi, G Yirgu, E Selmo, and A Teclu. “Geothermal Potential and Origin of Natural Thermal Fluids in the Northern Lake Abaya Area, Main Ethiopian Rift, East Africa.” *Journal of Volcanology and Geothermal Research* 336 (2017): 1–18.

Granulometric Studies of the Surface Sediments of Kulfo River, Southern Nations, Nationalities and People's Region (SNNPR), Ethiopia, East Africa

Jai Ram Ojha, Subodh Kumar Chaturvedi and Anirudh Bhowmick

ABSTRACT

The Kulfo River, flowing in the 'Main Ethiopian Rift Valley', is one of the important river of SNNPR. The river profile, volume of river water flow, rainfall, topography, geology, climate and land use are thecontrolling agents for the erosion, transportation and deposition of sediments in this area. A total of seven sediment samples collected at water-land interface along the Kulfo River have been utilized for their granulometric analysis. The study

reveals unimodal, moderately to well sorted fine sands in upstream indicating a single source of sediment supply in the river. Farther away from upstream, the textural properties of sediments indicate bimodal to polymodal, poorly to moderately as well as well sorted medium to fine sands reflecting more than one source of sediment supply.

Index Terms: Granulometric studies, Kulfo River, Main Ethiopian Rift Valley, Paleoclimate, Paleoenvironment.

Ojha, Jai Ram, Subodh Kumar Chaturvedi, and Anirudh Bhowmick. "Granulometric Studies of the Surface Sediments of Kulfo River, Southern Nations, Nationalities and People's Region (SNNPR), Ethiopia, East Africa," n.d.

Groundwater Distribution and Fluoride Content in the West Arsi Zone of the Oromia Region (Ethiopia)

Sabrina Bonetto, Domenico Antonio De Luca, Manuela Lasagna,

and Rachele Lodi

ABSTRACT

In several areas of the world, water distribution and quality influence the local development;more over water sometimes exceeds the World Health Organisation (WHO) drinking water limits, even if anthropogenic contamination is not present. As example, in the Main Ethiopian Rift Valley water distribution influences agriculture and breeding, as well as high concentration of many chemical elements should have a consequence on human health. The present study, carried out by the Department of Earth Science of the University of Turin in cooperation with LVIA, allowed a better understanding of the main hydro chemical features and groundwater distribution in the south-centre of the Main Ethiopian Rift Valley (MER).The research consisted in a census of the main water point (springs and wells) in the District of Shashemene, Arsi Negelle and Siraro; each of them have been examined with field instruments so that main physical features of the water and fluoride content have been defined.

Keywords: Groundwater resources, Fluoride, Main Ethiopian rift valley

Bonetto, Sabrina, Domenico Antonio De Luca, Manuela Lasagna, and Rachele Lodi. "Groundwater Distribution and Fluoride Content in the West Arsi Zone of the Oromia Region (Ethiopia)." In *Engineering Geology for Society and Territory-Volume 3*, 579–82. Springer, 2015.

Mobilization of arsenic and other naturally occurring contaminants in groundwater of the Main Ethiopian Rift aquifers

Tewodros Rango, Gary Dwyer,Gianluca Bianchini

ABSTRACT

This study investigates the mechanisms of arsenic (As) and other naturally occurring contaminants (F^-, U, V, B, and Mo) mobilization from Quaternary sedimentary aquifers of the Main Ethiopian Rift (MER) and their enrichment in the local groundwater. The study is based on systematic measurements of major and trace elements as well as stable oxygen and hydrogen isotopes in groundwater, coupled with geochemical and mineralogical analyses of the aquifer rocks. The Rift Valley aquifer is composed of rhyoliticvolcanics and Quaternary lacustrine sediments. X-ray fluorescence (XRF) results revealed that MER rhyolites (ash, tuff, pumice and ignimbrite) and sediments contain on average 72 wt. % and 65 wt. % SiO_2, respectively. Petrographic studies of the rhyolites indicate predominance of volcanic glass, sanidine, pyroxene, Fe-oxides and plagioclase. The As content in the lacustrine sediments (mean = 6.6 mg/kg) was higher than that of the rhyolites (mean: 2.5 mg/kg). The lacustrine aquifers of the Ziway-Shala basin in the northern part of MER were identified as high As risk zones, where mean As concentration in groundwater was 22.4 ± 33.5 (range of 0.60–190 μg/L) and 54% of samples had As above the WHO drinking water guideline value of 10 μg/L. Field As speciation measurements showed that most of the groundwater samples contain predominantly (~80%) arsenate-As(V) over arsenite-As(III) species. The As speciation together with field data of redox potential (mean Eh = +73 ± 65 mV) and dissolved-O_2 (6.6 ± 2.2 mg/L) suggest that the aquifer is predominantly oxidative. Water-rock interactions, including the dissolution of volcanic glass produces groundwater with near-neutral to alkaline pH (range 6.9–8.9), predominance of Na–HCO_3 ions, and high concentration of SiO_2 (mean: 85.8 ± 11.3 mg/L). The groundwater data show high positive correlation of As with Na, HCO_3^-, U, B, V, and Mo ($R^2 > 0.5$; $p < 0.001$). Chemical modeling of the groundwater indicates that Fe-oxides and oxyhydroxides minerals were saturated in the groundwater, suggesting that the As reactivity is controlled by adsorption/desorption processes with these minerals. The data show that As and other oxyanion-forming elements such as U, B, Mo, and V had typically higher concentrations at pH > ~8, reflecting the pH-dependence of their mobilization. Based on the

geochemical and stable isotope variations we have established a conceptual model for the occurrence of naturally occurring contaminants in MER groundwater: 1) regional groundwater recharge from the Highland, along the Rift margins, followed by lateral flow and water–rock interactions with the aquifer rocks resulted in a gradual increase of the salinity and naturally occurring contaminants towards the center of the valley; and (2) local $\delta^{18}O$-rich lake water recharge into adjacent shallow aquifers, followed by additional mobilization of As and other oxyanion-forming elements from the aquifer rocks. We posit that the combined physical-chemical conditions of the aquifers such as oxidizing state, Na–HCO_3 composition, and pH>∼8

lead to enhanced mobilization of oxyanion-forming elements from Fe-oxides and consequently contamination of local groundwater. These geochemical conditions characterize groundwater resources along the Eastern African Rift and thus constitute a potential threat to the quality of groundwater in larger areas of Eastern Africa.

Keywords: Study area, geology and hydrogeology

Groundwater resource potential and status of groundwater resource development in Ethiopia

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ABSTRACT

The groundwater resources potential of Ethiopia is estimated to be about 40 billion cubic meters. Groundwater has been used as the main source of water supply since the 1970s for the main cities, towns and dispersed rural communities across the country, where provision of reticulated surface-water schemes is often expensive because of initial project construction costs and poor water quality. The exponential growth of the urban population and agriculture-led industrial development have resulted in greater attention to groundwater as the potentially cost-effective water supply source. As part of the growing focus on the use of groundwater, the Ethiopian government is currently implementing irrigation projects. One plan involves nine irrigation projects covering an estimated area of 8,000 ha, being developed on a pilot scale, with 9,000 test wells, 28,000 monitoring wells and 14,657 spring improvements. If this unprecedented Ethiopian groundwater-centred development plan is implemented successfully at such a scale, it is highly likely that its success will persuade other Sub-Saharan developing nations to put in place the necessary policies, regulations and investment for infrastructure and capacity development for exploring, exploiting and managing their groundwater resources.

Mengistu, Haile A, Molla B Demlie, and Tamiru A Abiye. “Groundwater Resource Potential and Status of Groundwater Resource Development in Ethiopia.” Hydrogeology Journal 27, no. 3 (2019): 1051–65.

Groundwater Resources in the Main Ethiopian Rift Valley: An Overview for a Sustainable Development

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ABSTRACT

In arid and semi-arid areas, human health and economic development depend on water availability, which can be greatly compromised by droughts. In some cases, the presence of natural contaminants may additionally reduce the availability of good quality water. This research analyzed the water resources and hydrochemical characteristics in a rural area of the central Main Ethiopian Rift Valley, particularly in the districts of Shashemene, Arsi Negelle, and Siraro. The study was developed using a census of the main water points (springs and wells) in the area and the sampling and physico-chemical analysis of the water, with particular regard to the fluoride concentration. In many cases, fluoride content exceeded the drinking water limits set by the World Health Organization, even in the absence of anthropogenic contamination. Two different aquifers were recognized: A shallow aquifer related to the eastern escarpment and highlands, and a deep aquifer in the lowland areas of the rift valley on the basis of compositional changes from Ca–Mg/HCO_3 to Na–HCO_3. The distribution of fluoride, as well as pH and EC values, showed a decrease from the center of the lowlands to the eastern highlands, with similar values closely aligned along an NNE/SSW trend. All these data contribute to creating awareness among and sharing information on the risks with rural communities and local governments to support the adequate use of the available water resources and to plan appropriate interventions to increase access to fresh water, aimed at the sustainable human and rural local development of the region.

Keywords: **groundwater resources**; **fluoride**; **main Ethiopian Rift Valley**

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Groundwaters of the Central Ethiopian Rift: diagnostic trends in trace elements, δ18O and major elements

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ABSTRACT

The Ethiopian Rift (a major portion of the Great East African Rift) is characterized by a narrow elongated depression bounded by highlands from both sides. This topographic configuration leads to a monsoon redistribution which resulted in an arid rift floor and humid high rainfall highlands. The rifting and associated volcanism also caused a thinning of the crust and facilitates influx of CO_2 and other mantle gases as diffuse sources or along faults from deeper sources. Groundwaters in the rift floor are usually of high mineral content (high F, U, As and salinity) while those on the plateau are of low mineral content. Among many factors, groundwater availability and quality in the rift floor aquifers is the function of their connection to the aquifers in the high rainfall plateau and the residence time of groundwater prior to reaching the rift floor. This entails the need for addressing one basic hydrologic question in such a setting: at what depth and rate does recharge from the high rainfall highland reach the lowland rift aquifers? This study uses spatial variations in trace elements and relates them to ^{14}C variations, thereby investigating the suitability of using trace elements as proxies for residence time estimation of groundwaters of relatively short (1,000–2,000 years) residence time. This work also investigates the behavior of trace element trends along the groundwater flow path in a rifted setting and compares them with such trends in sedimentary aquifers elsewhere. The comparison shows a clear difference in behavior of trace elements along the groundwater flow path when compared with such variations in big sedimentary basins with no prominent rifting and volcanism, suggesting the need of calibrating the relation between trace elements and any direct residence time indicators. An integrated use of major elements, trace elements, and environmental isotopes

reveals that the main recharge of the aquifers originates from mountain blocks and that recharge takes place via fractures with no evidence of evaporation prior to recharge. Redox processes appear to play a limited role in trace element geochemistry of groundwaters in the region. Progressive trends in trace element composition along the groundwater flow path suggest continuous groundwater flow from the plateau.

Keywords: Groundwater, Trace elements, Groundwater flow, Ethiopian rift

Kebede, S., Travi, Y., & Stadler, S. (2010). Groundwaters of the Central Ethiopian Rift: diagnostic trends in trace elements, δ18O and major elements. Environmental Earth Sciences, 61(8), 1641-1655.

The contribution of CurvaTool semi-automatic approach in structural and groundwater investigations. A case study in the Main Ethiopian Rift Valley

Sabrina Bonetto, Anna Facello, Gessica Umili

ABSTRACT

In this study, a semi-automatic approach implemented in the code CurvaTool has been applied to the analysis of the structural asset and its potential relationship with local water distribution in an area of the central sector of the Main Ethiopian Rift Valley. A 30 m SRTM DEM was used as input for CurvaTool code. A first processing was performed over the whole area (about 10,640 km^2). Subsequently, a second processing was carried out over a smaller portion of the original DEM, in order to analyze in detail its morphological and structural features. CurvaTool output data show three main linear feature sets, characterized by non-homogeneous distributions, which have been validated by morphological and geological literature data. Concerning the hydrogeological framework, the analysis of water points distribution shows alignments coherent with the trends of linear features extracted by CurvaTool. This correspondence might suggest a structural control on the groundwater flow paths of the analyzed area and highlight the utility of the semi-automatic CurvaTool approach in the preliminary phase of an hydrogeological study in areas where groundwater flow is conditioned by topography and morphotectonic asset, particularly in case of fractured basement aquifer systems in region with lack of geological information or reduced accessibility.

Keywords: MER; CurvaTool **;**SRTM; Groundwater **;**Lineaments.

Sabrina Bonetto, Anna Facello, Gessica Umili The contribution of CurvaTool semi-automatic approach in structural and groundwater investigations. A case study in the Main Ethiopian Rift Valley

The Geomorphology of the Lake Region (Main Ethiopian Rift): The Record of Paleohydrological and Paleoclimatic Events in an Active Volcano-Tectonic Setting

M. Benvenuti, **S. Carnicelli**

ABSTRACT

This paper illustrates the main geomorphological features of the Lakes Region (Main Ethiopian Rift) which resulted from the interplay of Late Quaternary climatic and hydrological changes with volcanism and tectonics typical of an active continental rift. Studies carried out over several decades demonstrated that the evolution of Late Pleistocene–Holocene fluvio-lacustrine systems, recorded by a plethora of geomorphic and stratigraphic features, was forced by abrupt hydro-climatic events of regional to global extent which occurred at 10^4–10^2 years scales. Besides the widely acknowledged hydro-climatic forcing, the active rift setting concurred to regulate, through volcanism and fault activity, erosion/sedimentation rates, geometry of the lakes basin and of the hydrographic network, and water supply to the lakes. A volcano-tectonic imprint was left particularly during the transition from the Late Pleistocene to the Holocene when dramatic hydrological modifications affected the region.

Keywords: Lake evolution Paleogeography Paleohydrology Climate change Rift valley tectonics

M. Benvenuti, S. Carnicelli: The Geomorphology of the Lake Region (Main Ethiopian Rift): The Record of Paleohydrological and Paleoclimatic Events in an Active Volcano-Tectonic Setting.

The impact of climate change on the availability of irrigation water at the rift valley lakes basin in Southern Ethiopia: A review

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ABSTRACT

Agriculture is one of the foremost climate-responsive businesses, with open-air production systems sensitive to temperature and rainfall. This paper reviews recent literature and assesses the impact of climate change on the accessibility of water resources for irrigation. The paper critically reviews recent research findings on climate change's effect on the potential of surface water and groundwater for irrigation in Ethiopia's south rift valley (Abaya-Chamo) Sub-basin. Surface water in the south rift valley Ethiopia sub-basin, including the Abaya and Chamo lakes, is estimated to be just over 5,718 million m3yr-1. Finally, the implications for future study and development are emphasized. The effect of climate change (rainfall and temperature) on the water in the Abaya-Chamo lakes feeder Rivers is different for the near future (2021–2050) and extreme future (2071–2100) time using the RCP 8.5 scenario. Overall, findings show that the availability of water resources for irrigation purposes in the south rift valley Ethiopia sub-basin will be more vulnerable to changes in rainfall and temperature. In conclusion, Stream flow future projection (%) for each feeder river Bilate, Kulfo, Gidabo, and Hare are -9.07, -11.24, 3.89, 4.135, − 0.95, − 1.5, 13.4, and 15.4% respectively

Keywords: Climate Change, Water Resources, Irrigation, Ethiopia, Lakes

The impact of sedimentation and climate variability on the hydrological status of Lake Hawassa, South Ethiopia

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ABSTRACT

Lake Hawassa is a topographically closed lake in the Central Main Ethiopian Rift Valley. The water level of this lake has been rising significantly with an average rate of 4.9 cm/year over the study period (1970-2010). The cause of this rise is not yet sufficiently investigated. The main target of this study is to investigate causal variables for lake level variability in general, and its resultant rise in particular. The study is based on two main hypotheses. The first is concerned with the effect of climate variability on the lake level variability; and the second is related to the effect of sedimentation on the storage capacity of the lake.

The first hypothesis (the effect of climate variability) was investigated through the application of diverse statistical techniques. It comprises the coherence analysis to study the linear relationship between the 3.4 ENSO index and lake level changes. A sequential regime shift algorithm was employed to investigate the variations in the mean values of some selected hydro-climatic variables. Trend test was also used to investigate the variability of the hydro-climatic variables overtime. A simple water balance approach was applied to simulate the lake level variability so as to examine how the model behaves throughout the study period.

The second hypothesis (the effect of sedimentation) was approached by conducting a new bathymetric survey. The result of the new survey was compared with the existing bathymetric map of 1999. The Pacific-Southwest Inter-Agency Committee (PSIAC) model was also employed to identify the "hot-spots" of sediment production in the watershed. In this semi-quantitative model, nine factors affecting sediment yielding the watershed were characterized, rated, and an overlay analysis was performed. Participatory assessment of anthropogenic factors that affect the hydrological status of the lake was conducted through the application of DPSIR (Drivers-Pressures-State-Impact-Response) analytical framework.

The result of the coherence analysis between the monthly lake level changes and the corresponding changes in the ENSO index reveals that the two variables have significant linear relationship over frequencies ranging from 0.13 to 0.14 cycles/month or 1.56 to 1.68 cycles/year.

This corresponds to a dominant average periodicity (coincident cycle) of about 7.4 months. Furthermore, the result of sequential regime shift detections show that most of the significant change points coincide with the occurrences of ENSO events and climate shifts. Generally, the lake level tends to be high during El Niño and low during La Niña years. The typical example is the coincidence of extreme historical maximum lake level to the strongest El Niño event of the century that occurred in 1997/98. The coincidence of climate regime shift in the Pacific Ocean in 1976/77 with an equivalent regime shift in the lake level and rainfall records of this period is considered as additional evidence. The study further reveals the existence of sequential regime shifts in stream flow, runoff coefficient, and lake evaporation which clearly coincide with the occurrences of ENSO phenomena. Results of the Mann-Kendall trend analyses also reveal the significant increasing trend of the lake level and streamflow. On the contrary, decreasing trend of evaporation was observed while rainfall exhibits no trend over the study period. The long-term increasing trend of streamflow from Tikur Wuha sub-watershed without the corresponding increment in rainfall is found to explain the role of land use/cover changes at least in modifying the impact of climate. The application of simple spreadsheet water balance model estimates the long-term (1986-2006) average annual magnitudes of the water balance components as follows: over-lake precipitation (89 Mm3), evaporation from the lake surface (132 Mm3), streamflow from the Tikur Wuha sub-watershed (94 Mm3), and streamflow from the un-gauged sub-watershed (77 Mm3) and storage changes (3 Mm3). Comparison of the two bathymetric maps shows that the average accumulated sediment between the years 1999 and 2010 was estimated as 14 ± 5cm or 13.3 x106 m3. Assuming a constant rate, the mean annual average rate of sedimentation in the lake is about 1.2 cm/year or 1.1 x106 m3. Accordingly, the mean annual reduction in storage capacity of the lake due to siltation is 0.08 %. The attempt to link sediment yield estimate of the bathymetric approach with the estimates of the PSIAC model results in a considerable disagreement as the former estimates 967 m3/km2/year whereas the latter estimates the sediment yield to be in the range of 95-250 m3/km2/yr. The result of participatory assessment of anthropogenic factors and review of previous studies shows that anthropogenic factors show considerable impact on the hydrological status of the lake. Sedimentation and increased runoff are perceived as pressures (immediate causes) for the lake level rise (state). These pressures are perceived to arise from drivers (land use changes, deforestation and misuse/mistreatment of land resources). These drivers in turn had resulted from indirect drivers that comprised population growth and density, agricultural development,

the use of wood as fuel, socio-economic changes, and the existing land tenure system. The interesting finding of this assessment of anthropogenic factors is the presence of promising policy instruments (responses) that support the integrated management of the lake and the watershed. The failure of implementation of these policy instruments is the commonly complained issues among the stakeholders.

Keywords: Sedimentation, climate variability, Lake Hawassa, coherence, regime shift.

Belete, M. D. (2013). *The impact of sedimentation and climate variability on the hydrological status of Lake Hawassa, South Ethiopia* (Doctoral dissertation, Universitäts-und Landesbibliothek Bonn).

Groundwater flow dynamics in the complex aquifer system of Gidabo River Basin (Ethiopian Rift): a multi-proxy approach

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ABSTRACT

Hydrochemical and isotope data in conjunction with hydraulic head and spring discharge observations were used to characterize the regional groundwater flow dynamics and the role of the tectonic setting in the Gidabo River Basin, Ethiopian Rift. Both groundwater levels and hydrochemical and isotopic data indicate groundwater flow from the major recharge area in the highland and escarpment into deep rift floor aquifers, suggesting a deep regional flow system can be distinguished from the shallow local aquifers. The δ18O and δ2H values of deep thermal (≥30 °C) groundwater are depleted relative to the shallow (<60 m below ground level) groundwater in the rift floor. Based on the δ18O values, the thermal groundwater is found to be recharged in the highland around 2,600 m a.s.l. and on average mixed with a proportion of 30 % shallow groundwater. While most groundwater samples display diluted solutions, δ13C data of dissolved inorganic carbon reveal that locally the thermal groundwater near fault zones is loaded with mantle CO2, which enhances silicate weathering and leads to anomalously high total dissolved solids (2,000–2,320 mg/l) and fluoride concentrations (6–15 mg/l) exceeding the recommended guideline value. The faults are generally found to act as complex conduit leaky

barrier systems favoring vertical mixing processes. Normal faults dipping to the west appear to facilitate movement of groundwater into deeper aquifers and towards the rift floor, whereas those dipping to the east tend to act as leaky barriers perpendicular to the fault but enable preferential flow parallel to the fault plane.

Cite this article

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Groundwater origin and flow dynamics in active rift systems – A multi-isotope approach in the Main Ethiopian Rift

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ABSTRACT

In this study, we present a fused multi-scale approach to model habitat suitability index (HSI) maps for three different locust species. The presented methodology was applied for the Italian locust (Calliptamus italicus, CIT) in Pavlodar oblast, Northern Kazakhstan, for the Moroccan locust (Dociostaurus maroccanus, DMA) in Turkistan oblast, South Kazakhstan and for the desert locust (Schistocerca gregaria) in Awash river basin, Ethiopia, Djibouti, Somalia. The main novelty is based on implementing results from ecological niche modelling (ENM) with time-series analyses of high spatial resolution remote sensing data (Sentinel-2) and further auxiliary datasets in a fused HSI model. Within the ENM important climatic variables (e.g. temperature, rainfall) and edaphic variables (e.g. sand and moisture contents) are included at a coarse spatial resolution. The analyses of Sentinel-2 time-series data enables mapping locust breeding habitats based on recent remotely sensed land observation at high spatial resolution and mirror the actual vegetation state, land use, land cover and in this way identify areas with favorable conditions for egg survival and breeding. The fused HSI results for year 2019 were validated based on ground field observation and reach area under curve (AUC) performance of 0.747% for CIT, 0.850% for DMA and 0.801% for desert locust. The innovation of this study is a multi-scale approach which accounts not only for climatic and environmental conditions but also for current vegetation and land management situation. This kind of up-to-date spatial detailed information on breeding suitability could enable area prioritization for risk assessment, monitoring and early intervention of locust pests.

Bretzler, A., Osenbrück, K., Gloaguen, R., Ruprecht, J. S., Kebede, S., & Stadler, S. (2011). Groundwater origin and flow dynamics in active rift systems–A multi-isotope approach in the Main Ethiopian Rift. *Journal of Hydrology*, *402*(3-4), 274-289.

Groundwater Potential Assessment Using Vertical Electrical Resistivity Method: A Case of Selam Bere Town, Gamo Gofa Zone Main Ethiopian Rift Valley

Mulugeta Markos Tediso, Lamessa Fekede Neger

ABSTRACT

Electrical sounding method was supported to evaluate groundwater potential in Selam Ber catchment, Gamo Gofa district in southern Ethiopia. Records were collected after five sounding points via Schlumberger investigation arrays per maximum half-done current electrode separation (AB/2 =220). Qualitative analyses of Electrical resistivity data were described by means of curves, apparent resistivity, and pseudo depths. The numerical explanations of the electrical resistivity data were made by the data using IPI-Res3, IRIS, surfer software, building geo-electric unit near the survey line and geologic proof from the drill. The vertical electrical resistivity results of the data shown four geo-electric stratums which differ in range of cracking, enduring, and formation. Examining the potential aquifer of Traverse Route SELATr1, the fourth layer group with resistivity value of 45.76-50.66 Ωm. & infinite depth also reveals highly moderately weathered & fractured basalt. Geoelectric section obtained along Traverse Route SELTr1, the horizons of stratum four were enhanced potential aquifers such as the highly cracked and worn ignimbrite level of potential ground water depth could be realized if the fractured zone could be penetrated up to the fresh massive rock of the third depth layer group with estimated final depth of 250 meters. And Traverse Route SELATr2 the resistivity soundings have identified five layers excluding BfVES-6; all are having similar curve types. The value of the true resistivity does not vary significantly found in the same geologic and hydro geologic pattern. Generally the possibility of striking water is undeniable starting from 45 meters (shallow aquifer) in all Vertical Electrical Resistivity

Keywords:Ground Water, Vertical electrical sounding, Water resource, Traverse Route

Tediso, M. M., & Negero, L. F. (2022). Groundwater Potential Assessment Using Vertical Electrical Resistivity Method: A Case of Selam Bere Town, Gamo Gofa Zone Main Ethiopian Rift Valley. *JOURNAL OF ALGEBRAIC STATISTICS*, *13*(2), 3050-3059.

Groundwater prospective mapping using remote sensing and GIS techniques: the case of Meki watershed in Central Rift Valley, Ethiopia

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ABSTRACT

Groundwater prospective mapping has several functions, including irrigation water supply, domestic and industrial water uses. This study aimed to map prospective groundwater zones in the Meki watershed, Ethiopia. Climate, physiographic, geologic, and satellite image data were used as factors for groundwater mapping. Thematic maps of rainfall, land use/land cover, soil, drainage density, slope, geomorphology, elevation, and geology were analyzed using ArcGIS 10.4. Land use/land cover classification was based on the 2016 satellite images. The PCI Geomatica 10.3 package was used to produce the lineament map, and eventually, the lineament density map was produced using ArcGIS 10.4. We used the Analytical Hierarchical Process (AHP) tool to prioritize the different factors affecting the groundwater condition of the area. The reclassified thematic layers of the factors were overlaid using weighted linear combination analysis in Arc GIS 10.4. The result depicted that geomorphology, geology, and land slope shared a higher weight having 26%, 20%, and 18%, respectively. Small areal coverage is accounted for by very high and low zones of groundwater potential, and a significant portion of the watershed falls in high (30% of the watershed) to moderate (35% of the watershed) groundwater potential zones indicating good groundwater prospects in the region. The produced groundwater potential map was validated using data from groundwater well inventories. According to the groundwater flow vector, groundwater flows primarily from the northwest to the southeast. Therefore, this study's results could help locate potential groundwater well sites for various purposes in the Meki watershed, Ethiopia.

Keywords: AHP, GIS and remote sensing, Groundwater prospective zones, Meki watershed, Weighted overlay analysis

Doyo, D. W., Gebrekristos, S. T., Kasa, A. S., & Hatiye, S. D. (2022). Groundwater prospective mapping using remote sensing and GIS techniques: the case of Meki watershed in Central Rift Valley, Ethiopia. *Sustainable Water Resources Management*, *8*(6), 1-23.

Groundwater quality and its health impact: An assessment of dental fluorosis in rural inhabitants of the Main Ethiopian Rift

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ABSTRACT

This study aims to assess the link between fluoride content in groundwater and its impact on dental health in rural communities of the Ethiopian Rift. A total of 148 water samples were collected from two drainage basins within the Main Ethiopian Rift (MER). In the Ziway-Shala basin in particular, wells had high fluoride levels (mean: 9.4±10.5mg/L; range: 1.1 to 68 mg/L), with 48 of 50 exceeding the WHO drinking water guideline limit of 1.5mg/L. Total average daily intake of fluoride from drinking groundwater (calculated per weight unit) was also found to be six times higher than the No-Observed-Adverse-Effects-Level (NOAEL) value of 0.06 mg/kg/day. The highest fluoride levels were found in highly-alkaline (pH of 7 to 8.9) groundwater characterized by high salinity; high concentrations of sodium (Na^+), bicarbonate (HCO_3^-), and silica (SiO_2); and low concentrations of calcium (Ca^{2+}). A progressive Ca^{2+} decrease along the groundwater flow path is associated with an increase of fluoride in the groundwater. The groundwater quality problem is also coupled with the presence of other toxic elements, such as arsenic (As) and uranium (U). The health impact of fluoride was evaluated based on clinical examination of dental fluorosis (DF) among local residents using the Thylstrup and Fejerskov index (TFI). In total, 200 rural inhabitants between the ages of 7 and 40 years old using water from 12 wells of fluoride range of 7.8-18 mg/L were examined. Signs of DF (TF score of ≥ 1) were observed in all individuals. Most of the teeth (52%) recorded TF scores of 5 and 6, followed by TF scores of 3 and 4 (30%), and 8.4% had TF scores of 7 or higher. Sixty percent of the teeth exhibited loss of the outermost enamel. Within the range of fluoride contents, we did not find any correlation between fluoride content and DF. Finally, preliminary data suggest that milk intake has contributed to reducing the severity of DF. The study highlights the apparent positive role of milk on DF, and emphasizes the importance of nutrition in management efforts to mitigate DF in the MER and other parts of the world.

Du C, Xiao P, Gao S, Chen S, Chen B, Huang W, Zhao C.Front Bioeng Biotechnol. 2022 May 20;10:791433. doi: 10.3389/fbioe.2022.791433. e Collection 2022.

Investigating Causes of Origin and Engineering Geological Characterization of Ground Cracks around Ziway and Ropi Area in Central Rift Valley of Ethiopia

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ABSTRACT

The present study was conducted on, ground-cracks at Weyo, Someyen, Galo-Rephi and Ropi areas in Central Rift valley of Ethiopia, about 145 km south of Addis Ababa. The study was conducted to identify the causes of ground-cracks, mainly through engineering characterization of soils of the area. The soils were investigated in the field and through laboratory analysis. Further, based on the index and engineering properties, collapse potential of the soils was assessed. Two major types of soils namely, 'silty sands' and 'sandy silts' with minor gravel constituents were identified. The non-clayey constituent minerals of the soils were also identified. The observations revealed that volcanic glass is the most abundant mineral in most of the soils. The soils were also found to possess collapsible potential. The dispersiveness of the soils was also estimated. The high sodium content in soils indicated that soils are dispersive in nature. Thus, it has been found by engineering characterization of soils that it generally possesses low plasticity, high void ratio, low density, high collapse potential and high dispersivity. From the present investigation, it is concluded that apart from other triggering factors, the soils of the study area by itself possess a potential to collapse and thus, resulted into development of ground-cracks. Finally, the possible mechanism involved in the formation of various ground-cracks in the study area is also explained.

Keywords: Ground cracks, Hydro-compaction, Soil characterization, Soil collapse potential, Soil dispersivity

MIDEKSSA, K., RAGHUVANSHI, T. K., & ABEBE, B. (2015). Investigating Causes of Origin and Engineering Geological Characterization of Ground Cracks around Ziway and Ropi Area in Central Rift Valley of Ethiopia. *OF EARTH SCIENCES AND ENGINEERING*, 1069.

A Morphometric Analysis of Wonji Drainage Basins around Central Rift Valley, Ethiopia, using Geospatial Tools

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ABSTRACT:

The morphometric analysis of the Wonji drainage basin of central Ethiopian Rift valley was carried out using geospatial technique. The study was focused to observe the different aspects of drainage morphometry of the Wonji basin. It was observed that the Wonji basin is of mainly dendritic pattern in the upper reaches and trellis pattern in the lower part of the basin. A fifth order rivers drain the basins and morphometric study shows that the basins are characterized by undulating, highly dissected, moderately sloped region with homogeneous geological materials. The study indicates that the area is having poor to moderate ground water potential. It also illustrates that geospatial technique is an apt technology for drainage analysis.

Keywords: Geospatial technique, Digital elevation model, Morphometric analysis, Wonji Drainage Basin

Shreedhara, V., Shankar, K., & Haji, M. A Morphometric Analysis of Wonji Drainage Basins around Central Rift Valley, Ethiopia, using Geospatial Tools.

A scenario-based modeling of climate change impact on the hydrology of Ketar watershed, Central Rift Valley Basin, Ethiopia

Debele Abera Abdi & Tenalem Ayenew *Modeling Earth Systems and Environment* **volume 8**, pages3473–3486 (2022)Cite this article**141** Accesses**2** Citations Metricsdetails

ABSTRACT

Global climate change poses uncertainties and unpredictability to the watershed hydrologic processes in many parts of the world. In line with global climate change prediction and local studies, sets of scenarios were adapted with warming between 2.5 °C and 4 °C upon ending of 21 century and up to ± 20% variation in annual precipitation in the watershed. This study presents scenario-based modeling of climate variables on hydrologic processes of the Ketar watershed in the Central Rift Valley Basin, Ethiopia. The WEAP hydrologic model, a physically based model, was applied to assess the response to altering climate in the watershed. It is a lumped continuous model with a one-dimensional, two-layer soil water dynamic accounting system. The method used empirical functions to describe the hydrologic components of the watershed. In comparison with the baseline years, a 20% surge in annual precipitation and with a respective advance in temperatures would increase by 14–15% evapotranspiration, 34–36% interflow, 213–2001% surface runoff, and 34–36% recharge, respectively. In contrast, a 20% downward trend in mean annual precipitation amount with a respective increase in temperatures would decrease evapotranspiration, interflow, surface runoff, and recharge by 16–17, 37–38, 83, and 37–38%, respectively. The annual groundwater recharge shows high sensitivity to variation in precipitation and modest for temperature change. These findings will have implications on groundwater recharge and its vulnerability to climate at the watershed, and its effect on the water system (lakes and groundwater) in the low-lying rift floor region.

Abdi, D. A., & Ayenew, T. (2022). A scenario-based modeling of climate change impact on the hydrology of Ketar watershed, Central Rift Valley Basin, Ethiopia. *Modeling Earth Systems and Environment*, *8*(3), 3473-3486.

A systematic review of studies on freshwater lakes of Ethiopia

Author links open overlay panel Yonas Getaneh [a]Wuletawu Abera[b] Assefa Abegaz[a] Lulseged Tamene[b]

ABSTRACT

Study Region

The study covers the freshwater lakes of Ethiopia, which constitute about 87 billion cubic meters of water volume. The lakes are facing continued ecosystem degradation threats.

Study Focus

The aim of this study was to make an inventory of existing literature regarding the freshwater lakes of Ethiopia and identify gaps and priorities for future research directions. This was done through a systematic review of published scientific literature related to the lakes and characterizing each study based on different criteria.

New Hydrological Insights for the Region

We found a total of 231 articles on freshwater lakes of Ethiopia published in peer-reviewed journals between 1930 and March 2021. Most studies were focused on hydrochemical and biological characteristics of lakes, with less attention to physical structure and processes (including siltation, lake morphometry and catchment biophysical characteristics). Furthermore, (a) less attention was given to the spatial and temporal dynamics of variables that affect the freshwater lakes, (b) there was limited linkage between landscape hydrological dynamics and freshwater lakes and (c) the smaller highland lakes were given limited attention. Future research should be oriented to the study of the relationship between catchment biophysical dynamics and lake hydrological characteristics.

Keywords: Systematic literature review Freshwater Ethiopia Lake hydrological dynamics Hydrologic modeling

Getaneh, Y., Abera, W., Abegaz, A., & Tamene, L. (2022). A systematic review of studies on freshwater lakes of Ethiopia. *Journal of Hydrology: Regional Studies*, *44*, 101250.

Gully network expansion and spatial and temporal dynamics of catchment geomorphic characteristics and gully topographical thresholds in the semi-arid Ethiopian Rift Valley

Shiro Mukai, Paolo Billi, Nigussie Haregeweyn, Mesenbet Yibeltal, Tilahun Hordofa

ABSTRACT

To analyse the driving forces of gully erosion using a present dataset of geomorphic parameters and land use/cover involves limitations because past datasets at the time of gully incision may best explain the gully formation and evolution at that time. The recent development of photogrammetric techniques enabled to estimate temporal gully volume changes. This study conducted in semi-arid Ethiopian Rift Valley used field measurements and gully volume–length relation to analyse spatial and temporal dynamics of catchment geomorphology and topographical threshold of gully heads to explain the difference in the gully volumes and area-specific gully volumes between two study sub-areas. The topographic thresholds of the gully heads, expressed by the slope (= s) and drainage area (= a), (i) formed in each catchment and (ii) that had the same land use/cover items (forest, grassland, and farmland) in all the catchments of each sub-area were approximated by power functions ($s = ka^{-b}$). Analysis of covariance found that these threshold lines had clear spatial and temporal patterns: the threshold lines maintained almost the same exponent b specific to each sub-area while the threshold coefficient k significantly decreased in the order of forest, grassland, and farmland. The spatial variability and its temporal changes in relief aspect of the catchment morphology can responsible for the difference in the area-specific volumes of gullies between the sub-areas, while the continuous reduction in vegetation cover over time can be the main driving force of the similar scale and changing patterns of the gully volumes between the sub-areas.

Holocene Environmental History of Lake Chamo, South Ethiopia

Tsige Gebru Kassa

Universität zu Köln, 2015

ABSTRACT

East African Rift Valley Lakes hold a rich source of information for palaeoclimate change. Specifically, the sediment archives of Lake Chamo, one of the Ethiopian Rift Valley Lakes, reveal short-term climatic fluctuations and environmental instability during the Holocene, since it is located in a temporary endorhëic system. Currently there are no substantial studies yet that investigate palaeoenvironmental history of Lake Chamo. The objective of this thesis is to reconstruct the Holocene climatic and environmental history of Lake Chamo at high temporal resolutions. The specific aim of the project is to estimate climate-driven and anthropogenic environmental change during the Holocene, and to test a hypothesis that there were rapid climate fluctuations during the termination phase of the "African Humid Period" (AHP). Initially, the first continuous and high-resolution geochemical and geophysical core data from the sediments of Lake Chamo using X-Ray Fluorescence (XRF) core scanner and Geotek Multi-Sensor-Core-Logger (MSCL) respectively, is presented. Using these techniques palaeoclimatic conditions of the region during the Holocene are reconstructed. Additionally, the core chronology is established using Accelerator Mass Spectrometry (AMS) radiocarbon analysis, the results of which show that the core dates back to 9000 cal yr BP. Early-Holocene can be seen to be characterised wetter climatic conditions as recorded from the relative lower lightness values, high Silicon to Titanium ratio (Si/Ti), and minimum calcium concentration in the sediment. Pronounced peak in calcium and Strontium content, which are the main features of the early-mid Holocene transition period, are ascribed to a high evaporation to precipitation ratio, implying the aridity of the region in this time frame. In addition, the peak values of magnetic susceptibility (MS), Potassium (K), Titanium (Ti), Silicon (Si), and Iron (Fe) during 1500–800 cal yr BP are found to be associated to a change in intensity of anthropogenic land use in the area surrounding the lake. Subsequently, the charcoal counting and detection of benzene polycarboxylic acids (BPCA) methods are implemented to estimate paleofire occurrence in relation to climatic and anthropogenic impact of Lake Chamo. These results are used to correlate the long term trends in fire occurrence in relation to climate, vegetation and human activities at different spatial and

temporal scales. Fire occurrence was found to be higher during the early Holocene, typically identified through black carbon (BC) from woody or shrub vegetation sources. The occurrence of fire was found to be lower during the mid-Holocene, due to the presence of predominantly grass savannah which usually results in reduced biomass burning in response to drier condition. Climate and vegetation were found to be the main factors for fire occurrence during the early and mid Holocene, whereas the increased fire intensity since 2000 cal yr BP record is potentially attributed to anthropogenic forcing. Finally, ostracod analyses are used to gain evidence about climatic and hydrological instability of southern Ethiopia during the Holocene. The ostracod study focuses on the taxonomy, stratigraphy and the use of ostracod assemblages to interpret the palaeoenvironments established during Holocene period. Ostracod assemblages were found to be infrequent and of limited diversity in the sediment profile, implying a period of wetter conditions. The highest abundance and more diverse ostracod assemblage were found to be associated with periods of drier climatic condition in the Lake Chamo records. To summarize, the geophysical, geochemical, charcoal, and ostracod data analysis, alongside core chronology results of this thesis have been used to reconstruct Holocene climatic and environmental history of Lake Chamo region, and of the East Africa region as a whole. The main results of this study provide significant input for the understanding of climate variability in the Holocene, as well as identifying termination of the African human period was gradual in Lake Chamo region

Hydrochemical characterization and quality assessment of groundwater in Meki River Basin, Ethiopian Rift

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Sustainable Water Resources Management 6 (6), 1-21,

ABSTRACT

The present study was carried out in Meki River Basin (Ethiopian Rift) aiming at characterizing the hydrochemical composition of groundwater and evaluating the water quality status for drinking and irrigation uses. For this purpose, 63 primary groundwater samples from springs, hand-dug wells, and boreholes were collected and subjected to major ions analysis besides the in situ tests. The analysis result illustrates that Na+ and HCO3− are the principal cation and anion in the study area. The spatial investigation of the physiochemical parameters revealed that temperature, pH, TDS, EC, Na+, K+, HCO3−, Cl−, SO42−, and F− show a positive trend from the highland towards the rift floor along the groundwater flow direction. On the contrary, Ca2+ and Mg2+ show a negative tendency along the groundwater flow path. The groundwater of the study area generally evolves from predominantly fresh (TDS < 200 mg/l) Ca/Mg–HCO3 water type in the upland area to moderate TDS (200–750 mg/l) Na/Ca–HCO3 water type in the transitional escarpment and lastly to dominantly mineralized (TDS > 750 mg/l) Na–HCO3 water type in the rift floor following the regional groundwater flow path. Gibbs diagram supported by ionic ratio (Na+ + K+/Ca2+ + Mg2+ vs total cations (TZ+) and Chloro-Alkaline Indices (CAIs) suggests that rock–water interaction (silicate hydrolysis and cation exchange) is the major hydrochemical processes controlling the evolution of the groundwater in the study area. 19% of TDS, 11% of EC, 83% of K+, 84% of HCO3−, and 52% of F− of the total water samples were unsuitable for the drinking uses compared with WHO water quality guideline. Spatial distribution maps of major ions (Ca2+, Mg2+, Na+, K+, Cl−, HCO3−, SO42−, and F−) and binary plots of physical parameters (temperature, pH, TDS, and EC) with elevation were produced. Both the spatial maps and binary plots generally show a water quality drop rift wards. Similarly, using multiple agriculture water quality criteria such as EC, SAR, RSC, PI, and Na%,

the suitability of the groundwater for agricultural use was evaluated. Except a few samples in the rift floor, the majority of the water

Comprehensive and detailed investigation for the hydrochemical sources is suggested.

ABSTRACT

Study region

The Matahara region is located in the East Showa zone of Oromiya regional state (Ethiopia). Matahra Sugar Estate and Lake Basaka (highly saline, alkaline and sodic lake) are situated within the flat plains of Matahara region. The area is vulnerable to the occurrences of various tectonic and volcanic activities due to its location in the upper most part of the Main Ethiopian Rift Valley region.

Study focus

In this study, the hydrochemical properties of different surface water and groundwater bodies available at Matahara region have been characterized for quality compositions. Water samples were collected from different water sources and analyzed for important major quality parameters following standard test procedures. Other chemical indices were derived from the measured quality parameters. The potential sources of minerals were suggested for each of the considered water sources based on their quality characteristics.

New hydrological insights for the region

Overall, the study result elucidates that the chemical composition of different water bodies are due to natural processes and/or anthropogenic activities within the region. The local anthropogenic processes could be discharges from factory, domestic sewage and farming activities. Some of the water types are found to have relatively higher concentration of dissolved constituents. Irrigation waters have almost equal chemical compositions, indicating their hydrochemical sources are almost the same. Most of the concentrations are relatively high in Lake Basaka, groundwater and hot springs. It is easy to imagine the potential damaging effects of such quality waters on crop production, soil properties and environment of the region.

Keywords

Impact of Land Management Practices on Groundwater Recharge: Case of Edo-Watershed in the Ethiopian Rift Valley Basin

Ashenafi Dora Dokamo

ABSTRACT

Proper water resource planning requires an understanding of the availability and use of ground water. But, there is lack of information in the Edo watershed on groundwater availability, rate of recharge, and there is limited information on the impact of land management on groundwater. In line with this, the objective of this study was to determine the impact of land management practices on groundwater recharge and soil water dynamics on conserved land and bare land at the Edo watershed in Wondogenet. In this study, the Hydrus-1D model and water table fluctuation methods were used to estimate groundwater recharge. Hydrus -1D model is the Richards-based vadose zone hydrological model. The meteorological, and soil hydraulic data were used as input data to the Hydrus-1D model. Soil hydraulic parameters were estimated from easily measured soil physical properties using ROSETTA-derived prior information about soil hydraulic parameters. Water table data from twenty-five wells was used to estimate the recharge. The model performance was evaluated by comparing the observed and simulated soil water content values both on conserved land and bare land in the study area. The high value of 0.997 and a low value of ME (0.049) for calibration and a high value of 0.99 for Conserved land and 0.93 for bare land and low (RMSE of 0.23-0.28, MEB of 0.057-0.23) values during validation showed that there was a good agreement between the observed and simulated soil water content. The overall evaluation according to the common performance evaluation techniques revealed that the observed and simulated soil water content in conserved land washigher compared to those in bare land. From the Hydrus -1D, the long-term average annual groundwater recharge was 3,976,409.32 m3 or 297.8896mm, which is 26.92 % of average annual rainfall, and the water table fluctuation method 257mm, which is 23.23% of average annual rain fall. From the result, it can conclude the conserved land was better than bare land due to storing more water. The current observation showed that good land management practices were useful to sustain the water resources in the watershed.

Dokamo, A. D. (2022). Impact Of Land Management Practices On Groundwater Recharge: Case Of Edo-Watershed In The Ethiopian Rift Valley Basin (MSC Thesis).

Depth estimates of anomalous subsurface sources using 2D/3D modeling of potential field data: implications for groundwater dynamics in the Ziway-Shala Lakes Basin, Central Main Ethiopian Rift

ABSTRACT

Quantitative analysis of potential field data are made in the Ziway-Shala lakes basin over an area bounded by 38°00′ E - 39°30′ E and 7°00′ N - 8°30’ N. Most previous geophysical studies in the region under consideration focus on mapping the deep crustal structures and undulation of the Moho depth. Only few studies are targeted at mapping the shallow subsurface structures. The main focus of this paper is mapping geometries of the major lithological and structural units of the shallow subsurface using gravity and magnetic data. The ultimate objective of the research is to understand the hydrogeological dynamics of the region through mapping interfaces geometries. Automatic inversions, 2D joint forward modeling and 3D inversion are the major techniques employed. The 2D Werner de-convolution based on both gravity and magnetic data along the rift axis showed source depths tending to deepen northwards. Source depths estimates determined by Source Parameter Imaging also showed similar tendency. This is further strengthened by the joint 2D forward modeling of gravity and magnetic data which showed the top of the basement is sloping northwards. The result of the 3D gravity interface inversion agrees with results of the above mentioned depth estimation techniques. Finally, the gravity power spectral analysis resulted in two depth estimates, 1.53 km and 2.87 km which approximate the positions of two density interfaces. The shallow depth interface is thought to presumably delineate the low density Fluvio-lacustrine sediments including the rift floor volcanic units and crystalline basement. Our investigation results agree with the results of previous seismic studies which identified low velocity (“sediment-volcanic”) horizon in the rift floor with low resolution. The information obtained with regard to water balance of the basin, salinity level of the lakes and the conceptual hydrological flow model appears to reveal that the groundwater flow in the study region is controlled by subsurface structures, particularly, the mapped interface topographies.

Exploring future global change-induced water imbalances in the Central Rift Valley Basin, Ethiopia

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Climatic Change volume 164, Article number: 47 (2021) Cite this article

ABSTRACT

Lake Ziway, the only freshwater lake in Ethiopia's Central Rift Valley basin, has been the source for irrigation, floriculture, fish farming and domestic water supply in the region for the last few decades. This study examined the impacts of the planned future agricultural developments and climate change on the lake water balance by an integrated application of the Soil Water Assessment Tool and Water Evaluation and Planning models. The future projections of precipitation and temperature from the Coordinated Regional Downscaling Experiment, CORDEX-AFRICA, under the Representative Concentration Pathways 4.5 and 8.5 were used for the climate change impact assessment. Nine irrigation development and climate change scenarios were developed and simulated to examine the separate and combined impacts on the lake water balance and supply coverages. The study showed that the planned future agricultural developments could result in a mean annual lake water level decline by about 0.15 m, with a considerable reduction (27% to 32%) in the outflow to the downstream Bulbula River. Climate change could increase evaporation losses from the shallow lake resulting in a drastic decrease in the lake water level, especially during the dry season. It could also significantly reduce (by about 74%) the amount of water flowing out of the lake. The combined impacts of future development and climate change are likely to reduce the supply coverages of most of the competing demands. Approaches need to be studied to minimize the lake water evaporation losses and explore water demand/supply management options.This is a preview of subscription content, access via your institution.

Musie, M., Momblanch, A. & Sen, S. Exploring future global change-induced water imbalances in the Central Rift Valley Basin, Ethiopia. Climatic Change 164, 47 (2021). https://doi.org/10.1007/s10584-021-03035-x

Fluoride ion and total dissolved solid distribution in Ethiopian Rift valley: The case of Hawassa city aquifer

ABSTRACT

The Main Ethiopian Rift valley (MER) region, where millions rely on fluoride contaminated drinking water that is by far higher than the WHO standard resulting skeletal and tooth decay.Study focus Pumping test and drilling lithology data of the already drilled and productive 25 wells (25 m–200 m depth) to characterize the aquifer. Particular emphasis is given to the spatial distribution of fluoride ion (F-) and Total dissolved solids (TDS) applying SPSS (Statistical Package for the Social Scientists) statistical tool.New hydrological insights for the regionThe major water bearing formation is of weathered and fractured geologic formation having high porosity and permeability, which resulted in risk of shallow groundwater surface contamination. The concentration of fluoride ion, ranging from 0.65mg/l to 11mg/l is under significance influence by the geochemistry. Higher temperature at the shallow aquifer along with geological process like weathering of rocks and dissolution of CaF2 promotes the concentrated availability of fluoride ions. The deeper the strata along with igneous formation dominated by pumice, the lower the concentration showing strong inverse correlation with depth for both F- and TDS with R2 =0.78 and R2 =0.68 respectively at $\alpha < 0.001$. Either drilling wells beyond such formations (=60m) or blinding the poor quality strata is recommended to minimize the effect of high fluoride and TDS concentration in drinking water for Hawassa city aquifer.

Keywords: Aquifer Fluoride ion Geochemistry Hawassa catchment Drinking water Rift valley

Potential human health risks due to groundwater fluoride contamination: A case study using multi-techniques approaches (GWQI, FPI, GIS, and HHRA) in Bilate River

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ABSTRACT

The main focus of the present research was to examine the appropriateness of groundwater resources for drinking purposes in the Bilate River Basin of Southern Main Ethiopian Rift, Ethiopia. The groundwater quality index (GWQI), fluoride pollution index (FPI), and human health risk were used to examine the human health risk factors associated with the intake of high fluoride groundwater. For this purpose, 29 groundwater samples were collected from the existing wells and were analyzed for various physicochemical parameters. The dominant cation was Na^+, followed by Ca^{2+}, Mg^{2+}, and K^+. The dominant anion was HCO_3^-, followed by Cl^-, SO_4^{2-}, and F^-. The Gibbs plot shows that rock-water interactions are the dominant factor controlling the groundwater chemistry. By using the GWQI, the quality of groundwater samples was 31% excellent, 21% good, 31% poor, and 17% very poor. The fluoride concentration in groundwater ranges from 0.2 to 5.60 mg/L (mean, 2.10 mg/L). 59% (i.e., 17 wells) of the groundwater samples were not suitable for drinking, because they surpassed the drinking water quality limit of

1.5 mg/L. The remaining 41% (i.e., 12 wells) of the samples were suitable for drinking. The FPI indicates that 51.72% of the wells were highly polluted by fluoride. The noncarcinogenic health risk varies from 0.75 to 8.44 for children (83%), 0.34–3.84 for women (62%), and 0.27–3.01 for men (52%), which indicates that children are at higher health risk than women and men due to the physiological condition and the rates of ingestion.

Haji, M., Karuppannan, S., Qin, D., Shube, H., & Kawo, N. S. (2021). Potential human health risks due to groundwater fluoride contamination: A case study using multi-techniques approaches (GWQI, FPI, GIS, HHRA) in Bilate River Basin of Southern Main Ethiopian Rift, Ethiopia. *Archives of environmental contamination and toxicology*, *80*(1), 277-293.

Physicochemical and biological water quality assessment of Lake Hawassa for multiple designated water uses

ABSTRACT

Lake Hawassa is one of the Major Ethiopian Rift Valley Lakes which is situated in southern regional state, which has a closed basin system and receives water from only Tikurwuha River and runoff from the catchment. Quality of the lake water is vital for the surrounding community for proper and safe use of the lake. The present study was designed to examine the physicochemical and biological water quality suitability for multiple purposes and to determine trophic state index of the lake for a period of three months from December to February, 2011/12. Water samples were collected from the lake on monthly basis and analyzed for all water quality parameters by using standard methods. Data analysis was performed by descriptive, multivariate analysis (MANOVA) and Tukey-Kramer test. The overall water quality parameters analytical results have been observed as pH (7.5), TDS (450.1), temp.(21.23°C), DO (17.85), turbidity (8.44 NTU), COD (48.73), BOD5 (117), F^- (12.8), NO_3^- (5.27), PO_4^{3-} (1.12), NO_2^- (0.04), TN (5.42), TP (0.37), Cl^- (30.84), Mn (0.09), Zn(0.19), Na^+(331), Chlorophyll-a(25.45 µg/L), TC(11,883 MPN/100 ml) and FC (99.67 MPN/100 ml) and units for others in mg/L. On the other hand, the value of indices for irrigation water quality was SAR (12.2-16), SSP (83.77-84.34%), MAR (93.83-95.37%) and KR (5.71-7.18). The values of the whole analyzed parameters have shown significant variation in site ($P<0.05$). As irrigation water quality mainly focuses on the indices of SAR and EC/TDS, the lake water is in good condition for the purpose. The values of trace heavy metals were under permissible limits for multiple aspects. On average, the trophic state index of the Lake Hawassa was hypereutrophic (TSI=72.6), as Carlson value category. In general, the lake water is not suitable for drinking, recreational and irrigation of some raw consuming crops but it is suitable for aquatic life.

Adimasu, W. W. (2015). Physicochemical and biological water quality assessment of Lake Hawassa for multiple designated water uses. *Journal of Urban and Environmental Engineering (JUEE)*, *9*(2), 146-157.

Groundwater recharge modelling in a large scale basin: an example using the SWAT hydrologic

Gyamfi, Charles, Julius Musyoka Ndambuki, Geophrey Kwame Anornu, and Gislar Edgar Kifanyi

ABSTRACT

Groundwater constitutes an essential resource that augments surface water resources in meeting the water supply needs of man and the ecosystem. Most importantly in arid and semi-arid environments where rainfall patterns are erratic, groundwater resources are often the preferred source of water. This causes enormous pressure on the resource leading to diminishing groundwater resources. Land use changes also impact on groundwater resources through alterations in the hydrologic regime. It is imperative therefore to evaluate groundwater recharge dynamics under changing land uses to provide for a better resource planning and allocation. We present in this study, an investigation into groundwater recharge dynamics of the Olifants Basin, a water stressed basin in Southern Africa over the past decade with considerations to land use changes. Three land use change scenarios were developed to simulate the groundwater recharge of the basin within the Soil and Water Assessment Tool (SWAT) environment. The SWAT model was calibrated (1988–2001) and validated (2002–2013) with good model performance statistics; NSE, R^2, PBIAS, RSR of 0.88, 0.89, −11.49%, 0.34 and 0.67, 0.78, −20.69%, 0.57 respectively for calibration and validation stages. Findings indicate groundwater recharge declined by 10.37 mm (30.3%) and 2.34 mm (9.82%) during the periods 2000–2007 and 2007–2013 respectively. The decline in groundwater recharge was linked to the changes in urban (9.2%), agriculture (6.1%), rangelands (−16.8%) during the period 2000–2007 and urban (1.3%), agricultural (14%), rangelands (−14.8%) during 2007–2013. The SWAT model reveals it capabilities as a decision support tool (DST) in groundwater recharge assessment for large scale basins.

Gyamfi, C., Ndambuki, J. M., Anornu, G. K., & Kifanyi, G. E. (2017). Groundwater recharge modelling in a large scale basin: an example using the SWAT hydrologic model. *Modeling Earth Systems and Environment*, *3*(4), 1361-1369.

Estimation of Runoff and Sediment Yield Using SWAT Model: The Case of Katar Watershed, Rift Valley Lake Basin of Ethiopia Authors

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ABSTRACT

Estimating runoff and sediment yield at watershed level is important for better understanding of hydrologic processes and identifying hotspot area by using Soil and Water Assessment Tool (SWAT) model for intervention strategies. From the result of Global sensitivity analysis, 12 highly sensitive parameters identified. The obtained results were satisfactory for the gauging station (coefficient of determination (R^2)=0.8, Nash-Sutcliffe Efficiency (NSE)=0.6 and percent difference or percent bias (PBIAS)=0) from 1990 to 2005(16) years used calibration and (R^2=0.6, ENS=0.55and PBIAS=1.2) from 2006 to 2013(8 year) were used for validation period respectively. Among all sub-watersheds, nine sub watersheds were more vulnerable to soil loss and potentially prone to erosion risk, which was out of range of tolerable soil loss rate (18 $tha^{-1}yr^{-1}$). In conclusion, the SWAT model could be effectively used to estimate runoff and sediment yield; and identified hotspot area. In addition, the result could help different stakeholders to plan and implement appropriate interventions strategies in the Katar watershed.

Dulo Husen, Brook Abate, Estimation of Runoff and Sediment Yield Using SWAT Model: The Case of Katar Watershed, Rift Valley Lake Basin of Ethiopia, *International Journal of Mechanical Engineering and Applications*. Volume 8, Issue 6, December 2020 , pp. 125-134. doi: 10.11648/j.ijmea.20200806.11

Analysis of Physico-chemical Characteristics of Water Collected from Different Sampling Sites of Lake Hawassa, Ethiopia

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ABSTRACT

The research aimed to evaluate the current water quality status of Lake Hawassa in order to identify potential pollution sources, and put in place monitoring programs. Eleven potential sampling sites were included in the study. Water quality parameters, such as total dissolved solid (TDS), pH, temperature, conductivity, turbidity, dissolved oxygen (DO), five day biological oxygen demand (BOD5), total hardness as $CaCO_3$, total alkalinity as $CaCO_3$, nitrate, sulphate, orthophosphate, fluoride, K, Mg, Cu, Cd, Cr, Fe, Mn, Pb, and Zn were determined and compared with WHO standards. The results were compared with the WHO and FAO standards. And the values of TDS (381.7 to 1286.0 mg/L), SC (733.7 to 2151.3 µS/cm), turbidity (8.20 to 87.3 NTUs), BOD_5 (4.02 to 76.2 mg/L), phosphate (0.348 to 1.90 mg/L), fluoride (11.6 to 17.5 mg/L), chromium (0.173 to 0.665 mg /L), manganese (0.133 to 1.83 mg/L), and copper (1.40 L to 18.2 mg/L) were found above the prescribed limit of WHO guidelines for drinking purposes, while all the analysed water quality parameters were fall within the FAO standard limit for irrigation purposes. These suggested that both point and non-point pollution sources such as human sewage, industrial waste from ceramics, textile, plastics and food processing industries, urban stormwater, agricultural runoff and land development were impacting the lake. Thus, mitigation measures should be put in place to prevent the Lake from further deterioration.

Keywords: Water pollution, Water quality parameters, Toxic metals

Cite this paper: Melaku Zigde Haile, Endale Tsegaye Mohammed, Analysis of Physico-chemical Characteristics of Water Collected from Different Sampling Sites of Lake Hawassa, Ethiopia, *World Environment*, Vol. 9 No. 2, 2019, pp. 38-45. doi: 10.5923/j.env.20190902.02.

Recharge variability and sensitivity to climate: The example of Gidabo River Basin, Main Ethiopian Rift

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ABSTRACT

Study focus

The focus is to characterize the spatial and temporal variability of groundwater recharge, identify the drivers that govern its distribution, and to improve the understanding of its sensitivity to precipitation and temperature in the MER by applying the semi-distributed hydrological model, Soil and Water Assessment Tool (SWAT).

New hydrological insights for the region

The average annual recharge for 1998–2010 reveals a remarkable decrease from the highland (410 mm/year) towards the rift floor (25 mm/year). Both the spatial and temporal recharge variability is mainly controlled by the climate. In the rift floor, recharge is found to occur only when annual precipitation exceeds a threshold of approximately 800 mm. A sensitivity analysis reveals that annual recharge is very sensitive to variations in precipitation and moderately sensitive to temperature changes. The relative sensitivity increases from the highland to the rift floor across the watershed. Increases in both precipitation and temperature, as suggested by climate change projections for Ethiopia, appear to have an overall positive impact on recharge in the majority of the catchment. These findings have implications also for other catchments where recharge is spatially nonuniform and provide a basis for further investigations into the assessment of groundwater resources and their vulnerability to climate change at the watershed and sub-watershed scale.

Keywords: Recharge variability Recharge sensitivity Ethiopian rift SWAT

Mechal, A., Wagner, T., & Birk, S. (2015). Recharge variability and sensitivity to climate: the example of Gidabo River Basin, Main Ethiopian Rift. *Journal of Hydrology: Regional Studies*, *4*, 644-660.

Evaluating the Performance of HEC-HMS and SWAT Hydrological Models in Simulating the Rainfall-Runoff Process for Data Scarce Region of Ethiopian Rift Valley Lake Basin

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ABSTRACT

A number of physically-based and distributed watershed models have been developed to model the hydrology of the watershed. For a specific watershed, selecting the most suitable hydrological model is necessary to obtain good simulated results. In this study, two hydrologic models, Soil and Water Assessment Tool (SWAT) and Hydrological Engineering Centre-The Hydrologic Modeling System (HEC-HMS), were applied to predict streamflow in Katar River basin, Ethiopia. The performances of these two models were compared in order to select the right model for the study basin. Both models were calibrated and validated with stream flow data of 11 years (1990-2000) and 7 years (2001-2007) respectively. Nash-Sutcliffe Error (NSE) and Coefficient of Determination (R^2) were used to evaluate efficiency of the models. The results of calibration and validation indicated that, for river basin Katar, both models could simulate fairly well the streamflow. SWAT gave the model performance with the $R^2 > 0.78$ and NSE > 0.67; and the HEC-HMS model provided the model performance with the $R^2 > 0.87$ and NSE > 0.73. Hence, the simulated streamflow given by the HEC-HMS model is more satisfactory than that provided by the SWAT model.

Keywords: HEC-HMS, SWAT, Katar River Basin, Peak Flow, Rainfall-Runoff Simulation

Aliye, M. , Aga, A. , Tadesse, T. and Yohannes, P. (2020) Evaluating the Performance of HEC-HMS and SWAT Hydrological Models in Simulating the Rainfall-Runoff Process for Data Scarce Region of Ethiopian Rift Valley Lake Basin. *Open Journal of Modern Hydrology*, **10**, 105-122. doi: 10.4236/ojmh.2020.104007.

COMPARISON OF TWO MODELLING APPROACHES TO UNDERSTAND RAINFALL-RUNOFF PROCESSES''A CASE STUDY IN BILATE RIVER CATCHMENT RIFT VALLEY LAKES BASIN

ADDISU BEKELE SABA

Hawassa University; Institute of Technology

ABSTRACT

Rainfall-Runoff modeling in Bilate river catchment (5,518 km2) at Bilate Tena flow gauging station was examined using two hydrological modeling approaches, HEC-HMS and HBV Light version. In this study, HEC-HMS was used to divide the catchment into five sub- basins where the hydrologic parameters may vary from one sub-basin to another. In the case of HBV, the catchment was divided in to five elevation zone and two vegetation zone. Both models may be labelled as "semi-distributed." The hydrologic model HEC-HMS (Hydrologic Engineering Center,Hydrologic Modeling System) and HBV (Hydrologiska Byråns Vattenbalansavdelning), was used in combination with the Geospatial Hydrologic Modeling Extension, HEC-GeoHMS and GIS (Geographical Information System) application tools respectively. In the study daily time series data of hydrological and meteorological data for a fourteen years' period (2000-2013) was used. The models were carefully calibrated and validated in the catchment using historical observed data (2001-2009) for calibration and (2010-2013) for validation. The model performance was examined based on statistical measures and flow hydrograph observation. Nash and Sutcliffe coefficient and coefficients of determination from statistical comparison criteria for HEC-HMS on calibration was 0.78 and 0.83 and HBV resulted 0.86 and 0.91 respectively. The validation result of HEC-HMS and HBV was 0.81 and 0.88 by Nash and Sutcliffe coefficient and 0.87 and 0.94 by coefficient of determination. The low flow, mean flow and pick flow was examined from the computed flow hydrograph, flow duration curve and scatter plot by visual inspections and all the flow events were all within the acceptable range. Sensitivity analysis was adopted on both models for evaluating the models on predicting the main hydrological catchment process. From the analysis result, parameters which are found to be sensitives are initial abstraction, curve number and lag time from the HEC-HMS model and parameters from the HBV model are to be upper and lower groundwater recession coefficients and percolation. The

overall results show that the models have near efficiency performance on capturing the catchment processes. However, overall, the performance of both models was quite reasonable.

Keywords: - HEC-HMS, HBV, Rainfall-Runoff modelling, Sensitivity Analysis.

SABA, A. B. (2017). *''COMPARISON OF TWO MODELLING APPROACHES TO UNDERSTAND RAINFALL-RUNOFF PROCESSES''A CASE STUDY IN BILATE RIVER CATCHMENT RIFT VALLEY LAKES BASIN* (Doctoral dissertation).

A Bi-level Neuro-Fuzzy System Soft Computing for Reservoir Operation

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ABSTRACT

Reservoir operation studies purely based on the storage level, inflow, and release decisions during dry periods only fail to serve the optimal reservoir operation policy design because of the fact that the release decision during this period is highly dependent on wet season water conservation and flood risk management operations. Imperatively, the operation logic in the two seasons are quite different. If the two operations are not sufficiently coordinated, they may produce poor responses to the system dynamics. There are high levels of uncertainties on the model parameters, values and how they are logically operated by human or automated systems. Soft computing methods represent the system as an artificial neural network (ANN) in which the input- output relations take the form of fuzzy numbers, fuzzy arithmetic and fuzzy logic (FL). Neuro-Fuzzy System (NFS) soft computing combine the approaches of FL and ANN for single purpose reservoir operation. Thus, this study proposes a Bi-Level Neuro-Fuzzy System (BL-NFS) soft computing methodology for short and long term operation policies for a newly inaugurated irrigation project in Gidabo Watershed of Main Ethiopian Rift Valley Basin.

Keywords: Bankruptcy rule, BL-NFS, Reservoir operation, Sensitivity analysis, Soft computing, Water conservation

Redi, M., Dananto, M., & Thillaigovindan, N. (2021). A Bi-level Neuro-Fuzzy System Soft Computing for Reservoir Operation. *Int. J. Advance Soft Compu. Appl*, *13*(3).

Hydrologic soil group based curve number matrix modeling for Enset-Based land use system in Meki River Watershed, Western Lake Ziway Sub-Basin, Central Rift Valley of Ethiopia

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Abstract

Enset-Based land use system (EBLUS) exhibits good carbon stock and infiltration rate equivalent to forest covered areas, which enhances infiltration and water holding capacity and it can reduce the curve number (CN) of the watersheds but it was not considered in former studies. Therefore, this study is planned to model the hydrologic soil group (HSG) based CN matrix of EBLUS relative to other LUSs with established hydrological characteristics in the Meki river watershed. The soil data is used to determine the HSG of the watershed collected from Ministry of Water, Irrigation and Energy (MOWIE) and verified by Harmonized World Soil Database (HWSD). A Model is developed for CN of EBLUS relative to other LUSs (Alemu's formula). The model considers both infiltration rate measured using Amozi-meter and carbon stoke of soil weighed as 85% and 15% respectively. HEC-GEO-HMS model is used to consider the CN of EBLUS as a separate LUS to verify the developed CN matrix model to generate CN of the sub-watershede

Keywords: Enset, CN, SCS, In

Woldesenbet, A. B., Wudmatas, S. D., Denboba, M. A., & Gebremariam, A. G. (2021). Hydrologic soil group based curve number matrix modeling for Enset-Based land use system in Meki River Watershed, Western Lake Ziway Sub-Basin, Central Rift Valley of Ethiopia.

Investigating Causes of Origin and Engineering Geological Characterization of Ground Cracks around Ziway and Ropi Area in Central Rift Valley of Ethiopia

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Abstract

The present study was conducted on, ground-cracks at Weyo, Someyen, Galo-Rephi and Ropi areas in Central Rift valley of Ethiopia, about 145 km south of Addis Ababa. The study was conducted to identify the causes of ground-cracks, mainly through engineering characterization of soils of the area. The soils were investigated in the field and through laboratory analysis. Further, based on the index and engineering properties, collapse potential of the soils was assessed. Two major types of soils namely, 'silty sands' and 'sandy silts' with minor gravel constituents were identified. The non-clayey constituent minerals of the soils were also identified. The observations revealed that volcanic glass is the most abundant mineral in most of the soils. The soils were also found to possess collapsible potential. The dispersiveness of the soils was also estimated. The high sodium content in soils indicated that soils are dispersive in nature. Thus, it has been found by engineering characterization of soils that it generally possesses low plasticity, high void ratio, low density, high collapse potential and high dispersivity. From the present investigation, it is concluded that apart from other triggering factors, the soils of the study area by itself possess a potential to collapse and thus, resulted into development of ground-cracks. Finally, the possible mechanism involved in the formation of various ground-cracks in the study area is also explained.

Keywords: Ground cracks, Hydro-compaction, Soil characterization, Soil collapse potential, Soil dispersion

Isotope Hydrology Projects in Ethiopia Provide Valuable Information and Training

Kassa, T. . Isotope Hydrology Projects in Ethiopia Provide Valuable Information and Training

Abstract

Water Resources Programme involvement in Ethiopian projects since 1991 has been extensive. The information and training provided have equipped the country to better resolve its water resource issues. The International Atomic Energy Agency (IAEA) has been working with the Ethiopian government in the areas of agriculture, nutrition, nuclear medicine and isotope hydrology over the last four decades. Eight national and four regional Technical Cooperation (TC) projects on isotope hydrology have been carried out in collaboration with various Ethiopian institutions over the last two decades (1991-2011). The IAEA has also been analyzing the monthly isotopic composition of rainfall samples collected from a meteorological station in Addis Ababa since 1961. Environmental isotopes (2H, 3H, 18O, 13C and 14C) have been used as complementary tools in water resource assessment and management and in geothermal studies. These isotopes have been implemented mainly to trace recharge provenance, estimate recharge rates and investigate lake- groundwater interaction in the Ethiopian Rift Valley. Nitrogen-15 isotopes were also used to trace the source of nitrate pollution in Dire dawa, which lies in Ethiopia's south-east

Keyword; Atomic energy, Technical cooperation, Isotope hydrology,Environmental isotope and Geothermal study

Origin and geochemical evolution of groundwater in the Abaya Chamo basin of the Main Ethiopian Rift: application of multi-tracer approaches

M Haji

Abstract

The fractured volcanic aquifer of the Abaya Chamo basin in the southern Ethiopian Rift represents an important source for water supply. This study investigates the geochemical evolution of groundwater and the groundwater flow system in this volcanic aquifer system using hydrochemistry and environmental tracers. Water types of groundwater were found to transform from Ca-Mg-HCO3 (western part of Lake Abaya area) to Na-HCO3 (northwestern part), from the highland down to the Rift Valley. Silicate hydrolysis and Ca/Na ion exchange are the major geochemical processes that control groundwater chemistry along the flow path. Groundwaters are of meteoric origin. The δ18O and δD content of groundwater ranges from −4.9 to −1.1‰ and –27 to 5‰, respectively. The δ18O and δD values that lie on the summer local meteoric water line indicate that the groundwater was recharged mainly by summer rainfall. δ13CDIC values of cold groundwater range from −12 to −2.7‰, whereas δ13CDIC of thermal groundwater ranges from −8.3 to +1.6‰. The calculated δ13CCO2(g) using δ13CDIC and DIC species indicates the uptake of soil CO2 for cold groundwater and the influx of magmatic CO2 through deep-seated faults for thermal groundwater. In the western part of Lake Abaya area, the shallow and deep groundwater are hydraulically connected, and the uniform water type is consistent with a fast flow of large gradient. In contrast, in the northern part of Lake Abaya area, water underwent deep circulation and slow flow, so the water types—e.g. high F− (up to 5.6 mg/L) and Na+—varied laterally and vertically.

Challenges of Groundwater Development for Towns And Big Cities Water Supply In Rift Valley Areas

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ABSTRACT

The experiences of the last 30 years developed an understanding in the Addis Ababa Water Utility that groundwater sources are not fully dependable for such a big city. Notwithstanding this, additional wells and well-fields are being developed especially in the last 10 years to meet the ever increasing demand. The Akaki well-field was initially designed for an abstraction rate of up to 35,000 m^3/day for 20 years until 2020 though the current abstraction rate is nearly ten-fold. The current developments are only demand driven irrespective of safe and sustainable utilization. What is making things worse is the rise of other water competing demands for irrigation projects in adjacent well-fields. The present water supply coverage of the Addis Ababa city is not more than 50%. The situation in other urban centers in the Upper Awash basin is not different. Conceptual modelling, time series well water level measurements and operational assessments showed that the aquifer systems are not uniform and dotted with many volcanic flow barriers; there is sharp decline of water table (up to 70 meters since 2000) in some well-fields and the decline is propagating upstream of the Akaki well-field. Moreover, the excessive and uncontrolled pumping is impacting regional groundwater table. Topographic and technical issues are hampering upstream water distribution, and the once exemplary hundreds of wells are now abandoned. The frequent tapping of thermal and high fluoride water is another complication. Unless proper intervention is devised, grave environmental problems are likely to come in the near future

Keywords Uncontrolled pumping Conceptual model Time series water level Wellfield.

Assefa E., Tenalem A., Tilahun A.(2020) Challenges of Groundwater Development For Towns And Big Cities Water Supply In Rift Valley Areas, Addis Ababa University, Ethiopia.

Characteristics of hydrological extremes in Kulfo River of Southern Ethiopian Rift Valley Basin

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Abstract

Hydrological extreme events such as foods and drought are common in Ethiopia which eventually causes environmental hazards. Kulfo River is one of Southern Ethiopian Rift Valley Basin that has experienced fooding for years. Therefore, this study aimed characteristics of hydrological extremes (1985–2014) in the Kulfo River, which is important for efective drought and food monitoring and early warning systems. The hydrological drought was assessed using the streamfow drought index (SDI). Flood frequency distribution (FFD) software package was deployed to determine the food frequency curve of the Kulfo River. The goodness-of-ft test results showed that the Generalized Extreme Values (GEV) distribution was found the best-ft probability distribution model in the Kulfo River, while the results of SDI values showed that extreme drought events were observed in 1991, 1992, and 2014 with magnitudes ranging from −2.04 to −2.7, −2.0 to −2.3, and −2.10 to −2.24, respectively, which cause reduction of lake level, lowing of groundwater level, and decreased the amount of river fow. SDI value indicated 6-year drought duration has occurred with the relative frequency of 20% in the 3- and 6-month timescales. The food frequency results show the lowest probability of having food magnitude has afected the river morphology. The study provides valuable information for policy and decision makers to implement diferent adaptation and mitigation measures for extreme hydrological events in the Kulfo River.

Keywords: Probability distribution model, Hydrological drought, Streamfow drought index, Flood frequency

Yisehak, B., Adhena, K., Shiferaw, H., Hagos, H., Abrha, H., & Bezabh, T. (2020). Characteristics of hydrological extremes in Kulfo River of southern Ethiopian Rift Valley basin. SN Applied Sciences, 2(7), 1-12.

Anthropogenic impacts on Rift Valley water bodies: The case of Lakes Ziway, Langano and Abijata

Mathewos Hailu, G Senbete, M Endebu

ABSTRACT

The Ethiopian central rift valley encompasses a series of lakes, rivers and wetlands with high socioeconomic importance to the country. This study focused on the central rift valley which encompasses Lake Zeway, Langanoo and Abijata located 38o 00'-39o 30' E and 7o 00'-8o 30' concentrating on the districts around the lakes. Community perception and users attitude was assessed regarding the lakeside environment including vegetation cover (past and present), water utilization, economic benefit, type of agrochemical utilization and fisheries management, etc. The economic benefit from Lake Zeway was mainly from fishing and water extraction for irrigation with the irrigated farms' production of horticulture including flower farming covering 500 ha. Lake Abijata was mainly used for soda ash production and mineral salt for livestock as means of income as revelealed by 12.5 % households.. In Lake Langanoo, the water was used by the local community for fishing and livestock as well as home consumption. However the areas surrounding the lakes are fragile ecosystem, which are facing threat from irrigated agriculture, improper water abstraction in line with population increment. Expansion of farmland by 50 % around Lake Langanoo has aggravated the deforestation activity. Absence of regional fisheries policy has encouraged the involvement of 27.7% and 7.7%, illegal fishermen in Lake Zeway and Lake Langanoo respectively. The existing cooperatives do not have clear cooperative structure.96 % of the beach seine in Lake Zeway is below the recommended mesh size. Overall problems in fishery production were indicated as illegal fishery (58.6%), followed by inappropriate mesh size of 31.0%. The absence of soil conservation practice accelerated siltation process in Lake Abijata. Lack of regulation has aggravated the use of extremely toxic pesticides including endosulfan that is used in proximity of Lake Zeway. Despite the existence of institutional environment regarding water and environment, government rules are hardly implemented at local level. This paper reviews some of the adverse socioeconomic activities that exert pressure around the lakeside environment.

Keywords: Abijata, Anthropogenic impact, environmental degradation, Zeway, Langanoo, Rift valley, water abstraction.

Hailu, M., Senbete, G., & Endebu, M. (2010, February). Anthropogenic impacts on Rift Valley water bodies: The case of Lakes Ziway, Langano and Abijata. In *EFASA sec. national conf. proceed, Bahir Dar, Ethiopia* (pp. 210-216).

Application of a semi-distributed swat model to estimate groundwater recharge in the lake Ziway watershed, Ethiopian rift

MISGANA FIRDISA

Abstract

Ethiopia, like many other developing countries, is faced with escalating challenges of water supply. Abstraction of groundwater for water supply, especially for rural communities, requires an understanding of the spatial and temporal variability of ground water recharge. In this study, a semi-distributed hydrological model, SWAT (Soil-Water Assessment Tool) was applied to estimate spatial and temporal variability of recharge in Ziway watershed, Ethiopian rift. The model was calibrated and validated against observed river discharge over the period 1981–2000 and 2000-2010 using SWAT-CUP (Calibration and Uncertainty Program). The long-term (1981-2010) water balance of the SWAT model reveals that the annual precipitation of 878 mm was distributed as: surface runoff of 70 mm (7.8%), evapotranspiration of 710 mm (81.8%), and groundwater recharge of 98 mm (11.2%). From the water balance analysis, evapotranspiration is the most consuming parameter for precipitation in the area. The average annual groundwater recharge shows that a general decreasing trend from the highland (160 mm/year) towards the rift floor (34 mm/year). Both the seasonal and annual variability of groundwater recharge shows similar trend with precipitation throughout the basin. In general, the spatial and temporal groundwater recharge variability is mainly controlled by the variability of precipitation. Finally, observational data sets over longer periods with higher resolution are required to constrain model parameterization and thereby reduce uncertainty in future simulations of groundwater recharge in the area. **Keywords**: Groundwater recharge variability, SWAT model, Ziway Lake watershed, Ethiopian Rift

Keywords: Groundwater recharge variability, SWAT model, Ziway Lake watershed,

FIRDISA, M. (2019). *APPLICATION OF A SEMI-DISTRIBUTED SWAT MODEL TO ESTIMATE GROUNDWATER RECHARGE IN THE LAKE ZIWAY WATERSHED, ETHIOPIAN RIFT* (Doctoral dissertation, ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY)

Application of multi-hydrochemical indices for spatial groundwater quality assessment: Ziway Lake Basin of the Ethiopian Rift Valley

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Environmental Earth Sciences 81 (1), 1-22, 2022

Abstract

The Ethiopian Rift Valley (ERV) is characterized by arid and semi-arid climate with groundwater as the most important water resource used for drinking and irrigation purposes. However, in the region, people are suffering from severe water scarcity exacerbated by climate effect. Besides water availability, endemic water quality issues are critical and affect the suitability of the water and human health risks. The present study evaluates the suitability of groundwater for drinking and agricultural purposes in the Ziway Lake Basin (ZLB) of the ERV. Groundwater used for drinking contains multiple inorganic contaminants in levels that surpass the World Health Organization recommended limits. The most frequent of these violations were for Na+, K+, HCO3−, F− and few samples for Mn, As, U, Pb and Mo. The modeled Drinking Water Quality Index (DWQI) values of the groundwater show wide variation ranging from 12.7 (Excellent category) to 714 (Unsuitable category) with mean value of 94. Likewise, Irrigation Water Quality Index (IWQI) computed by considering EC, SAR, Na%, RSC and PI of the groundwater varies from 13.2 to 520 with a mean value of 106. Both DWQI and IWQI values suggest that groundwater is generally of Excellent quality for drinking and irrigation use in the headwater regions of the ZLB and progressively becomes extremely Unsuitable toward the rift floor. The exceptionally high DWQI values to the west of Lake Ziway is mainly associated with the co-occurrence of multiple toxic elements from a groundwater from the Quaternary sediments and rhyolitic volcanic aquifers.

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