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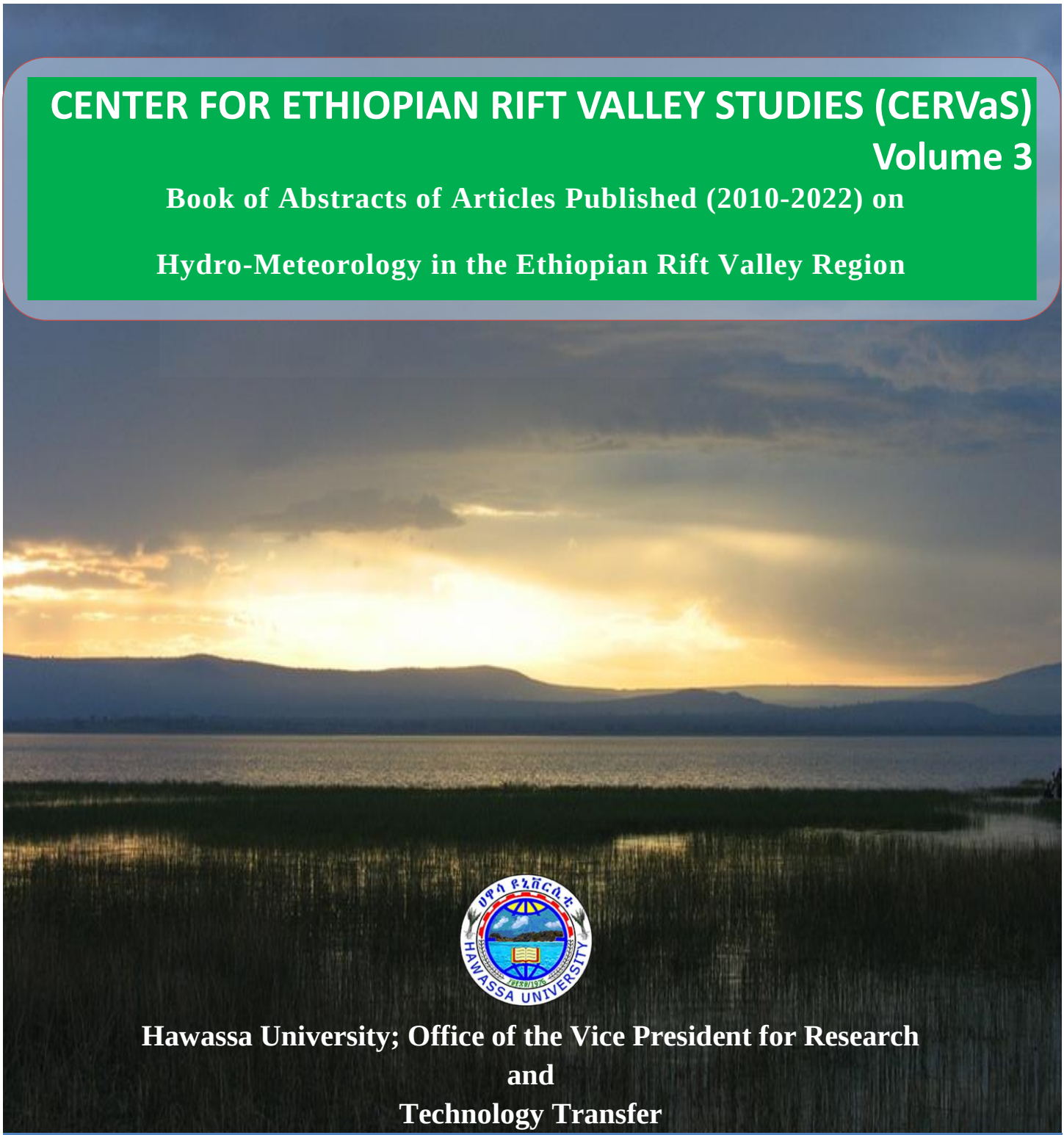

Hawassa University; Office of the Vice President for Research and Technology Transfer

"Joining Hands to Reverse the Alarming Situations"

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The Effect of Climate Change on Loss of Lake Volume: Case of Sedimentation in Central Rift Valley Basin, Ethiopia

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Abstract

Evaluating the impact of climate change on sediment yield has become one of the major topics in climate research. The purpose of this study was to investigate sediment yield contribution to lake volume change under changing climatic conditions in the Central Rift Valley Basin. The ensemble mean of five regional climate models (RCMs) in the coordinated regional climate downscaling experiment (CORDEX)-Africa was considered for the purpose of this study. The climate variables (precipitation, minimum and maximum temperatures) in RCMs were bias corrected against observed data (1985–2016) using linear scaling (LS), power transformation (PT), variance of scaling (VS), and quantile mapping (QM). Two emission scenarios, the Representative Concentration Pathways, RCP4.5 and RCP8.5, were considered for the future scenario period (2041–2070). Better results were obtained when the ensemble values of the bias correction methods were used. Hence, the projected values of climate variables after bias correction were used in the Soil and Water Assessment Tool (SWAT) hydrological model to estimate the sediment yield contribution to lake volume change due to climate change. The results show that the average projected precipitation will decrease by 7.97% and 2.55% under RCP4.5 and RCP8.5, respectively. On average, the maximum temperature will increase by 1.73 ◦C and 2.36 ◦C under RCP4.5 and RCP8.5, respectively, while the minimum temperature will increase by 2.16 ◦C and 3.07 ◦C under RCP4.5 and RCP8.5, respectively. The average annual sediment yield contributions to Lake Ziway were 431.05 ton/km2 and 322.82 ton/km2 for the Meki and Ketar rivers, respectively, in the historical period (1985–2010). The study also reveals that the annual sediment yield that was estimated for the Meki River was 323 ton/km2 and 382 ton/km2 under RCP4.5 and under RCP8.5, respectively. The sediment estimations for the Ketar River were 157 ton/km2 and 211 ton/km2 under RCP4.5 under RCP8.5, respectively. This will decrease the rate of volume change in Lake Ziway by 38% under RCP4.5 and by 23% under RCP8.5. The results show that the life expectancy of the lake is likely to increase under climate change scenarios. This will help water resources managers make informed decisions regarding the planning, management, and mitigation of the river basins.

Keywords: climate change; CORDEX-Africa; lake volume; sediment; SWAT; Ziway

Behulu, F., Mutua, B. M., Gadissa, T., & Nyadawa, M. (2018). The effect of climate change on loss of lake volume: case of sedimentation in central rift valley basin, Ethiopia.

Water balance components of the potential agricultural grabens along the Rift Valley in northern Ethiopia

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Abstract

Region: Ethiopia's Rift Valley.

Focus: matching agricultural water demand and supply is a growing policy challenge in drylands. We investigated the water balance components in Raya (3507 km2) and Ashenge (80.5 km2) grabens. The rainfall depth, river discharge, abstraction, climate and soil data (2015–2017) were used to address the research question.
New hydrological insights: the average annual rainfall of the graben's escarpment and its bottom was 806 ± 162 and 508 ± 110 mm, respectively. Heavy rains produce floods up to 732 $m^3 s^{-1}$ in the rivers that flow into the Raya graben. Moreover, greater runoff and river discharges volumes were recorded at the graben escarpments than at the graben bottom outlets ($p < 0.001$) due to the greater contributing area ($p < 0.001$, $R2 = 0.98$) and headwater elevation ($p < 0.001$, $R2 = 0.98$). About 24% of the water entering both graben bottoms comes from the runoff from the adjacent slopes, and about 40% of the runoff reaching the Raya graben bottom flowed out at the outlet. About 76% and 77.5% of the annual rainfall was lost through evapotranspiration from the Raya and Ashenge grabens, respectively. So about 16% and 33% of the average annual inflows infiltrated into the sediments in the Raya and Ashenge grabens, respectively. These insights provided by this study into the water balance in grabens along the Rift Valley can be used to help achieve sustainable agricultural development.

Keywords: Erratic rainfall, Flash flood, Evapotranspiration, Recharge, Rift Valley Ethiopia

Meaza, H., Frankl, A., Demissie, B., Poesen, J., Zenebe, A., Gebresamuel, G., ... & Nyssen, J. (2019). Water balance components of the potential agricultural grabens along the Rift Valley in northern Ethiopia. *Journal of Hydrology: Regional Studies*, *24*, 100616.

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

Addisu Bekele Saba

Abstract

Rainfall-Runoff modeling in Bilate river catchment (5,518 km^2) 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.

A modeling approach for evaluating the impacts of Land Use/Land Cover change for Ziway Lake Watershed hydrology in the Ethiopian Rift

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Abstract

Many parts of the Ethiopian Rift are undergoing significant Land Use/Land Cover (LULC) changes. In many places, the natural LULCs are converted into agricultural land to sustain the increasing food demand arising from a rapidly growing population. Modelling the responses of LULC changes on the hydrology of the area at the watershed scale is crucial for sustainable development of land and water resources. This study investigates the historic LULC change and its potential impacts on the hydrology of Ziway Lake Watershed in the Ethiopian Rift. Commonly, such assessments are accomplished by integrating physically based and semi-distributed hydrological model with Remote Sensing and Geographic Information System techniques. A hybrid LULC classification approach was applied to classify Landsat images of 1985, 1995, 2005 and 2020 and detect the LULC changes in the watershed. Subsequently, Soil and Water Assessment Tool was utilized to simulate the response of the hydrological process (water balance and stream flow) to LULC changes from 1985 to 2020. The image classifications of 1985, 1995, 2005 and 2020 revealed four LULC maps with eight LULC types. The relative change assessment results in the past 35 years from 1985 to 2020 revealed that the major expansion in Settlement, Cultivation and Agroforest resulting in a reduction of Woodlands. However, 58.3% of the watershed has remained intact while 41.7% has shown some degree of change. At the watershed level, these LULC changes had increased SURQ (87.07%), WYLD (31.86%) and ET (4.91%). Conversely, the observed change had reduced PERC (63.22%). But, the spatial analysis of the water balance components due to LULC changes were found to be non-uniform across the watershed. On the other hand, the seasonal stream flow analysis results indicated that Katar flow is increased by 15.36% and declined by 3.86% during the wet and dry seasons, respectively. Similarly, Meki flow showed a decrement during the dry seasons and an increment during the wet seasons by 7.04% and 20.66%, respectively. Beside the observed change, the results of the hypothetical LULC change scenarios justified a pronounced impact of

historic LULC change on the water balance components of the watershed. These change in hydrological components and stream flow substantially attributed to the transformation of Woodland to agricultural land. Among the water balance components, the increment of SURQ may have a wider implication for increasing soil erosion and lake bed siltation. The continuous decline in PERC also highly affected the available groundwater resource of the watershed. The study will have significance for watershed managers and decision makers to improve the LULC and water management practices in the area by formulating mechanisms to maintain a sustainable hydrological balance in the watershed.

Keywords: RS, GIS, LULC change, SWAT model, Hydrological response, ZLW, Ethiopian Rift

Mechal, A., Takele, T., Meten, M., Deyassa, G., & Degu, Y. (2022). A modeling approach for evaluating the impacts of Land Use/Land Cover change for Ziway Lake Watershed hydrology in the Ethiopian Rift. Modeling Earth Systems and Environment, 8(4), 4793-4813.

Seasonal effect on the accuracy of Land use/Land cover classification in the Bilate Sub-basin, Abaya-Chamo Basin, Rift valley Lakes Basin of Ethiopia

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ABSTRACT

A correct and timely land use/land cover (LULC) classification provides indispensable information for the effective management of environmental and natural resources. However, earlier studies mapped the LULC map of Bilate Sub-basin using remote sensing images that were acquired for a single season. Hence, these studies did not consider the seasonal effects on the accuracy of LULC classification. Therefore, the objective of this study was to evaluate changes in classification accuracy for images acquired during wet and dry seasons in the Bilate Sub-basin. LULC of the study area was classified using the Landsat 8 satellite imageries. Based on field observations, we classified the LULC of the study area into 9 dominant classes. The classification for the two seasons resulted in a noticeable difference between the LULC composition of the study area because of seasonal differences in the classification accuracy. The overall accuracy of the LULC maps was 80%for the wet season and 90% for the dry season with Kappa coefficient values of 0.8 and 0.9 respectively. Therefore, the two seasons showed a significant difference in the overall accuracy of the classification. However, we discovered that when the classification accuracy was tested locally, that is for individual pixels, the results were not the same. In Bilate Sub-basin, several pixels (14.71%) were assigned to different LULC classes on the two seasons maps while 85.29% of the LULC classes remained unaltered in the two maps. According to the classification results, the season had a noticeable effect on the accuracy of LULC classification. This suggests that for LULC classification, multi- temporal images should be used rather than a single remote sensing image.

Keywords: Bilate, classification accuracy, Image classification, LULC, multi-temporal analysis, remote sensing

Yimer, A. K., Haile, A. T., Hatiye, S. D., & Gedle, A. (2021). Seasonal effect on the accuracy of Land use/Land cover classification in the Bilate Sub-basin, Abaya-Chamo Basin, Rift valley Lakes Basin of Ethiopia. Ethiopian Journal of Water Science and Technology.

Impact of land use/land cover change on hydrologic processes in Dijo watershed, central rift valley, Ethiopia

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Abstract

The aim of this study was to assess the impact of land use / land cover changes on the hydrological process in the central valley basin of Ethiopia, from 1985 to 2018 and evaluate historical land use/land cover change using satellite image. Satellite images were classified by supervised classification technique with maximum likelihood. SWAT model were used to simulate hydrological processes in the watershed. The result of the study shows that barren lands, agricultural and settlement lands were expanded by 7 and 64%; whereas, forestlands, water bodies, shrub and grasslands were declined by 13, 57 and 41% respectively over the past three decades. The calibrated and validated SWAT model used also showed that there has been good agreement between simulated and observed streamflow on monthly basis. Streamflow evaluation due to LULC change influence showed that mean monthly simulated streamflow was increased by 10.84% between the years 1985 and 2003, also increased from the year 2003 to 2018 by 9.3% in wet months; whereas, decreased by 8.23 and 11.4% between 1985-2003 and 2003-2018 in dry months. Therefore, hydrological process of the watershed was highly influencedby LULC changes and it requires integrated watershed management techniques.

Key words: Digital image processing, GIS, hydrologic process, landsat image.

Ashenafi, N., & Mihret, D. (2021). Impact of land use/land cover change on hydrologic processes in Dijo watershed, central rift valley, Ethiopia. International Journal of Water Resources and Environmental Engineering, 13(1), 37-48.

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

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Abstract

Hydrological extreme events such as floods and drought are common in Ethiopia which eventually causes environmental hazards. Kulfo River is one of Southern Ethiopian Rift Valley Basin that has experienced flooding for years. Therefore, this study aimed characteristics of hydrological extremes (1985–2014) in the Kulfo River, which is important for effective drought and flood monitoring and early warning systems. The hydrological drought was assessed using the streamflow drought index (SDI). Flood frequency distribution (FFD) software package was deployed to determine the flood frequency curve of the Kulfo River. The goodness-of-fit test results showed that the Generalized Extreme Values (GEV) distribution was found the best-fit 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 flow. SDI value indicated 6-year drought duration has occurred with the relative frequency of 20% in the 3- and 6-month timescales. The flood frequency results show the lowest probability of having flood magnitude has affected the river morphology. The study provides valuable information for policy and decision makers to implement different adaptation and mitigation measures for extreme hydrological events in the Kulfo River.

Keywords: Probability distribution model, Hydrological drought, Streamflow, 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.

Performance Evaluation and Comparison of Satellite-Derived Rainfall Datasets over the Ziway Lake Basin, Ethiopia

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Abstract

Consistent time series rainfall datasets are important in performing climate trend analyses and agro-hydrological modeling. However, temporally consistent ground-based and long-term observed rainfall data are usually lacking for such analyses, especially in mountainous and developing countries. In the absence of such data, satellite-derived rainfall products, such as the Climate Hazard Infrared Precipitations with Stations (CHIRPS) and Global Precipitation Measurement Integrated Multi-SatellitE Retrieval (GPM-IMERG) can be used. However, as their performance varies from region to region, it is of interest to evaluate the accuracy of satellite-derived rainfall products at the basin scale using ground-based observations. In this study, we evaluated and demonstrated the performance of the three-run GPM-IMERG (early, late, and final) and CHIRPS rainfall datasets against the ground-based observations over the Ziway Lake Basin in Ethiopia. We performed the analysis at monthly and seasonal time scales from 2000 to 2014, using multiple statistical evaluation criteria and graphical methods. While both GPM-IMERG and CHIRPS showed good agreement with ground-observed rainfall data at monthly and seasonal time scales, the CHIRPS products slightly outperformed the GPM-IMERG products. The study thus concluded that CHIRPS or GPM-IMERG rainfall data can be used as a surrogate in the absence of ground-based observed rainfall data for monthly or seasonal agro-hydrological studies.

Keywords: CHIRPS; GPM-IMERG; rainfall data scarcity; agro-hydrology; Rift Valley Lake Basin

Hordofa, A. T., Leta, O. T., Alamirew, T., Kawo, N. S., & Chukalla, A. D. (2021). Performance evaluation and comparison of satellite-derived rainfall datasets over the Ziway lake basin, Ethiopia. Climate, 9(7), 113.

Rainfall retrieval and drought monitoring skill of satellite rainfall estimates in the Ethiopian Rift Valley Lakes Basin

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Abstract.

Satellite-based rainfall products are essential for retrieving rainfall, particularly in data-scarce and drought-prone countries like Ethiopia. However, their quality needs to be validated prior to their use. Therefore, we evaluated the performance of the Climate Hazards group Infrared Precipitation with Stations version 2.0 (CHIRPS), the Tropical Applications of Meteorology using Satellite data version 3.0 (TAMSAT3), and the African Rainfall Climatology version 2 (ARC2) satellite rainfall estimates in the Ethiopian Rift Valley Lakes Basin. Their skill of retrieval was evaluated against ground-measured rainfall at dekadal, monthly, and seasonal scales across agroclimatic zones over 2001 to 2017. Finally, these satellite products have demonstrated different levels of agreement with the reference data, being the highest for CHIRPS and the lowest for ARC2. At all timescales and agroclimatic zones, ARC2 has severely underestimated the actual rainfall while TAMSAT3 has persistently overestimated it. However, TAMSAT3 has demonstrated better performance than ARC2. Generally, except for its slightly larger dekadal false alarm ratio, CHIRPS has achieved the highest and most consistent agreement with the reference data at all the timescales and agroclimatic classes. Consequently, CHIRPS was further assessed for its suitability of drought monitoring, and it has exhibited promising skill in detecting specific historical drought events. Therefore, to overcome the scarcity of ground-measured rainfall data in the study area, we recommend the CHIRPS rainfall estimate to be used as an alternative data source for drought monitoring. Conversely, owing to its overestima- tion tendency, TAMSAT3 could be used for flood monitoring in this region.

Keywords: agroclimatic zones; drought monitoring skill; Ethiopian Rift Valley Lakes Basin; satellite rainfall estimates; validation.

Tesfamariam, B. G., Melgani, F., & Gessesse, B. (2019). Rainfall retrieval and drought monitoring skill of satellite rainfall estimates in the Ethiopian Rift Valley Lakes Basin. Journal of Applied Remote Sensing, 13(1), 014522.

Regionalization of Low Flow Analysis in Data Scarce Region: The Case of the Lake Abaya-Chamo Sub-basin, Rift Valley Lakes Basin, Ethiopia

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Abstract

Prediction of low flows in ungauged catchments is desirable for planning and management of water resources development and for sustaining the environment. The main objective of this study was to regionalize low flow indexes (the baseflow index BFI, Q80, Q90, and Q95) in the Lake Abaya–Chamo sub-basin by using multiple linear regression models. To develop the regional equation, nine baseflow separation methods were compared: two digital graphical methods and seven recursive digital filters were com-pare and applied in eight gauged catchments. The methods were evaluated through the coefficient of determination (R2) and the root mean square error (RMSE) as performance measures. The flow duration analyses were conducted to compute the flow exceedance quantiles Q80, Q90, and Q95. Regionalizing those indexes required the identification of homogeneous regions, which was accomplished through cluster analysis, based on physiographic and climatic data. Three significantly different homogeneous areas were identified using k-means clustering, and multiple linear regression models were developed for every low flow index in each homogeneous region. The R2 values in the model developed for BFI, Q80, Q90, and Q95 range from 0.75 to 0.98 throughout the region. For checking the performance of the model, verification of regional models was carried out by determining the relative error over four gauged catchments assuming they were ungauged. All regional models performed well by having relative errors <10% in the regions showing high performance. Therefore, the developed regional models could potentially solve the low flow estimation in the vast majority of ungauged catchments in the sub-basin. Consequently, current and future water resources development endeavors may use such estimation methods for planning, designing, and management purposes

Abdi, D., & Gebrekristos, S. (2022). Regionalization of Low Flow Analysis in Data Scarce Region: The Case of the Lake Abaya-Chamo Sub-basin, Rift Valley Lakes Basin, Ethiopia.

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

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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.

Keywords: Climate change, WEAP model, Scenarios, Hydrologic processes, Recharge

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.

Hydrological Responses of Climate Change on Lake Ziway Catchment, Central Rift Valley of Ethiopia

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Abstract

This study predicts future runoff conditions under changing climate using multi model outputs from Coupled Model Intercomparison Project Phase 5 (CMIP5) over Lake Ziway Catchment. The River system is located in the Central Rift Valley of Ethiopia which serves for wide range of socio-economic activity, but recently different water use sectors are increasing their pressure on the water balance of the catchment. Bias corrected precipitation, maximum and minimum temperature data from three climate models HadGEM2-ES, CSIRO-MK-3-6-0 and CCSM4 under representative concentration pathways RCP 8.5 and RCP 4.5 were used as input for the hydrologic model. A calibrated and validated HBV model is used to simulate the future inflow from Katar River and Meki River towards Lake Ziway. The result revealed that the maximum and minimum temperature increased under RCP 8.5 and RCP 4.5 scenarios. However, precipitation showed a decreasing trend. The percentage change in monthly average precipitation showed extremes for HadGEM2-ES model which range between -51.19% during January 2050s and +23.15% during February 2080s under RCP 8.5. The model output showed an annual decrement in runoff depth on Katar River up to 19.45% during RCP 8.5 on CSIRO MK-3-6-0 model and maximum reduction was recorded for RCP 4.5 at 17.49% for CCSM4 model. Meki River has shown maximum annual reduction of 20.28% during 2080s on RCP 8.5 for HadGEM2-ES model and seasonally during Bulg maximum increment was recorded for the same model which ranges up to 10.23% on 2050s for RCP 4.5. However seasonal maximum reduction is obtained from Bulg season by 40.27% on HadGEM2-ES model during 2050s. From the study, a reduction in rainfall has brought larger effects on runoff reduction than evapotranspiration components. Due to future reduction of River flow on the region optimal allocations for water use purposes at all levels of water resource development projects are crucial for future water planning and management.

Keywords: CMIP5; HBV model; Lake Ziway catchment; RCP; Runoffestimation

Abraham, T., Woldemicheala, A., Muluneha, A., & Abateb, B. (2018). Hydrological responses of climate change on Lake Ziway catchment, Central Rift Valley of Ethiopia. J. Earth Sci. Clim. Change, 9(6), 474.

Runoff and Sediment Yield Modeling of Meki River Watershed Using SWAT Model in Rift Valley Lakes Basin, Ethiopia

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Abstract:

Loss of soil fertility in agricultural lands and sedimentation in lakes of central rift valley of Ethiopia are major watershed problem threatening the agro economy in the area. To develop effective erosion control plans through implementing appropriate soil conservation practices, runoff and sediment yield in Meki watershed was estimated and analyzed using the SWAT model. The model showed the simulated mean annual surface runoff was 114.03mm and the mean annual streamflow was 9.41m3/s. Similarly, mean annual sediment load of 13.12 t/ha enters to Lake Ziway. The model was calibrated and validated on daily and monthly time step for flow and on monthly time step for sediment yield. The results of Nash Sutcliff Efficiency of 0.71 on daily and 0.89 on monthly time steps for streamflow and its value of 0.80 on monthly time step for sediment yield during calibration showed that there is a good match between measured and simulated data for both variables on daily basis and very good match on monthly basis. The potential erosion source areas were identified. Likewise, 51.34% of the watershed area was found to be potential erosion sources and priorized for erosion control plans.

Keywords: Meki Watershed, Runoff, Sediment Yield, SWAT, SWAT-CUP

Bunta, A., & Abate, B. (2021). Runoff and Sediment Yield Modeling of Meki River Watershed Using SWAT Model in Rift Valley Lakes Basin, Ethiopia. American Journal of Civil Engineering, 9(5), 155-166.

Irrigation Water Management in Small Scale Irrigation Schemes: the Case of the Ethiopian Rift Valley Lake Basin

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Abstract

Appraisals of irrigation water management scenarios are crucial in project performance monitoring. A comprehensive irrigation water management study has been conducted on four small scale irrigation schemes in the Ethiopian rift valley lake basin. It is observed that from 147 irrigators 68% faced irrigation water supply unreliability, 79.1% encountered unfair distribution of water and 66 % underwent through timeliness problem in water distribution occasionally. All the investigated schemes witnessed a weak (50 % of all scheme users noted poor) organization of irrigation scheme administration. The Water Users Associations (WUAs) lack clear laws/by-laws and strategies to lead small or major canal operations and maintenances. Without a strong WUA it is impossible to think of filling farmer's skill gap, to have a working maintenance strategy, fair distribution of irrigation water, reliable irrigation water supply and timely delivery of irrigation water.

Keywords: Irrigation, Small scale, Water management, WUA

Ulsido, M. D., & Alemu, E. (2014). Irrigation water management in small scale irrigation schemes: The case of the Ethiopian rift valley lake basin. Environmental Research, Engineering and Management, 67(1), 5-15.

Quantifying the Regional Water Balance of the Ethiopian Rift Valley Lake Basin Using an Uncertainty Estimation Framework

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Abstract.

In Ethiopia more than 80 % of big freshwater lakes are located in the Rift Valley Lake Basin (RVLB), serving over 15 million people a multipurpose water supply. The basin covers an area of 53,035 km2, and most of the catchments recharging these lakes are ungauged and their water balance is not well quantified, hence limiting the development of appropriate water resource management strategies. Prediction for ungauged basins (PUB) has demonstrated its effectiveness in hydro-climatic data-rich regions. However, these approaches are not well evaluated in climatic data-limited conditions and the consequent uncertainty is not adequately quantified. In this study we use the Hydrologiska Byråns Vattenbalansavdelning (HBV) model to simulate streamflow at a regional scale using global precipitation and potential evapotranspiration products as forcings. We develop and apply a Monte-Carlo scheme to estimate model parameters and quantify uncertainty at 16 catchments in the basin where gauging stations are available. Out of these 16, we use the 14 most reliable catchments to derive the best regional regression model. We use three different strategies to extract possible parameter sets for regionalization by correlating the best calibration parameters, the best validation parameters, and parameters that give the most stable predictions with catchment properties that are available throughout the basin. A weighting scheme in the regional regression accounts for parameter uncertainty in the calibration. A spatial cross-validation is applied multiple times to test the quality of the regionalization and to estimate the regionalization uncertainty. Our results show that, other than the commonly used best-calibrated parameters, the best parameter sets of the validation period provide the most robust estimates of regionalized parameters. We then apply the regionalized parameter sets to the remaining 35 ungauged catchments in the RVLB to provide regional water balance estimations, including quantifications of regionalization uncertainty. The uncertainties of elasticities from the regionalization in the ungauged catchments are higher than those obtained from the simulations in the gauged catchments. With these results, our study provides a new procedure to use global precipitation and evapotranspiration products to predict and evaluate streamflow simulation for hydro-climatically data-scarce regions considering uncertainty. This procedure enhances the confidence to understand the water balance of under-represented regions like ours and supports the planning and development of water resources.

Keywords: Parameter Estimation, Uncertainties, Ungauged Catchment, Weighted Regression, Water Balance

Abraham, T., Liu, Y., Tekleab, S., & Hartmann, A. (2021). Quantifying the regional water balance of the Ethiopian Rift Valley Lake basin using an uncertainty estimation framework. Hydrology and Earth System Sciences Discussions, 1-25.

Comparative Assessment of the Effect of Climate Change and Human Activities on Streamflow Regimes in Central Rift Valley Basin, Ethiopia

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Abstract

Climate change and anthropogenic activities are the main driving factors for changes in hydrological processes of a given watershed. This research was conducted to assess the relative contribution of climate change and human activities to streamflow change. The ensemble mean of five regional climate models (RCMs) in the coordinated regional climate downscaling experiment (CORDEX)-Africa was considered for the purpose of this study. Two emission scenarios, the Representative Concentration Pathways, RCP4.5 and RCP8.5, were considered for the future scenario period (2041–2070). Streamflow change due to climate change and human activities was assessed using coefficient of elasticity method and SWAT hydrological model. A change due to climate change was further split into change due to precipitation and evapotranspiration. Climate change contributed 46.7% while human activities contributed 53.3% to changes in streamflow. It was found that a 10% decrease in precipitation caused a reduction of 25.1% in streamflow, while 10% increase in potential evapotranspiration caused a reduction of 15.5% in streamflow. The results from ensemble mean of Regional Climate Models (RCMs) show that the average projected precipitation will decrease by 7.97% and 2.55% under RCP4.5 and RCP8.5 respectively. On average, temperature will increase by 1.9°C and 2.7°C under RCP4.5 and RCP8.5 respectively. This corresponds to 4.89% and 6.59% increase in potential evapotranspiration under RCP4.5 and RCP8.5 respectively. Using coefficient of elasticity method, the estimated values of streamflow change were – 26.9% and – 15.8% under RCP4.5 and RCP8.5 respectively. The results of this study show that the reduction in streamflow due to human activities was higher than the reduction due to climate change. The streamflow change induced by anthropogenic factors can be associated with factors such as water abstraction, land use change, ground water abstraction, and the other catchment properties. Hence, further research is recommended to separate changes from these factors.

Keywords: climate change, human activity, streamflow, precipitation, evapotranspiration

Gadissa, T., Nyadawa, M., Mutua, B. M., & Behulu, F. (2019). Comparative assessment of the effect of climate change and human activities on streamflow regimes in Central Rift Valley Basin, Ethiopia.

Implications of water abstraction on the interconnected Central Rift Valley Lakes sub-basin of Ethiopia using WEAP

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Abstract

Study region: Central Rift Valley Lakes sub-basin, Ethiopia.

Study focus: The competition for water is rapidly increasing in Central Rift Valley lakes sub-basin due to the combined effect of various water resources developments. However, the impacts of recent and future water resources development pathways on the water balance of the three interconnected lakes (i.e. Lake Ziway, Langano and Abiyata) are unknown. The Water Evaluation And Planning (WEAP) model was used to assess the development impacts on water resources of the interconnected lakes. We considered three development pathways that are, recent (2009–2018), short-term (2019–2028) and long-term development (2029–2038). Lake Ziway water inflows from six catchments were estimated using the Hydrologiska Byråns Vattenbalansavdelning (HBV) rainfall-runoff model. Crop water requirements for irrigation schemes were estimated by the CROPWAT model.

New hydrological insights for the region: WEAP simulations show a total water demand of 102.3 Mm3 under the recent development pathway that increases by 46% and 118% for short-term and long-term development pathways, respectively. This will notably affect the water balance of the interconnected lakes and cause an unmet water demand of 47.9 Mm3 for the long-term (2028–2038). For Lake Ziway and Abiyata, water levels will decrease substantially to cause water scarcity in the long-term, and developments in Lake Ziway will significantly affect water storage in Lake Abiyata storages in Lake Abiyata. Overall, future developments will threaten the water resource of the interconnected lake system.

Keywords: Water demand, Central Rift Valley, Water abstraction, WEAP, water resources development, Ethiopia

Goshime, D. W., Haile, A. T., Rientjes, T., Absi, R., Ledésert, B., & Siegfried, T. (2021). Implications of water abstraction on the interconnected Central Rift Valley Lakes sub-basin of Ethiopia using WEAP. Journal of Hydrology: Regional Studies, 38, 100969.

Error propagation of climate model rainfall to streamflow simulation in the Gidabo sub-basin, Ethiopian Rift Valley Lakes Basin

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Abstract

This study assesses bias error of rainfall from climate models and related error propagation effects to simulated streamflow in the Gidabo sub-basin, Ethiopia. Rainfall is obtained from a combination of four global and regional climate models (GCM-RCMs), and streamflow is simulated by means of the Hydrologiska Byråns Vattenbalansavdelning (HBV-96) rainfall-runoff model. Five bias correction methods were tested to reduce the rainfall bias. To assess the effects of rainfall bias error propagation, percent bias (PBIAS), difference in coefficient of variation (CV), and 10th and 90th percentile indicators were applied. Findings indicate that the bias of the uncorrected rainfall caused large errors in simulated streamflow. All five bias correction methods improved the HBV-96 model performance in terms of capturing the observed streamflow. Overall, the findings of this study indicate that the magnitude of the error propagation varies subject to the selected performance indicator, bias correction method and climate model.

Keywords: Bias correction, climate change, error propagation, HBV model, systematic error

Worako, A. W., Haile, A. T., Rientjes, T., & Woldesenbet, T. A. (2022). Error propagation of climate model rainfall to streamflow simulation in the Gidabo sub-basin, Ethiopian Rift Valley Lakes Basin. Hydrological Sciences Journal, (just-accepted).

Regionalization of catchments for flood frequency analysis for data scarce Rift Valley Lakes Basin, Ethiopia

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Abstract

Study region: Rift Valley Lakes Basin, Ethiopia
Study focus: We performed regionalization of catchments using K-means method based on variety of catchment characteristics and tested hydrological homogeneity of the regions using flood statistics. Following that, flood frequency analysis (FFA) for the identified regions was computed using regional flow data.
New hydrological insights for the region: Four hydrologically homogeneous regions were identified. Generalized extreme value (GEV), Lognormal (LN2), Wakeby, and Generalized Pareto (GP) were the best fitted distribution models for regions; one up to four respectively. Maximum likelihood was chosen as the most efficient parameter estimation method for regions two, three, and four, whereas the method of moment was chosen for region one. Region one contained one gauged catchment, therefore regression equation was not developed for this region. The linear regression between mean annual flood (MAF) and catchment characteristics performed well (R2 = 0.827, 0.899 and 0.994) for regions two, three and four respectively. The relative errors between observed and estimated MAF in the pseudo ungauged catchments resulted 0.511, 0.039 and 0.166 for regions two, three and four respectively. Hence, the developed regional frequency curves and regression equations can be used for flood estimation at the required return period (T) in the homogeneous regions of the basin.

Keywords: Rift Valley Lakes Basin Regionalization Flood frequency analysis Regression equation

Kebebew, A. S., & Awass, A. A. (2022). Regionalization of catchments for flood frequency analysis for data scarce Rift Valley Lakes Basin, Ethiopia. Journal of Hydrology: Regional Studies, 43, 101187.

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

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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 (R2)=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 (R2=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-1yr-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.

Keywords: Runoff, Sediment Yield, SWAT, Calibration and Validation

Husen, D., & Abate, B. (2020). 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, 8(6), 125.

Prediction at Ungauged Catchments through Parameter Optimization and Uncertainty Estimation to Quantify the Regional Water Balance of the Ethiopian Rift Valley Lake Basin

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Abstract.

Quantifying uncertainties in water resource prediction in data-scarce regions is essential for resource development. We use globally available datasets of precipitation and potential evapotranspiration for the regionalization of model parameters in the data-scarce regions of Ethiopia. A regional model was developed based on 14 gauged catchments. Three possible parameter sets were tested for regionalization: (1) the best calibration parameters, (2) the best validation parameter set derived from behavioral parameters during the validation period, and (3) the stable parameter sets. Weighted multiple linear regression was applied by assigning more weight to identifiable parameters, using a novel leave-one-out cross-validation technique for evaluation and uncertainty quantification. The regionalized parameter sets were applied to the remaining 35 ungauged catchments in the Ethiopian Rift Valley Lake Basin (RVLB) to provide regional water balance estimations. The monthly calibration of the gauged catchments resulted in Nash Sutcliffe Efficiencies (NSE) ranging from 0.53 to 0.86. The regionalization approach provides acceptable regional model performances with a median NSE of 0.63. The results showed that, other than the commonly used best-calibrated parameters, the stable parameter sets provide the most robust estimates of regionalized parameters. As this approach is model-independent and the input data used are available globally, it can be applied to any other data-scarce region.

Keywords: data-scarce region; parameter estimation; uncertainties; ungauged catchment; weighted regression; water balance

Abraham, T., Liu, Y., Tekleab, S., & Hartmann, A. (2022). Prediction at Ungauged Catchments through Parameter Optimization and Uncertainty Estimation to Quantify the Regional Water Balance of the Ethiopian Rift Valley Lake Basin. Hydrology, 9(8), 150.

Multi-site calibration of hydrological model and the response of water balance components to land use land cover change in a rift valley Lake Basin in Ethiopia

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Abstract

Study region: Rift Valley Lakes Basin, Ethiopia
Study focus: We performed regionalization of catchments using K-means method based on variety of catchment characteristics and tested hydrological homogeneity of the regions using flood statistics. Following that, flood frequency analysis (FFA) for the identified regions was computed using regional flow data.
New hydrological insights for the region:Four hydrologically homogeneous regions were identified. Generalized extreme value (GEV), Lognormal (LN2), Wakeby, and Generalized Pareto (GP) were the best fitted distribution models for regions; one up to four respectively. Maximum likelihood was chosen as the most efficient parameter estimation method for regions two, three, and four, whereas the method of moment was chosen for region one. Region one contained one gauged catchment, therefore regression equation was not developed for this region. The linear regression between mean annual flood (MAF) and catchment characteristics performed well (R2 = 0.827, 0.899 and 0.994) for regions two, three and four respectively. The relative errors between observed and estimated MAF in the pseudo ungauged catchments resulted 0.511, 0.039 and 0.166 for regions two, three and four respectively. Hence, the developed regional frequency curves and regression equations can be used for flood estimation at the required return period (T) in the homogeneous regions of the basin.

Keywords: Multi-site calibration Sensitivity analysis SWAT-CUPWater balance Gidabo river sub-basin

Serur, A. B., & Adi, K. A. (2022). Multi-site calibration of hydrological model and the response of water balance components to land use land cover change in a rift valley Lake Basin in Ethiopia. Scientific African, 15, e01093.

Hydro-meteorological trends in the Gidabo catchment of the Rift Valley Lakes Basin of Ethiopia

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Abstract

The global and regional variability and changes of climate and stream flows are likely to have significant influence on water resource availability. The magnitude and impacts of climate variability and change differs spatially and temporally. This study examines the long term hydroclimatic changes, analyses of the hydro-climate variability and detect whether there exist significant trend or not in the Gidabo catchment, rift valley lakes basin of Ethiopia. Precipitation, temperature and stream flow time series data were used in monthly, seasonal and annual time scales. The precipitation and temperature data span is between 1982 and 2014 and that of stream flow is between 1976 and 2006. To detect trends the analysis were done by using Mann Kendal (MK), Sen's graphical method and to detect change point using the Pettit test. The comparison of trend analysis between MK trend test and Sen graphical method results depict mostly similar pattern. The annual rainfall trends exhibited a significant decrease by about 12 mm per year in the upstream, which is largely driven by the significant decrease in the peak season rainfall. The Pettit test revealed that the years 1997 and 2007 were the change points. It is noted that the rise of temperature over a catchment might have decreased the availability of soil moisture which resulted in less runoff. The temperature analyses also revealed that the catchment was getting warmer; particularly in the upstream. The minimum temperature trend showed a significant increase about 0.08°c per annum. There is generally a decreasing trend in stream flow. The monthly stream flow also exhibited a decreasing trend in February, March and September. The decline in annual and seasonal rainfall and the increase in temperature lead to more evaporation and directly affecting the stream flow negatively. This trend compounded with the growth of population and increasing demand for irrigation water exacerbates the competing demand for water resources. It thus calls for prudence in devising appropriate intervention in the planning and sustainable development of the basin water resources.

Keywords: Climate variability Trends Stream flow Gidabo catchment Ethiopia

Belihu, M., Abate, B., Tekleab, S., & Bewket, W. (2018). Hydro-meteorological trends in the Gidabo catchment of the Rift Valley Lakes Basin of Ethiopia. Physics and Chemistry of the Earth, Parts A/B/C, 104, 84-101.

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 (R2) 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 R2 > 0.78 and NSE > 0.67; and the HEC-HMS model provided the model performance with the R2 > 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. A., Aga, A. O., Tadesse, T., & 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(04), 105.

Quantitative evaluation of watershed attributes for water resources management in the Rift Valley Lakes Basin, Ethiopia: a case from Tikur Wuha river watershed

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[2]Chair of Hydrological Modeling and Water Resources, Albert-Ludwigs University of Freiburg, Freiburg, Germany
[3]Graduate Programme Head, Institutefof Technology at Hawassa University, Awassa, Ethiopia

Abstract

Characterization of watershed hydrological process is vital for sustainable water resource management. The principal goal of this study was to investigate the inference of drainage attributes on basic hydrological processes using spatial-based morphometric analysis on Tikur Wuha river watershed. The result obtained indicated that the area was characterized with fifth-order stream. Drainage area with higher stream order has lower infiltration capacity, and the shorter stream lengths were associated with the steepness of the area which affects water flow. Based on Nu value, sub-watersheds were categorized in the active erosion stage (SW7) and matured topography development (SW6). The interpretation from watershed geometry identified circular areas most susceptible to rapid hydrological response (SW11). Hydrological process and underlying materials are mainly correlated with the drainage texture parameter, and the lower the values indicated less rocky terrain and very high infiltration capacity which contributes toward less erosion (SW11). Relief parameters such as Rr value indicate the rate of stream flow and are well used in sediment yield estimation. The findings of this investigation will provide core information for water resource planning and further studies like identification of groundwater potential zones; flood risk assessment; erosion-prone area prioritization; and to select suitable sites for the construction of water harvesting structures.

Keywords: Water resource ·Hydrology Morphometric analysis·Tikur Wuha

Girma, R., Abraham, T., & Muluneh, A. (2020). Quantitative evaluation of watershed attributes for water resources management in the Rift Valley Lakes Basin, Ethiopia: a case from Tikur Wuha river watershed. Applied Water Science, 10(8), 1-15.

Hydrologic response to land use land cover change in the Upper Gidabo Watershed, Rift Valley Lakes Basin, Ethiopia

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Abstract

The purpose of the study was to assess land use and land cover changes (LULCC) effects on stream flow of the upper Gidabo Watershed, Ethiopia. The data subjected to analyses were satellite imageries of 1985, 2000, and 2018, Digital Elevation Model, climate and streamflow records. Syntheses of SWAT and SWAT-CUP algorithms have been done using ArcSWAT. Accordingly, seven types of land uses are identified and agroforestry is the dominant land use (64%). LULCC depicted that agricultural land and urban settlement increased by 59.8% and 28.7% respectively at the expense of forest and grassland. The impact of land dynamics on the hydrological response depicted that an increase in surface runoff and evapotranspiration by 9.2% and 1.7% respectively. The wet season flow increased by 5.6% while the dry season decreased by 12.7%. Surface flow variation particularly in the dry season demand close intervention in land use management and utilization of water resources.

Keywords: ARCSWAT, Upper Gidabo Watershed, LULCC, Stream flow, ERDAS, MAGINE, SWAT model

Belihu, M., Tekleab, S., Abate, B., & Bewket, W. (2020). Hydrologic response to land use land cover change in the Upper Gidabo Watershed, Rift Valley Lakes Basin, Ethiopia. HydroResearch, 3, 85-94.

Assessing the Impact of Existing and Future Water Demand on Economic and Environmental Aspects (Case Study from Rift Valley Lake Basin: Meki-Ziway Sub Basin), Ethiopia

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Abstract

In the development of water resource projects there is an increase and extensive use of water resources, which causes exploitation of the existing systems and ecosystem of the natural environment. The Water Evaluation and Planning (WEAP) model is used to assess water demand by considering the existing development situation and future water resources development with scenarios analysis in the study area (Ziway Meki Sub Basin, Ethiopia). Three different development scenarios were developed to simulate water use at demand sites. In the simulations, the catchment was divided into 5 main sub-catchments where the supply and demand nodes were spatially located. The competing water sectors were irrigation development, domestic users, soda ash industry and environmental flow requirements. Hydro Meteorological data, net evaporation from Lake Reservoir, and monthly water demand from user sectors were the basic inputs to the model. The results of the reference scenario were validated using observed flows. Accordingly, the simulation result revealed that the total average annual inflow volume into the study area is declining significantly for reference scenarios and water availability is limited in the months of January (17 Mm3) and December (171 Mm3) while in the other months the availability is efficient and all users have 100% coverage. Except Langano irrigation site that have between 33.33% to 86.5% coverage in average during the month of Feb to May (2.57 Mm3) and April in Bulbula 95.2% coverage, others get full coverage. The minimum reliability observed mostly in the ongoing and likely future development scenarios at Bulbula irrigation demand sites which have 92.11% and 66.67% reliability in Langano irrigation demand sites throughout all development scenarios. On the other hand, in Sher-Ethiopia expansion, 51.75% reliability is observed in ongoing and likely future development scenarios and in demand site of Katar irrigation diversion and Meki irrigation from dam 51.75% is observed in likely future development scenarios.

Keywords: Central rift valley; WEAP model; Water allocation; Demand sites; Demand coverage; Reliability; Scenario analysis

Shumet, A. G., & Mengistu, K. T. (2016). Assessing the impact of existing and future water demand on economic and environmental aspects (Case study from Rift Valley Lake Basin: Meki-Ziway Sub Basin), Ethiopia. Int J Waste Resour, 6(223), 2.

Spatial and seasonal water level dynamics in dryland grabens along the Rift Valley of northern Ethiopia

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Abstract

We investigated water levels in semi-closed grabens of northern Ethiopia. Springs (n = 79), streamflows (n = 48), wetlands (n = 3), endorheic lakes (n = 3), hand-dug wells (n = 48) and boreholes in unconfined aquifers (n = 25) were monitored (2015–2017). Spring discharge fluctuates between wet (2.75 ± 1.5 L/s) and dry seasons (0.87 ± 0.21 L/s) (n = 68, $p < .0001$). Spring discharge and streamflow were larger at the foot of the escarpment than at the horst ($p < .001$). The water level of wells varied between horsts and escarpments in the grabens ($p < .02$). A water level depletion of up to 2.23 m/year occurred in response to withdrawals in the irrigated plains. Importantly, water level fluctuation was faster in streams, springs and hand-dug wells than in boreholes. Striking water level variations in the grabens were linked to rainfall deficit and management scarcity. An integration of surface water and groundwater management responses will bring the water table nearer to the surface; this could mitigate water storage in the fertile and productive grabens.

Keywords: graben, natural spring, stream flow, dry season, escarpment, Ethiopia

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Combining multisource satellite data to estimate storage variation of a lake in the Rift Valley Basin, Ethiopia

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Abstract

Integration of remote sensing data sets from multiple satellites is tested to simulate water storage variation of Lake Ziway, Ethiopia for the period 2009-2018. Sixty Landsat ETM+/OLI images served to trace temporal variation of lake surface area using a water extraction index. Time series of lake levels were acquired from two altimetry databases that were validated by *in-situ* lake level measurements. Coinciding pairs of optical satellite based lake surface area and radar altimetry based lake levels were related through regression and served for simulating lake storage variation. Indices for extracting lake surface area from images showed 91–99 % overall accuracy. Lake water levels from the altimetry products well agreed to *in-situ* lake level measurements with $R2 = 0.92$ and root mean square error of 11.9 cm. Based on this study we conclude that integrating satellite imagery and radar altimetry is a viable approach for frequent and accurate monitoring of lake water volume variation and for long-term change detection. Findings indicate water level reduction (4 cm/annum), surface area shrinkage (0.08km2/annum) and water storage loss (20.4Mm3/annum) of Lake Ziway (2009–2018).

Keywords: Landsat lake surface estimation, Lake level radar altimetry, Water volume variation, Change monitoring, Lake Ziway

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Simulated surface and shallow groundwater resources in the Abaya-Chamo Lake basin, Ethiopia using a spatially-distributed water balance model

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Abstract

Study region: The volcano-tectonic lakes basin of Abaya-Chamo is part of the Main Ethiopian Rift system and exhibits large variations in geomorphology, physiography and climate between the rift floor and the plateau. Study focus: Despite the importance of streamflow for water resources management and planning in the basin, many of the rivers there are ungauged. To make quantitative estimates of streamflow for spatially resolved water availability in such a highly heterogeneous environment, therefore, requires numerical modeling. This study is the first to quantify the surface and shallow groundwater resources in Abaya-Chamo, and to validate the physically fully distributed hydrologic model WetSpass under highly data-limited conditions, in a complex two-lake environment. New hydrological insights: Simulated total river flow and estimated baseflow were verified at 15 gauging stations, with a good agreement. The WetSpass model is shown to be suitable for such a complex setting with a correlation coefficient of 0.95 and 0.97 for total flow and baseflow respectively at a statistically significant level (p-value < 0.05). The simulated annual water budget reveals that 74.6% of the 22.1 billion lit/yr in total precipitation in the basin is lost through evapotranspiration, 15.7% through surface runoff, and only 9.7% recharges the groundwater system. The simulations also revealed the surface runoff and groundwater recharge are the most sensitive to soil textural class, while evapotranspiration depends more strongly on land use.

Keywords: Surface water Groundwater Water balance WetSpass Abaya-Chamo Lake basin

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