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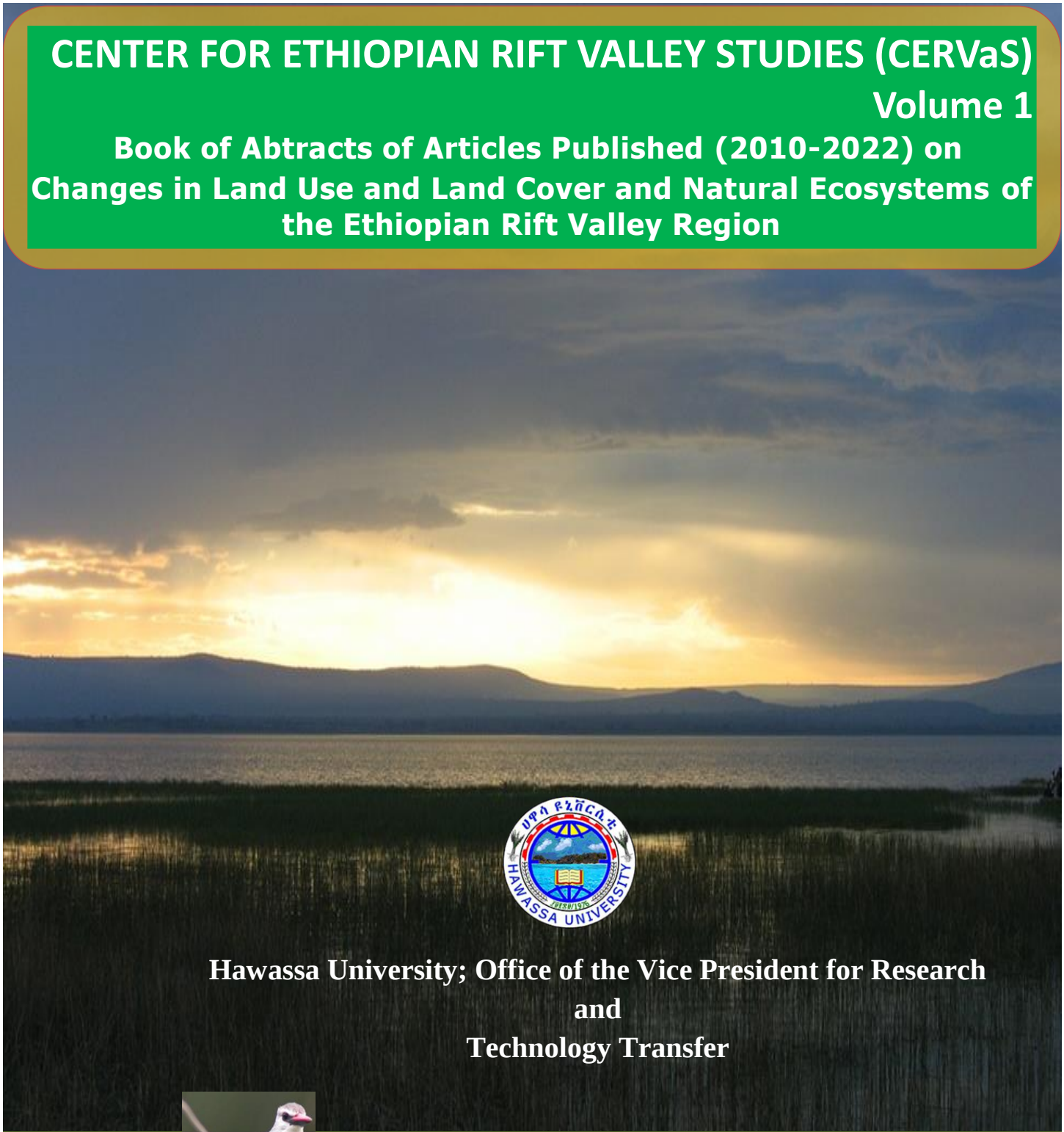

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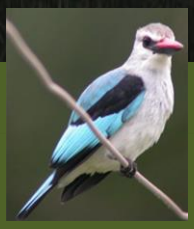

"Joining Hands to Reverse the Alarming Situations"

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Effects of Long-Term Land Use and Land Cover Changes on Ecosystem Service Values: An Example from the Central Rift Valley, Ethiopia

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Abstract

Changes in land use and land cover (LULC) are the leading contributors to the decline and loss of ecosystem services in the world. The present study covered the Central Rift Valley lakes basin in Ethiopia, focusing on the valley floor and the East and West escarpments, to analyze changes in LULC and to estimate associated losses in ecosystem service values (ESVs). Covering both upstream and downstream areas in the basin, the study addressed major gaps in existing studies by connecting the sources and sinks of material (e.g., sediment and water) in source-to-lake systems. Additionally, the study facilitated the identification of critical areas for conserving natural resources and reversing the decline of associated ESVs in the Central Rift Valley. A post-classification comparison approach was used to detect LULC changes between 1973 and 2020 using four Landsat images from 1973, 1990, 2005 and 2020. The value transfer valuation method was used to estimate the changes in ESVs due to LULC changes. Among the seven major identified LULC classes, farmlands, settlements, and bare lands showed positive changes, while forestlands, grasslands, shrublands and waterbodies showed negative changes over the last 47 years. The expansion of farmlands, for example, has occurred at the expense of grasslands, forestlands and shrublands. The changes in LULC over a period of 47 years resulted in a total loss of US $62,110.4 × 10^6 in ESVs. The contributors to the overall loss of ESVs in decreasing order are provisioning services (US $33,795.1 × 10^6), cultural services (US $28,981.5 × 10^6) and regulating services (US $652.9 × 10^6). The results imply that addressing the degradation of land and water resources is crucial to reversing the loss of ecosystem services and achieving the national Sustainable Development Goals (SDGs) related to food and water security (SDGs 2 and 6) and life on land (SDG 15).

Keywords*:* ecosystem service; ecosystem service values; forestland; SDGs; waterbodies

Mekuria, W., Diyasa, M., Tengberg, A., & Haileslassie, A. (2021). Effects of long-term land use and land cover changes on ecosystem service values: An example from the central rift valley, Ethiopia. *Land*, *10*(12), 1373.

Changes of ecosystem service values in response to land use/land cover dynamics in Munessa–Shashemene landscape of the Ethiopian highlands

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Abstract

Land use/land cover (LULC) dynamics alter ecosystem services values (ESVs), yet quantitative evaluations of changes in ESVs are seldom attempted. Using Munessa–Shashemene landscape of the Ethiopian highlands as an example, we showed estimate of changes in ESVs in response to LULC dynamics over the past four decades (1973–2012). Estimation and change analyses of ESVs were conducted, mainly, by employing GIS using LULC datasets of the year 1973, 1986, 2000 and 2012 with their corresponding global value coefficients developed earlier and our own modified conservative value coefficients for the studied landscape. The results between periods revealed a decrease of total ESVs from US$ 130.5 million in 1973, to US$ 118.5, 114.8 and 111.1 million in 1986, 2000 and 2012, respectively. While using global value coefficients, the total ESVs declined from US$ 164.6 million in 1973, to US$ 135.8, 127.2 and 118.7 million in 1986, 2000 and 2012, respectively. The results from the analyses of changes in the four decades revealed a total loss of ESVs ranging from US$ 19.3 million when using our own modified value coefficients to US$ 45.9 million when employing global value coefficients. Changes have also occurred in values of individual ecosystem service functions, such as erosion control, nutrient cycling, climate regulation and water treatment, which were among the highest contributors of the total ESVs. However, the value of food production service function consistently increased during the study periods although not drastically. All in all, it must be considered a minimum estimate of ESV changes due to uncertainties in the value coefficients used in this study. We conclude that the decline of ESVs reflected the effects of ecological degradation in the studied landscape and suggest further studies to explore future options and formulate intervention strategies.

Keywords: GIS; Value coefficients; Ecosystem service functions; Database; Valuation; Natural capital; Remote sensing

Kindu, M., Schneider, T., Teketay, D., & Knoke, T. (2016). Changes of ecosystem service values in response to land use/land cover dynamics in Munessa–Shashemene landscape of the Ethiopian highlands. *Science of the Total Environment*, *547*, 137-147, https://doi.org/10.1016/j.scitotenv.2015.12.127

Local perceptions of ecosystem services and human-induced degradation of Lake Ziway in the Rift Valley Region of Ethiopia

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Abstract

Ecosystems supply beneficial contributions to people's quality of life and well-being. Freshwater lakes provide diverse consumptive and non-consumptive ecosystem services (ESs) to people. This study examined ecosystem goods and services that Lake Ziway in the Rift valley region of Ethiopia supply and identified the anthropogenic pressures that impact the lake and its services. The lake currently supports investment projects and livelihoods of the local communities. It contributes to the local and national economy from the export of cut flowers. The biggest commercial floriculture investment in the country is located on the shore of this lake, depending mainly on its water. Assessing the views and knowledge of local communities towards the contributions of ESs to human life, well-being, and livelihoods is important to protect and prolong the long-term benefits of ESs. A total of 41 experts, 137 households, and 20 discussants from two districts were selected for interviews and focus group discussions (FGDs). Pearson's Chi-square tests were used to test the association between dependent and independent variables. Multiple regression models were developed to examine the ESs of the lake and human impacts. The result showed that respondents prioritize the ESs of the lake as provisioning > supporting > cultural > regulating services. The Chi-square results revealed a strong association among ESs with respondents' type and residence locations. The multiple regression results revealed that respondents' types and residence locations were significant determinants in prioritizing the importance of ESs of Lake Ziway ($p < .01$). The degradation of Lake Ziway is increasing along with the increasing human population and increasing demands for provisioning services. The major anthropogenic activities are intensive water abstraction, pollution, overharvesting of resources, wetland conversion, and the introduction of invasive species. Such human activities are degrading the capacities of the lake ecosystem and its ecosystem service provisions. Our results indicate that understanding the links between these human pressures on Lake Ziway and its ES provisions is crucial for the sustainable management of the lake. The study could serve as a reference for decision-making for prioritizing the conservation measures needed towards ensuring the sustainable use of the various ecosystem services of the lake. Conservation interventions by involving local communities as major actors are needed to minimize human pressures and ensure the sustainability of the lake and its ESs.

Keywords: Ecosystem services; Anthropogenic pressures; Lake Ziway; Lake management; Ethiopia; Eastern Africa

Desta, H. (2021). Local perceptions of ecosystem services and human-induced degradation of lake Ziway in the Rift Valley region of Ethiopia. *Ecological Indicators*, *127*, 107786, https://doi.org/10.1016/j.ecolind.2021.107786.

Assessing Dynamics in the Value of Ecosystem Services in Response to Land Cover/Land Use Changes in Ethiopia, East African Rift System

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Abstract

Ecosystem services (ES) are essential to human well-being. Assessing dynamics of ES is crucial to shaping the concept of sustainable development and creating public understanding of the status of ES. This study proposes to quantify the change in ES value in response to Land cover/land use (LCLU) changes over the past 33 years in the Rift Valley Lakes Region of Ethiopia. A combined approach of LCLU classification and modified ES value coefficients was employed for quantifying the ES value. Results revealed that approximately USD196.04 ×106 (12.4%) of ES value was lost during the study period. Although cropland experienced a dramatic expansion, the total gain in ES value of the cropland was too small to balance out the overall loss. A continuous reduction in values of specific ES functions has also occurred except for food production, biological control, and pollination service function over the last three decades, indicating an apparent deterioration of the fragile Rift Valley ecosystem. Hence, to enhance the continuous supply of ES and economic development, an integrated approach to managing land and water resources is recommended. Moreover, payment for ES is also a potential remedy for ES loss at the regional and local scale.

Keywords: combined approach, benefit transfer, modified coefficient, East Africa Rift system, average ecosystem service value, loss, water bodies, woodland, cropland

Negussie, W., Wu, W., Alemayehu, A., & Yirsaw, E. (2019). Assessing dynamics in the value of ecosystem services in response to land cover/land use changes in Ethiopia, East African Rift System. *Applied Ecology and Environmental Research*, *17*(3), 7147-7173, DOI: http://dx.doi.org/10.15666/aeer/1703_71477173

Assessing Changes in Ecosystem Service Values over 1985–2050 in Response to Land Use and Land Cover Dynamics in Abaya-Chamo Basin, Southern Ethiopia

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Abstract

This study evaluated the effect of Land Use and Land Cover (LULC) dynamics on the value of ecosystem services in Abaya-Chamo basin over 1985–2050. The main objectives of the study were to estimate the value of ecosystem services of Abaya-Chamo basin using local and global ecosystem service value coefficients, assess how it changes over time, and develop tools to inform policy and public decision-making to protect lands and waters in the region. The study utilized observed (1985 and 2010) and predicted (2030 and 2050) LULC datasets and ecosystem service value coefficients obtained from publications in peer-reviewed scientific journals. The results indicated that the total ecosystem service value of Abaya-Chamo basin was 12.13 billion USD in 1985 and 12.45 billion USD in 2010. The value is predicted to increase to 12.47 billion USD by the year 2050, which is 2.84% (344.5 million USD) higher than the total value of ecosystem services of the basin in 1985. Although the total ecosystem service value of the basin showed a slight increase over the study period, it was observed that the total value of services obtained from natural ecosystems is expected to decline by 36.24% between 1985 and 2050. The losses of services obtained from natural ecosystems, such as water regulation and erosion control, are major concern as the consequence has already been reported in the basin in the form of reduced water quality and productivity of the lakes due to an increased soil erosion and sediment transport in the basin. Therefore, special attention should be given to the rehabilitation of degraded ecosystems and the protection of remaining natural vegetation and water bodies to enhance natural capital and ecosystem services in the basin. A large-scale dissemination of eco-agricultural land use practices, which provide multiple ecosystem services (such as agroforestry and heterogeneous agricultural areas) in the basin, needs to be considered in the future.

Keywords*:* ecosystem services; landscape change; valuation of ecosystem services; land use/land cover; Abaya-Chamo Basin

Woldeyohannes, A., Cotter, M., Biru, W. D., & Kelboro, G. (2020). Assessing changes in ecosystem service values over 1985–2050 in response to land use and land cover dynamics in Abaya-Chamo Basin, Southern Ethiopia. *Land*, *9*(2), 37, https://doi.org/10.3390/land9020037

Analyzing Trends and Drivers of Land Use and Land Cover Dynamics in Drought-Prone Livelihood Zones of the Northwestern Escarpment of the Ethiopian Rift Valley

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Abstract

The current study looked at the patterns and causes of land use and land cover (LULC) dynamics from 1985 to 2019 in three drought-prone areas of the Ethiopian Rift Valley's Northwestern Escarpment. Spatial data, focus group discussions, and key informant interviews were used to study the trends and causes of LULC dynamics. For Landsat image processing, ERDAS Imagine 2015 was used, and for LULC change analysis, ArcGIS 10.8 was employed. From the result, fast LULC exchange occurred in all study LZs throughout the study years. Raya Valley LZ (RVLZ) is, however, more highly shifted than Allagie Ofla LZ (ALOFLZ) and Tsirare catchment LZ (TCLZ). From the total area, only 17.7, 28.3, and 23.2 percent of RVLZ, ALOFLZ, and TCLZ persisted over the study years, respectively. The LULC change in the studied LZs was driven by population pressure and recurrent droughts. The research area's local ecosystem services have been disrupted by these changes, which have impacted the livelihood system of the local community. Consequently, the government should reform the appropriate land use policy, which benefits local farmers and their ecosystems. In addition, farm activities must be environmentally friendly to increase farmland productivity.

Keywords: Driving forces; Landsat images; livelihood zone; LULC dynamics; key-informant interviews

Ahmed, J. N., Tilahun, E. A., Italemahu, T. Z., Sintayehu, E. G., & Said, S. M. (2022). Analyzing Trends and Drivers of Land Use and Land Cover Dynamics in Drought-prone Livelihood Zones of the Northwestern Escarpment of the Ethiopian Rift Valley. *Papers in Applied Geography*, 1-30, https://doi.org/10.1080/23754931.2022.2074304

Land Use/Land Cover Dynamics and Its Impact on Biodiversity Resources in the Abijata Shalla National Park, Central Rift Valley Lakes Region, Ethiopia

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Abstract

Land use and land cover (LULC) dynamics have been among the most important visible changes that have taken place everywhere in the Ethiopian landscape. Such changes are severely affecting ecosystem health including degradation of nature reserves and wild animal sanctuaries. One such nature reserve in Ethiopia is the Abijata-Shala National Park (ASNP). A digital LULC detection technique was applied by using multi-temporal satellite imagery interpretation in order to understand the landscape dynamics in the ASNP. In order to assess the state of the environment over time, four timelines associated with biodiversity loss were considered: 1973, 1994, 2000 and 2016. Supervised classifications in ERDAS imagine 2014 software and post-classification in Arc GIS software was performed. The image was classified into five major land use classes namely water bodies, grazing land, cultivated land, Acacia dominated wood land and bare land. It was observed that water bodies decreased in the first period (1973-1994) and increase in the second period (1994-2000) but fallen drastically afterwards in the third period (2000-2016). This is a pattern opposite to what we see in the cultivated land. The overall trend shows that grazing and cultivated land increase by 14% and 15% respectively while, the water bodies decreased by about 16%. The reduction of woodlands and water bodies means loss of habitat for large number of aquatic and terrestrial species of animals including endemic and migratory birds. Bare land trend shows that decrease by 1.02% in first period, increase by 0.56% in second period and decrease in third period by 4.17%. We conclude that in the park there is substantial change in LULC, which could affect the biodiversity of the park.

Keywords: Abijata Shalla Lakes National Park; Arc GIS; Biodiversity loss; ERDAS imagine; Land use/cover change

Yohannes, H., Mohammed, A., & Elias, E. (2017). Land use/land cover dynamics and its impact on biodiversity resources in the Abijata Shalla National Park, central rift valley Lakes Region, Ethiopia. *Environ Sci Ind J, 13*(5), 152.

Dynamics of urban landscape nexus spatial dependence of ecosystem services in rapid agglomerate cities of Ethiopia

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Abstract

Understanding the dependence of ecosystem services (ESs) on the dynamics of human-semi nature-coupled ecosystems is crucial for urban ecosystem resilience. In the present study, the responses of ESs to land use land cover transitions were explored and compared, selecting Addis Ababa, Adama, Hawassa, and Bahir Dar cities in Ethiopia. The geospatial data and benefit transfer approach was used to estimate the nexus over a three-decade period (1990–2020). Moreover, the bivariate Moran's I and spatial regression models were employed to analyze the spatial dependence of ESV on urbanization. The findings showed that the built-up increased by 17,341.0 ha (32.2%), 2151.3 ha (19.6%), 2715.2 ha (12.2%), and 2599.7 ha (15.7%) for Addis Ababa, Adama, Bahir Dar, and Hawassa cities, respectively over the investigated periods. Besides, the total ESV weighed by 24.8%, 8.9%, 0.7%, and 3.9% from the US$ 277.9, 55.5, 100.3, and 90.9 million for Addis Ababa, Adama, Bahir Dar, and Hawassa cities, respectively from1990 to 2020. Synergies occurred among local climate regulation and recreation services, and trade-offs existed among other services. A persistent rising trend in the ESVt was found for all cities the upsurge in Addis Ababa being much sturdier than in others. However, the elasticity of ecosystem of land use (EEL) showed that 1% of the LULC transformation was caused by 8.9% changes in ESV. Besides, the results from the global bivariate Moran's I show substantial positive spatial correlations between ESV, and Integrated Land use Dynamic Degree (ILUDD), Land-Use Intensity (LUI), and Land Use Diversity (LUD) ($p < 0.001$). Spatial lag model and special error model were shown to be fitting more than the Ordinary Least Square in establishing relationships among the spatial dependence of ESV on urbanization. In contrast, the aggregated ESV is significantly influenced not only by LULC dynamics but also by the spatial spillover effect. Thus, overall findings suggested an antagonistic nexus between the aggregated ESV and ESVf, since 98% of individual ESs were negatively declined as the built-up ecosystem expanded.

Keywords: Bivariate Moran's I; Ecosystem services; ESV; Spillover effect; Urbanization

Degefu, M. A., Argaw, M., Feyisa, G. L., & Degefa, S. (2021). Dynamics of urban landscape nexus spatial dependence of ecosystem services in rapid agglomerate cities of Ethiopia. *Science of The Total Environment, 798*, 149192, https://doi.org/10.1016/j.scitotenv.2021.149192

Modeling and prediction of effects of land use change in an agroforestry dominated southeastern Rift-Valley escarpment of Ethiopia

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Abstract

Through the increased use of innovation, human population has been growing rapidly in its ability to derive resources from the environment. Predicting how land use/cover (LUC) changes affect regions and the society requires a good understanding of the dynamic human-environment interactions associated with land use change. This article addresses the future spatial distribution of land use and the impacts that ongoing LUC change have on the ecosystems of Gedeo-Abaya landscape. The actual LUC maps of 2000 and 2015 reference years together with natural and socioeconomic indicators were used in a combined Markov–CA model with GIS technology to simulate and forecast the changes in 2025 and 2035. Our prediction processes shows among the indicators used, distance to the nearest road and slope have more significant effects on the transition potential maps followed by elevation. Area based prediction change generally shows significant increase in agroforestry, cultivation land, and wetland/marshes LUC classes, while most natural vegetation classes, particularly woodland/shrubland (−29.8%), and grazing land (−5.7%) show significant reduction from 2015 to 2035. The present and forecasted trend of LUC changes has visible environmental and socioeconomic impacts, particularly on woodland ecosystems and on the well-being of (agro)pastoral communities in the downstream. Whilst, the betterment of the upstream study region strongly depends on the continuity with the current government landscape restoration policy as well as on the permanence of farmers current environmental friendly land management practices. Forecasting LUC changes in the study landscape offers the possibility that unwanted changes are prevented through proper and timely interventions.

Temesgen, H., Wu, W., Legesse, A., & Yirsaw, E. (2021). Modeling and prediction of effects of land use change in an agroforestry dominated southeastern Rift-Valley escarpment of Ethiopia. *Remote Sensing Applications: Society and Environment*, *21*, 100469, https://doi.org/10.1016/j.rsase.2021.100469

Implications of land use/land cover dynamics and *Prosopis* invasion on ecosystem service values in Afar Region, Ethiopia

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Abstract

Land use/land cover (LULC) dynamics and the resulting changes in ecosystems, as well as the services they provide, are a consequence of human activities and environmental drivers, such as invasive alien plant species. This study assessed the changes in LULC and ecosystem service values (ESVs) in the Afar National Regional State, Ethiopia, which experiences a rapid invasion by the alien tree *Prosopis juliflora* (Swartz DC). Landsat satellite data of 1986, 2000 and 2017 were used in Random Forest algorithm to assess LULC changes in the last 31 years, to calculate net changes for different LULC types and the associated changes in ESVs. Kappa accuracies of 88% and higher were obtained for the three LULC classifications. Post-classification change analyses for the period between 1986 and 2017 revealed a positive net change for *Prosopis* invaded areas, cropland, salt flats, settlements and waterbodies. The rate of *Prosopis* invasion was estimated at 31,127 ha per year. Negative net changes were found for grassland, bareland, bush-shrub-woodland, and natural forests. According to the local community representatives, the four most important drivers of LULC dynamics were climate change, frequent droughts, invasive species and weak traditional law. Based on two different ESVs estimations, the ecosystem changes caused by LULC changes resulted in an average loss of ESVs in the study area of about US$ 602 million (range US$ 112 to 1091 million) over the last 31 years. With an increase in area by 965,000 ha, *Prosopis*-invaded land was the highest net change during the study period, followed by grassland (−599,000 ha), bareland (−329,000 ha) and bush-shrub-woodland (−327,000 ha). Our study provides evidence that LULC changes in the Afar Region have led to a significant loss in ESVs, with serious consequences for the livelihoods of the rural people.

Keywords: Ecosystem service values; Land use and cover dynamics; Machine learning algorithm; Random forest classifier; *Prosopis juliflora;* Ethiopia

Shiferaw, H., Bewket, W., Alamirew, T., Zeleke, G., Teketay, D., Bekele, K., ... & Eckert, S. (2019). Implications of land use/land cover dynamics and Prosopis invasion on ecosystem service values in Afar Region, Ethiopia. *Science of the total environment*, *675*, 354-366, https://doi.org/10.1016/j.scitotenv.2019.04.220.

Geospatial Analysis of Wetland Dynamics on Lake Abaya-Chamo, The Main Rift Valley of Ethiopia

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Abstract

Wetlands worldwide and in Ethiopia have long been subject to severe degradation due to anthropogenic factors. This study was aimed at analyzing the impact of land use/land cover dynamics on Lake Abaya-Chamo wetland from 1990–2019. Data were acquired via Landsat TM of 1990, ETM+ of 2000, and OLI of 2010 and 2019 images plus using interview. Supervised classifications (via ERDAS14 and ArcGIS10.5) were applied to detect land use/land cover classes. Change matrix model and Kappa coefficients were used for analysis of the land use/land cover dynamics in the lake-wetland. It was found that forest; water body, shrub land, agricultural land, settlement and swamp area were the main land use/land cover classes. Wetland/swamp area has continuously declined throughout 1990–2000, 2000–2010 and 2010–2019 where its magnitude of shrinkage in the respective periods was 11.4 % (700 ha), 16 % (867 ha) and 31.3 % (1,424 ha). While 'settlement' and 'water body' of the lake-wetland increased at progressively increasing magnitudes of changes in three periods within 1990–2019, 'shrub land' and wetland/'swamp' declined at progressively increasing magnitudes of loss in the same periods. Siltation, rapid population growth-led expansion of settlement and irrigation-based farming were the main drivers of the land use/land cover dynamics and degradation of the lake-wetland. Thus, consistent mapping and integrated actions should be taken to curb the threats on the sustainability of the lake-wetland in Southern Ethiopia. To reduce the impact of LULC dynamics on wetlands, the regime should: advance a clear political, institutional and legal framework for wetland management.

Keywords: Land use/land cover; Wetland dynamics; Magnitude; Multispectral; Lake Abaya-Chamo wetland

Zekarias, T., Govindu, V., Kebede, Y., & Gelaw, A. (2021). Geospatial Analysis of Wetland Dynamics on Lake Abaya-Chamo, The Main Rift Valley of Ethiopia. *Heliyon*, *7*(9), e07943, https://doi.org/10.1016/j.heliyon.2021.e07943

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Impact of land use/cover changes on lake ecosystem of Ethiopia central rift valley

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Abstract

Central Rift Valley (CRV) Ethiopia is an important region in terms of its vast ecosystem services (ES) and enriched biodiversity. However, its ES and biodiversity are under terrific pressure from hurried population growth, unsustainable developmental activities, unplanned urbanization, aggressive agricultural expansion, climate change, and the associated changes in land use and land cover (LULC). This study was aimed at analyze LULC changes in the Ethiopia CRV areas from 1985 to 2015 through Geographic Information System (GIS) and Remote Sensing (RS) techniques. Satellite images were accessed, pre-processed and classified. Field observations, discussion with dwellers (elders) were also employed to validate results from remotely sensed data. Major LULC types were detected and change analysis was executed. Consequently, nine LULC changes were successfully evaluated. The classification result revealed that in 1985 the area was covered by 44.34% with small-scale farming followed by mixed cultivated/acacia (21.89%), open woodland (11.96%), and water bodies (9.77%), respectively. Though the area measure varied among land use classes, the trend of share occupied by the LULC types in the study area remained the same in 1995 and 2015. In this research increase in small and large-scale farming, settlements and mixed cultivation/acacia while a decrease in water bodies, forest, and open woodlands is noted. Accordingly, the overall accuracy of this study was 84.46, 86.86 and 88.86 with kapa value of 0.82, 0.84 and 0.87, respectively. Lastly, the DPSIR framework analysis was done and integrated land use and policy reform are suggested as a response for sustainable land use planning and management.

Keywords: central rift valley; Ethiopia; landsat images; lake; land use/land cover

Elias, E., Seifu, W., Tesfaye, B., & Girmay, W. (2019). Impact of land use/cover changes on lake ecosystem of Ethiopia central rift valley. *Cogent Food & Agriculture*, *5*(1), 1595876, https://doi.org/10.1080/23311932.2019.1595876.

The impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia

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Abstract

Ecosystems provide a wide range of services that are important for human-well being. Estimating the multiple services obtained from ecosystems is vital to support decision-making processes at different levels. This study analyzes land use/land cover (LU/LC) dynamics over four decades (i.e., 1973, 1986, 2001, 2015) to assess its impact on ecosystem services. Ecosystem Service Values (ESV) was determined using LU/LC analysis and established global data base. LU/LC analysis showed that forest cover reduced by 54.2% during study period; and settlement, bare land, shrub land and cultivated land increased considerably. The study indicates that due to forest cover change from 1973 to 2015, approximately US$ 3.69 million of ecosystem services values was lost. Among the ecosystem services reduced were: nutrient cycling, provision of raw material and erosion control. The use of LU/LC data along with established global ESV data sets reduce the costs of ground data collection, and help in tracking of past environmental changes and acquisition of quick and reliable results that can be used for decision making processes. We believe that the results obtained can be helpful in designing payment for environmental services and rural development policies.

Keywords: Ecosystem service; Landscape change; Payment for ecosystem services Land use/land cover; Chillimo; Livelihood

Tolessa, T., Senbeta, F., & Kidane, M. (2017). The impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia. *Ecosystem services*, *23*, 47-54, https://doi.org/10.1016/j.ecoser.2016.11.010

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Ecosystem Service Values Changes in Response to Land-Use/Land-Cover Dynamics in Dry Afromontane Forest in Northern Ethiopia

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Abstract

Despite their importance as sources of ecosystem services supporting the livelihoods of millions of people, forest ecosystems have been changing into other land use systems over the past decades across the world. While forest cover change dynamics have been widely documented in various ecological systems, how these changes affect ecosystem service values has received limited attention. In this study we assessed the impact of land-use/land-cover dynamics on ecosystem service values in dry Afromontane forest in Northern Ethiopia. We estimated ecosystem service values and their changes based on the benefit transfer method using land cover data of the years 1985, 2000, and 2016 with their corresponding locally valid value coefficients and from the Ecosystem service valuation database. The total ecosystem service values of the whole study area were about USD 16.6, 19.0, and 18.1 million in 1985, 2000, and 2016, respectively. The analyses indicated an increase in ecosystem service values from 1985 to 2000 and a decrease in ecosystem service values from 2000 to 2016. Similarly, the contribution of specific ecosystem services increased in the first study period and decreased in the second study period. The findings highlight how forest cover dynamics can be translated into changes in ecosystem service values in dry Afromontane forest ecosystems in Northern Ethiopia and showed how specific ecosystem services contributed to the observed trends. The findings also illustrated the temporal heterogeneity in the impacts of land-use/land-cover dynamics on values of ecosystem services. The findings can serve as crucial inputs for policy and strategy formulations for the sustainable use and management of forest resources and can also guide the allocation of limited resources among competing demands to safeguard the ecosystems that offer the best-valued services.

Keywords*:* forest ecosystems; ecosystem service values; land-use/land-cover change; Afromontane forest; ecosystem services; Ethiopia

Solomon, N., Segnon, A. C., & Birhane, E. (2019). Ecosystem service values changes in response to land-use/land-cover dynamics in dry afromontane forest in northern Ethiopia. *International Journal of Environmental Research and Public Health, 16*(23), 4653, **https://doi.org/10.3390/ijerph16234653**
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Ecosystem Service Valuation along Landscape Transformation in Central Ethiopia

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Abstract

Land degradation and discontinuation of ecosystem services (ES) are a common phenomenon that causes socio-economic and environmental problems in Ethiopia. However, a dearth of information is known about how ES are changing from the past to the future with regard to land use land cover (LULC) changes. This study aimed at estimating the values of ES based on the past and future LULC changes in central Ethiopia. Maximum likelihood classifier and cellular automata-artificial neuron network (CA-ANN) models that integrate the module for land use change evaluation (MOLUSE) were used to classify and predict LULC. The CA-ANN model learning and validation was employed to predict LULC of 2031 and 2051. Following LULC change detection and prediction, the total ES values were estimated using the benefit transfer method. Results revealed that forests, wetlands, grazing lands, shrub-bush-woodlands, and water bodies were reduced by 9755 ha (37%), 4092 ha (38.4%), 21,263 ha (81%), 63,161 ha (25.7%), and 905 ha (1%), respectively, between 1986 and 2021. Similarly, forests, wetlands, grazing lands, shrub-bush lands, and water bodies will experience a decline of 1.5%, 0.5%, 2.6%, 19.6%, and 0.1%, respectively. Meanwhile, cultivated lands, bare-lands, and built-up areas will experience an increase between 1986 and 2051. The estimated total ES values were reduced by US$58.3 and 85.4 million in the period 1986–2021 and 1986–2051. Food production and biological control value increased while 15 other ES decreased throughout the study periods. Proper land use policy with strategic actions, including enforcement laws for natural ecosystems protection, afforestation, ecosystems restoration, and conservation practices, are recommended to be undertaken to enhance multiple ES provision.

Keywords*:* landscape transitions; ecosystem services; ecosystem service valuation; CA-ANN; MOLUSE

Biratu, A. A., Bedadi, B., Gebrehiwot, S. G., Melesse, A. M., Nebi, T. H., Abera, W., ... & Egeru, A. (2022). Ecosystem Service Valuation along Landscape Transformation in Central Ethiopia. *Land, 11*(4), 500, https://doi.org/10.3390/land11040500.

Multitemporal Land Use/Land Cover Change Detection for the Batena Watershed, Rift Valley Lakes Basin, Ethiopia

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Abstract

A majority of the rural population in Ethiopia depends on agriculture. Land use changes during the past couple of decades are mostly linked to agricultural development attributed to factors such as population pressure and environmental changes. Mapping land use/land cover (LULC) to analyze the type, rate, and extent of changes in land use patterns has far reaching significance for policy/decision makers and resource managers to provoke the wide range of applications at regional scales for erosion, landslide, land planning, forest management, and ecosystem conservation. The focus of this chapter is to depict quick and practical approaches to generate spatially and temporally quantified information on land cover dynamics using high-resolution satellite images for the years (1973–2008) in Batena watershed and its environs in southwestern Ethiopia. To quantify the magnitude of LULC change, supervised classification technique was applied using Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) images employing Bayesian maximum likelihood classifier (MLC) with the aid of ground truth training sites. A majority/minority analysis was used for smoothing the classification results and the accuracy of image classification was carried out by means of a confusion matrix generated through geographic information system (GIS) overlay of the classified maps and the test samples. The classification accuracy was further verified by the strong kappa statistical estimate of more than 90 % as a measure of overall agreement between image and reference data. The final output of remote sensing imagery revealed five land cover classes: Grazing land, bush land, mixed forest, dominantly cultivated agricultural land, and water body. It has been discovered that, there were more active LULC change processes in the area in the first study period (1973–1984) than the second study period (1984–1995) and the third study period (1995–2003). On the other hand, areal extent of cultivated and uncultivated agricultural land has been on a steady decline from 39.7 % in 1995 to 41.4 % in 2003 and a mere 50.1 % in 2008. In the first period, nearly half of the landscape underwent land cover change with more than 17 % of the entire landscape experiencing agricultural expansion. In the second period, the extent of the changes was limited to less than 1/3 of the total area with a smaller amount of agricultural area expansion than before. Though the rate of land cover change was observed to vary across the three periods of study, a general decline of forest cover and amplified increase of agricultural lands of more than 41.7 % was found in the area.

Keywords: Change detection; Land cover dynamics; Maximum likelihood classifier; Landsat Imagery; Remote sensing; GIS; Batena Watershed; Ethiopia

Ayele, G. T., Demessie, S. S., Mengistu, K. T., Tilahun, S. A., & Melesse, A. M. (2016). Multitemporal land use/land cover change detection for the Batena Watershed, Rift Valley Lakes Basin, Ethiopia. *Landscape Dynamics, soils and hydrological processes in varied climates* (pp. 51-72).

Ecosystem service variation and its importance to the wellbeing of smallholder farmers in contrasting agro-ecological zones of East African Rift

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Abstract

Smallholder farmers lead their lives using multiple ecosystem services (ESs). Understanding the contribution of these services to smallholder farmers' wellbeing is essential for addressing ecosystem-related problems. While the economic valuation of ESs has received major emphasis, smallholder farmer perceptions of ESs, ecosystem disservices (EDs), and the importance of their wellbeing are repeatedly overlooked. We analyzed variations in ES values (ESVs) in response to land use land cover (LULC) change, perceptions of ES/ED and the importance of these ecosystems to wellbeing in contrasting agro-ecological zones (AEZs). To obtain datasets, we used geospatial technology, focus group discussion, and face-to-face cross-sectional surveys in a highly populated area of the Southeastern escarpment of the Ethiopian Rift Valley. The research was carried out between October 1 and December 30, 2018. The results revealed the following. (1) Total area of 75,246.98 ha (34%) was changed to various LULC classes across AEZs. Woodland decreased at annual rates of 5.28% while agroforestry increased at annual rates of 1.03%, respectively. (2) ESV was estimated to be approximately $164 million and declined by approximately $24 million between 1988 and 2018, owing to the expansion of cultivated land. (3) More than 55% of smallholder farmers consistently identified benefits from food-cereal and vegetables, food-meat, and erosion control, problems associated with human disease vectors, as of very high importance for their wellbeing. ESs are the positive benefits while ecosystem functions that are perceived as negative for human wellbeing are termed as EDs. ESs were perceived as positively contributing to wellbeing, while EDs detracted from health and material wellbeing. The assigned values varied significantly with AEZs and socioeconomic groups, highlighting the need for careful consideration of site-specific ecosystem management strategies that improve smallholder farmers' wellbeing and sustainable development. Moreover, the cost incurred due to ESV loss may not be covered by economic gains resulting from the expansion of cultivated land and thus, implementing appropriate land-use policies at the local level would recuperate ES values.

Keywords: agro- ecological zone, ecosystem disservice, ecosystem service, smallholder farmers' wellbeing|

Ketema, H., Wei, W., Legesse, A., Zinabu, W., Temesgen, H., & Yirsaw, E. (2021). Ecosystem service variation and its importance to the wellbeing of smallholder farmers in contrasting agro-ecological zones of East African Rift. *Food and Energy Security*, *10*(4), e310, https://doi.org/10.1002/fes3.310.

Land use and land cover changes and the link to land degradation in Arsi Negele district, Central Rift Valley, Ethiopia

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Abstract

Accurate information on land use and land cover change (LULCC) is critical for understanding the causes of change and for developing effective policies and strategies to slow and reverse land degradation. In Ethiopia, the speed and scale of LULCC has been accelerated in the last 3–4 decades of the 21st century. The objectives of this study were to assess: (i) the extent of LULCC and normalized difference vegetation index (NDVI) and the link to land degradation; (ii) the causes of LULCC and implication for climate change adaptation. Satellite images analysis was used to detect the change in area and vegetation index, and farmers' perception to see the magnitude of LULCC dynamics and causes of deforestation. Correlations were made between vegetation index with dry season rainfall and temperature. The analysis of confusion matrix of LULC classification showed 87% accuracy with Kappa coefficient of 0.84. In the period 1986–2016, agriculture and settlement areas have increased by 250% and 618%, respectively. On the other hand, forests and woodlands have decreased by 72% and 84%, respectively. These were also validated with the farmers' quantification results with similar trends. Different causes have played roles in the dynamics of LULCC. The results showed that vegetation dynamics vary both spatially and temporally against precipitation and temperature. This study informs the need to focus on halting deforestation and development of alternative energy sources. It further helps to design future land management directions, landscape based adaptation and rehabilitation strategies to be considered by policy makers.

Mekonnen, Z., Berie, H. T., Woldeamanuel, T., Asfaw, Z., & Kassa, H. (2018). Land use and land cover changes and the link to land degradation in Arsi Negele district, Central Rift Valley, Ethiopia. *Remote Sensing Applications: Society and Environment*, *12*, 1-9, https://doi.org/10.1016/j.rsase.2018.07.012.

Impact of climate change on biodiversity and associated key ecosystem services in Africa: a systematic review

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Abstract

Introduction:

Biodiversity and biodiversity-based ecosystems services are intrinsically dependent on the climate. During the twentieth century, climate change has posed major threats to biodiversity in Africa, and impacts are expected to increase as climate change continues and perhaps even accelerates.

Outcomes: Our review shows that the multiple components of climate change are projected to affect all levels of biodiversity, from genes over species to biome level. Loss of biodiversity as a result of climate change can alter the structures and functions of African ecological systems. As a result, the provision of biodiversity-based ecosystem services and the well-being of people that rely on these services are being modified. Of particular concerns are "tipping points" where the exceedance of ecosystem thresholds will possibly lead to irreversible shifts of the structure of ecosystems and their services. In recent years, climate prediction models have portended continued warming and more frequent extreme weather events across the region. Such weather-related disturbances such as El Niño will place a premium on biodiversity and biodiversity-based ecosystem services that people rely on.

Conclusion: As biodiversity underlies all goods and services provided by ecosystems that are crucial for human survival and well-being, this paper synthesizes and discusses observed and anticipated impacts of climate change on biodiversity and biodiversity-based ecosystem service provision and livelihoods, and what strategies might be employed to decrease current and future risks on the well-being of human in Africa.

Keywords: Agricultural production; climate regulation; disease regulation; provisioning services; regulating services; tipping points

Sintayehu, D. W. (2018). Impact of climate change on biodiversity and associated key ecosystem services in Africa: a systematic review. *Ecosystem health and sustainability*, *4*(9), 225-239, https://doi.org/10.1080/20964129.2018.1530054

Understanding the Impact of Land Use and Land Cover Change on Water–Energy–Food Nexus in the Gidabo Watershed, East African Rift Valley

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Abstract

Land use and land cover (LULC) changes have significant influences on the water–energy–food (WEF) nexus, as the WEF nexus characteristics change naturally due to dynamic LULC changes. However, understanding the WEF nexus' potential and characteristics in the watershed under the influence of LULC changes is less commonly explored. This study used the social network analysis (SNA) model to analyze the interaction between land use (LU) types and water, energy, and food nexus attributes. Moreover, we used regression analysis to analyze the impact of various LU types on the WEF nexus. The LULC maps of 1986, 2000, 2011, and 2019 were prepared by digital classification method with proper accuracy using satellite imagery. The results show that agroforestry is the dominant LU type, accounting for 25.8–53.1% from 1986 to 2019. Further, settlement increased a 100-fold, which shows the dynamic LULC changes. SNA computed the maximum inter-linkage for forest and water access attributes, while agroforestry and food attributes acted as bridge in the network. This shows that there was inter-dependence between LULC changes and the WEF nexus. This result suggests that LU dynamics can exert pressure on the WEF nexus' resource potential, resulting in WEF insecurity. The analysis of impacts of LULC changes on the WEF nexus shows that the changes that occurred in major LUs (i.e., agroforestry, bare land, settlements, and grass land) had significantly impacted hydrological behaviors, energy characteristics, and food production potential. Understanding LULC changes helps us to conserve and manage WEF nexus resources and to resolve the current dilemmas between land, water, energy, and food sector policies and decisions to improve resource productivity, lower environmental pressure, and enhance human wellbeing and security.

Wolde, Z., Wei, W., Likessa, D., Omari, R., & Ketema, H. (2021). Understanding the impact of land use and land cover change on water–energy–food nexus in the gidabo watershed, east African rift valley. *Natural Resources Research*, *30*(3), 2687-2702.

Spatiotemporal dynamics of soil loss and sediment export in Upper Bilate River Catchment (UBRC), Central Rift Valley of Ethiopia

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Abstract

Soil loss is one of the major challenges for agricultural production in the Ethiopian highlands. The rate and distribution of soil loss (SL) and sediment export (SE) are essential to map degradation "hotspot" areas for prioritizing soil and water conservation measures. The objective of this study was to estimate the dynamics of SL and SE in the Upper Bilate River Catchment of Central Ethiopia. The Sediment Delivery Ratio (SDR) module of the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) model was used to estimate and map SL and SE. The primary input data were rainfall, soil data, land use, and other biophysical parameters of the study area. The model output confirmed that the average total soil loss of the catchment was 36.8 million ton/yr. It is modeled that soil loss doubles within 30 years. The average annual sediment export was about 3.62 ton/ha/yr. The mean annual soil loss of the study area was 23 ton/ha/yr, which exceeded the soil loss tolerance (SLT), estimated to range between (2–18 ton/ha/yr) in Ethiopia. Based on the soil erosion risk level, about 22% of the catchment area was classified as severely degraded, while 62 % was moderately degraded. Severe soil erosion prevails in the sub-watershed (SW)-5, SW-4, and SW-13. Therefore, these sub-watersheds need priority conservation action to restore the ecosystem processes of the study area.

Keywords: Central rift valley; InVEST SDR model; Sediment export; Soil loss; Conservation prioritization

Tamire, C., Elias, E., & Argaw, M. (2022). Spatiotemporal dynamics of soil loss and sediment export in Upper Bilate River Catchment (UBRC), Central Rift Valley of Ethiopia. *Heliyon*, e11220, https://doi.org/10.1016/j.heliyon.2022.e11220

Land-use and land-cover change in Lake Ziway watershed of the Ethiopian Central Rift Valley Region and its environmental impacts

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Abstract

Assessing land use and land cover (LULC) change in Lake Ziway watershed is important to evaluate the degradation of ecosystems and their environmental processes caused by the ongoing increase in human pressures. The present study analyzed the long-term LULC dynamics in the Lake Ziway watershed, which covers 7300 km^2 in the Ethiopian Central Rift Valley region. Three Landsat Satellite Image Series - Landsat MSS (1973), Landsat TM (1989) and Landsat Enhanced ETM+ (2018) - were the main input data from which three LULC maps were produced by employing Remote Sensing Techniques and Geographical Information Systems. The satellite data were supported by Google Earth and information gathered from informal discussions from local elderly people who are knowledgeable about the area. The results over the last 45 years show that the major LULC changes in the study watershed have been the expansion of cultivated, agroforestry and settlement areas and the corresponding reduction in woodlands. Cultivation, agroforestry, and settlement LULC categories increased by 45%, 10.9%, and 141.4%, respectively. These changes are attributable to a combination of the ever increasing human population and the subsequent demands on environmental resources like agricultural lands, commercial and domestic fuelwood and charcoal. Other factors include poorly defined ownership arrangements and weak enforcement strategies on the existing land use policy. This has created open access mentalities among communities and intensified LULC changes in the watershed. Awareness raising and provision of technical training about conservation interventions should be provided to communities in the watershed. This study provides information for corrective measures to protect further degradation and irreversible losses that might happen to the biotic and abiotic resources in Lake Ziway watershed.

Desta, H., & Fetene, A. (2020). Land-use and land-cover change in Lake Ziway watershed of the Ethiopian Central Rift Valley Region and its environmental impacts. *Land use policy*, *96*, 104682, https://doi.org/10.1016/j.landusepol.2020.104682

Assessment of drivers and dynamics of gully erosion in case of Tabota Koromo and Koromo Danshe watersheds, South Central Ethiopia

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Abstract

Globally erosion has been considered as an environmental and agricultural problem since the first agricultural revolution. In Ethiopia gully erosion has been recorded as a very serious and common socio-economic and environmental problem of several watersheds. Therefore, the objective of this research was to assess the drivers, dynamics and impacts of gully erosion in case of Tabota Koromo and Koromo Danshe watersheds, South-Central Ethiopia. The intended objectives were achieved by triangulating the image analysis with the data obtained from GPS, group discussion, interview, house hold survey, field observation and field measurement. The result of the study indicated that gully erosion was initiated in the steep slope following the 1970s and 1980s land cover change and other anthropogenic factors. In addition, the soil properties and steep slope (gravity) of the land have contributed in exacerbating the problems. Gully erosion caused physical, social and economic impacts in the area. According to the participants on group discussion and interview, the socio-economic impacts of gully erosion were loss of life for a 12 year boy, injuries of five live stocks, and decline of yields throughout the year. Result from field measurement and observation depicted that loss of soil (1,080,782.6m3) and loss of biodiversity are the major physical impacts of gully erosion. Yet there are promising conditions to rehabilitate the gullied area for sustainable ecosystem services in the watersheds. These promising conditions are the availability of high labour forces, access of transportation, civic societies working on natural resource conservation and the green economy development policy of the country. Therefore, concerned government bodies and the local communities at different level need to set plan and work for implementation in a way to use the existing opportunities. Keywords: Gully erosion, Dynamics, Drivers, Impacts, Rehabilitations.

Hassen, G., & Bantider, A. (2020). Assessment of drivers and dynamics of gully erosion in case of Tabota Koromo and Koromo Danshe watersheds, South Central Ethiopia. *Geoenvironmental Disasters*, *7*(1), 1-13, https://doi.org/10.1186/s40677-019-0138-4.

Geospatial Analysis of Land Use/Land Cover Dynamics on Lake Abaya-Chamo Wetland in Southern Rift-Valley of Ethiopia

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Abstract

Wetlands worldwide and in Ethiopia have long been subject to severe degradation due to anthropogenic factors. This study was aimed at analyzing the impact of land use/cover dynamics on Lake Abaya-Chamo wetland in 1990 – 2019. Data were acquired via Landsat TM of 1990, ETM+ of 2000, and OLI of 2010 and 2019 images plus using interview. Unsupervised and supervised classifications (via ERDAS14 and ArcGIS10.5) were applied to detect land use/cover classes. Normalized difference vegetation index, normalized difference water index, change matrix model and Kappa coefficients were used for analysis of the land use/cover dynamics in the lakewetland. It was found that forest; water, shrub land, agricultural land, settlement and swamp area were the main land use/cover classes. While 'settlement' and 'water body' of the lake-wetland increased at progressively increasing magnitudes of changes in three periods within 1990 – 2019, 'shrub land' and 'swamp' declined at progressively increasing magnitudes of loss in the same periods. The NDWI result revealed that 'swamp' area shrank by 48.9% (2,991 ha) due to siltation-led expansion of the lake-water in three decades. Siltation, rapid population growth-led expansion of settlement and irrigation-based farming were the main drivers of the land use/cover dynamics and degradation of the lake-wetland. Thus, consistent mapping and integrated actions should be taken to curb the threats on the sustainability of the lake-wetland in Southern Ethiopia.

Keywords: land use/land cover, dynamics, magnitude, NDWI, multispectral, Lake Abaya-Chamo wetland

Zekarias, T., Govindu, V., Kebede, Y., & Gelaw, A. (2021). Geospatial Analysis of Wetland Dynamics on Lake Abaya-Chamo, The Main Rift Valley of Ethiopia. *Heliyon*, *7*(9), e07943.

Variation in Ecosystem Service Values in an Agroforestry Dominated Landscape in Ethiopia: Implications for Land Use and Conservation Policy

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Abstract

Human pressure on a rugged and fragile landscape can cause land use/cover changes that significantly alter the provision of ecosystem services. Estimating the multiple services, particularly those obtained from agroforestry systems, is seldom attempted. A combined approach of geospatial technology, cross-sectional field investigations, and economic valuation of natural capital was used to develop an ecosystem service valuation (ESV) model to estimate changes in ESV between 1986 and 2015 in southern Ethiopia. Over 120 values were sourced, mainly from an ecosystem service valuation database and allied sources, to establish value coefficients via benefit transfer method. Our 1848 km2 study landscape, with eight land use categories, yielded an annual total ESV of $129 × 106 in 1986 and $147 × 106 in 2015, a 14.2% ($18.3 million) increase in three decades, showing its relative resilience. Yet we observed losses of natural vegetation classes whose area and/or value coefficients were too small to offset their increased value from expanding agroforestry and wetland/marshes, which have the largest cover share and highest economic value, respectively. Appreciating the unique features of agroforests, we strongly recommend that their economic value is studied as a separate ecosystem for further valuation accuracy improvement.

Keywords: ecosystem services; ecosystem service valuation; agroforestry; Gedeo-Abaya; Ethiopian; land use and conservation policy

Temesgen, H., Wu, W., Shi, X., Yirsaw, E., Bekele, B., & Kindu, M. (2018). Variation in ecosystem service values in an agroforestry dominated landscape in Ethiopia: Implications for land use and conservation policy. *Sustainability*, *10*(4), 1126, https://doi.org/10.3390/su10041126.

Scenario modelling of land use/land cover changes in Munessa - Shashemene landscape of the Ethiopian highlands

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Abstract

Models under a set of scenarios are used to simulate and improve our understanding of land use/land cover (LULC) changes, which is central for sustainable management of a given natural resource. In this study, we simulated and examined the possible future LULC patterns and changes in Munessa-Shashemene landscape of the Ethiopian highlands covering four decades (2012–2050) using a spatially explicit GIS-based model. Both primary and secondary sources were utilized to identify relevant explanatory variables (drivers) and LULC datasets for the model. Three alternative scenarios, namely Business As Usual (BAU), Forest Conservation and Water Protection (FCWP) and Sustainable Intensification (SI) were used. The simulated LULC map of 2012 was compared with the actual for model validation and showed a good consistency. The results revealed that areas of croplands will increase widely under the BAU scenario and would expand to the remaining woodlands, natural forests and grasslands, reflecting vulnerability of these LULC types and potential loss of associated ecosystem service values (ESVs). FCWP scenario would bring competition among other LULC types, particularly more pressure to the grassland ecosystem. Hence, the two scenarios will result in severe LULC dynamics that lead to serious environmental crisis. The SI scenario, with holistic approach, demonstrated that expansion of croplands could vigorously be reduced, remaining forests better conserved and degraded land recovered, resulting in gains of the associated total ESVs. We conclude that a holistic landscape management, i.e. SI, is the best approach to ensure expected production while safeguarding the environment of the studied landscape and elsewhere with similar geographic settings. Further study is suggested to practically test our framework through a research for development approach in a test site so that it can be used as a model area for effective use and conservation of our natural resources.

Keywords: GIS; Scenario; Regression; Remote sensing; Model; Resource management

Kindu, M., Schneider, T., Döllerer, M., Teketay, D., & Knoke, T. (2018). Scenario modelling of land use/land cover changes in Munessa-Shashemene landscape of the Ethiopian highlands. *Science of the Total Environment, 622*, 534-546, https://doi.org/10.1016/j.scitotenv.2017.11.338.

Land-use/cover changes in relation to stream dynamics in a marginal graben along the northern Ethiopian Rift Valley

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Abstract

This paper investigates land-use/cover changes related to river dynamics in northern Ethiopia. Aerial photographs from 1965 to 1986, and SPOT images of 2007 and 2014 were used to extract land units. Land-use/cover changes took place in 48% of the entire landscape around the river across the last five decades. Changes related to swap accounted for 37%, whereas net changes accounted for 11%. The most systematic transitions in terms of gain were from shrubland to farmland, alluvial deposit to settlement, and alluvial deposit to active channel and settlement. Most of these transitions were related to the river dynamics and depict cyclic transitions: farmland → active channel → alluvial deposits → grassland/shrubland → farmland. Human interventions and natural vegetation succession were also very important. The study concludes that river systems have considerable impact on livelihood and need attention in land management undertakings in graben bottoms.

Keywords: Vegetation succession, river, landuse/cover; Raya graben; land transition; steam dynamics

Demissie, B., Nyssen, J., Billi, P., Haile, M., Vaneetvelde, V., & Frankl, A. (2019). Land-use/cover changes in relation to stream dynamics in a marginal graben along the northern Ethiopian Rift Valley. *Physical Geography*, *40*(1), 71-90, https://doi.org/10.1080/02723646.2018.1458577.

A call to action: strong long-term limnological changes in the two largest Ethiopian Rift Valley lakes, Abaya and Chamo

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Abstract

The 2 largest Ethiopian Rift Valley lakes, Abaya and Chamo, are dominant socioecological systems with important potential for ecotourism because of their attractive setting with Nechisar National Park. We report on changes in water quality in these lakes during recent decades. We integrated data on key limnological variables during the last 55 years by supplementing historical literature data with our own field measurements. Our analyses provide strong evidence for a steady increase in nutrient concentrations and decrease in water transparency. Total phosphorus and total nitrogen concentrations in both lakes over the study period increased 5- and 7-fold, respectively. Similarly, water transparency decreased, especially in Lake Chamo, which used to have clear water but is now becoming a sediment-loaded lake similar to Lake Abaya. We reconstructed fertilizer use and land use changes in the region during the past decades. The combined data suggest that the dramatic eutrophication we observed in the lakes is likely associated with increased fertilizer use or other activities related to intensified agricultural practices, and the decline in water transparency is probably associated with low tree cover due to deforestation. The profound changes in the ecology of both lakes may jeopardize the delivery of ecosystem services in the region, including water supply, fisheries, and ecotourism. Our results stress the urgent need for measures that prevent further environmental deterioration of the unique heritage provided by the Ethiopian Rift Valley lakes.

Keywords: deforestation; ecological deterioration; Ethiopian Rift Valley Lakes; nutrient enrichment

Teffera, F. E., Lemmens, P., Deriemaecker, A., Brendonck, L., Dondeyne, S., Deckers, J., ... & De Meester, L. (2017). A call to action: strong long-term limnological changes in the two largest Ethiopian Rift Valley lakes, Abaya and Chamo. *Inland Waters*, *7*(2), 129-137, https://doi.org/10.1080/20442041.2017.1301309.

Impact of Landscape Management Scenarios on Ecosystem Service Values in Central Ethiopia

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Abstract

This study aimed at modeling scenarios of future land use and land cover (LULC) change and estimating ecosystem service (ES) values for the year 2051 compared to 2021 in Central Ethiopia. The future LULC changes for the year 2051 were simulated for four scenarios, namely Business-as-Usual (BAU), Rapid Agricultural Expansion (RAE), Ecosystems Protection and Agricultural Development (EPAD) and Landscape Ecosystems Restoration and Conservation (LERC). The four LULC change scenarios were simulated based on anticipated assumptions that were derived from existing spatial policies, a consultation workshop report on scenarios of agricultural development in Ethiopia, suitability analysis, population growth analysis and expert knowledge of the study area characteristics. We used a Multi-Layer Perceptron–Artificial Neuron Network (MLP–ANN) model-based projected LULC for the BAU scenario and the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model to generate RAE, EPAD and LERC scenarios in the study landscape. The benefit transfer method was used to estimate the total ES values and for trade-off analysis. The result showed that LULC changes in the study area varied across simulated scenarios compared to the base year 2021. Under the BAU and RAE scenarios, cultivated land increased by 146,548 ha (22%) and 193,965 ha (29%), whereas forest, water body, wetland and shrub-bush land were reduced. However, forest cover increased by 31,725 ha and 100,080 ha but bare land was reduced by 8466 ha (21%) and 10,379 ha (25%) under the EPAD and LERC scenarios. The forest cover annual rate of change was 3.2% and 6% under the EPAD and LERC scenarios. As a result, the total ES value increased by USD 24.5 and 78.5 million under the EPAD and LERC scenarios for the year 2051, whereas the total ES value was reduced under the BAU and RAE scenarios by USD 27.1 and 73.2 million. The trade-offs among ecosystem services were significantly synergized under the LERC scenario compared to RAE. Therefore, EPAD and LERC could be used as a reference for sustainable landscape planning and management. Landscape ecosystems restoration integrated with a sustainable agricultural intensification approach would enable us to ensure the sustainability of both agricultural production and ecosystem service synergies without negatively affecting the natural environment.

Keywords*:* landscape; ecosystemservices; restoration; scenarios; MLPANN; InVEST; trade-offs

Biratu, A. A., Bedadi, B., Gebrehiwot, S. G., Melesse, A. M., Nebi, T. H., Abera, W., ... & Egeru, A. (2022). Impact of Landscape Management Scenarios on Ecosystem Service Values in Central Ethiopia. *Land, 11*(8), 1266, https://doi.org/10.3390/land11081266.

Determinants of household wetland resources use and management behavior in the Central Rift Valley of Ethiopia

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Abstract

Sustainability of wetland resources requires pro-environmental behavior of use and management. This study examines determinants of household wetland resources use and management behavior in the Central Rift Valley of Ethiopia. The study used data generated from 405 randomly selected sample households complemented with that collected through Participatory Rural Appraisals. Multiple linear regression and the Sobel Mediator Test analyses were employed to investigate factors that determine household behavior. The study showed that majorities (94.1%) of the households believe that the wetlands are already degraded; however, only 54.1% of the households have high level of pro-environmental behavior. The result of multiple regression analysis revealed that household wetland use and management behavior is significantly and positively influenced by age, family size, gross annual income, deriving benefit from wetlands, number of livestock owned, farmland size, knowledge about wetlands and their ecosystem services, attitude and participation intention to wetland resources management. Off-farm job participation and distance to wetlands negatively influence wetland use and management behavior. The study result suggests the need to devise strategies to reinforce locals' pro-environmental behavior of use and management of wetland resources of the study area. Accordingly, measures that enhance and promote knowledge, attitude and participation intention should be targeted to fortify the pro-environmental behavior of locals. Providing incentives in the form of tax holiday, payment for environmental service and creating off-farm livelihood options in their locality could be the most proactive measures to promote locals' pro-environmental behavior while safeguarding livelihood and easing pressures on wetlands.

Dechasa, F., Senbeta, F., & Diriba, D. (2019). Determinants of household wetland resources use and management behavior in the Central Rift Valley of Ethiopia. *Environmental Sustainability*, *2*(4), 355-368.

Excessive pruning and limited regeneration: Are *Faidherbia albida* parklands heading for extinction in the Central Rift Valley of Ethiopia?

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Abstract

Scattered *Faidherbia albida* trees provide multiple ecological and production benefits across the Sahel. The intensive management and use of this important tree may impede its regeneration. Regeneration bottlenecks were explored and population dynamics modelled. On experimental plots in which seed of *F. albida* was sown, exposure to the first 2 months of dry season resulted in a quarter of seedling mortality. Exposure to season-long free grazing and browsing caused significantly greater seedling mortality. Results from monitoring 100 permanent plots scattered over the landscape showed that adult population density was 4.2 ± 0.3 (mean ± *SE*) trees ha^{-1} and dominated by old age classes. Sixty percent of the total population were older than 30 years. The mean density for juveniles was 1.4 ± 0.2 (mean ± *SE*) individuals ha^{-1}. The annual rates of decline were 1.2%, 51.3%, and 63.2% for adults, seedlings, and saplings, respectively. Our model predicted that the *F. albida* population will start to decline within 1–2 decades to eventually fall below 1 tree ha^{-1} within 60 years under current management. The model highlighted that the limited seed source, caused by excessive pruning, was the main constraint for recruitment. Appropriate land management policy to ensure adequate seed production would avert current trends in decline of *F. albida* population.

Keywords: agrobiodiversity, climate change, farmer-managed natural regeneration, farmland degradation, winter thorn

Sida, T. S., Baudron, F., Deme, D. A., Tolera, M., & Giller, K. E. (2018). Excessive pruning and limited regeneration: Are Faidherbia albida parklands heading for extinction in the Central Rift Valley of Ethiopia?. *Land Degradation & Development*, *29*(6), 1623-1633, https://doi.org/10.1002/ldr.2959.

Physico-chemical properties of soil under the canopies of Faidherbia albida (Delile) A. Chev and Acacia tortilis (Forssk.) Hayen in park land agroforestry system in Central Rift Valley, Ethiopia

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Abstract

This study was conducted to evaluate the effect of Faidherbia albida and Acacia tortilis on soil physicochemical properties at Langano and Tuka in farm fields of Bora District where both trees are traditionally retained on the farm. At each site, four F. albida and four A. tortilis trees were purposively selected and soil sample collected from four directions at three distances (1.35, 3.35 and 26.35 m) from tree trunk and composite soil samples was taken for both physico-chemical analyses. Collected data was analyzed by two way ANOVA and mean separation with LSD (%). Mean moisture levels of all sites, 1.35 (14.32%) were significantly ($p < 0.05$) greater than that of openland (10.79%) at 26.35 m from tree trunk. Bulk density was also significantly affected by tree canopies ($p< 0.05$) under the canopy than out of the canopy (it was reduced from 6.05 under canopy to 7.00 at open land). Soil organic matter, total nitrogen available phosphorus, exchangeable calcium, exchangeable magnesium and cation exchange capacity were significantly higher ($p < 0.05$) under the canopy of trees as compared to openland. Apart from these, the recorded values of exchangeable sodium, potassium and electrical conductivity revealed statistically non-significant difference among the treatments. The research finding showed that trees have positive relation with availability of soil nutrient and to enhance these trees in the farm, farmers knowledge improvement and further research regarding tree age class should be conducted.

Keywords: Parkland agroforestry, canopy position, soil physicochemical properties

Komicha, N. D., Nigatu, L., & Mohammad, M. (2018). Physico-chemical properties of soil under the canopies of Faidherbia albida (Delile) A. Chev and Acacia tortilis (Forssk.) Hayen in park land agroforestry system in Central Rift Valley, Ethiopia. *Journal of Horticulture and Forestry*, *10*(1), 1-8, DOI: 10.5897/JHF2016.0491

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Future land use management effects on ecosystem services under different scenarios in the Wabe River catchment of Gurage Mountain chain landscape, Ethiopia

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Abstract

In this study, we have modeled and examined future land use management effects on ecosystem services in the Wabe River catchment of the Gurage Mountain chain landscape, Ethiopia. In addition to the climate-resilient scenario designed to meet the strategic plan of Ethiopia, the business as usual (BAU) and an alternative agroforestry scenario were modeled for the year 2030 to align with the government long-term development plan. Through the statistical and biophysical modeling approach, this study quantified and mapped the food production, water provision, carbon storage, and sequestration and sediment retention ecosystem services. The land use land cover and the other datasets were obtained from various primary and secondary sources, and prepared according to the models requirement. The future scenarios were modeled through the Land Change Modeler for ArcGIS and InVEST Scenario Generator models. The simulated BAU scenario result revealed that all of the ecosystem services decreased from the baseline status. In contrast, implementation of the climate-resilient strategy could enhance the existing status of ecosystem services. In the agroforestry scenario, all of the quantified ecosystem services increased even more than the climate-resilient scenario. We conclude that landscape management activities described in the climate-resilient strategy could ensure sustainable production while conserving the environment. However, we recommend the enset-based agroforestry system expansion, which could boost food production and enhance other ecological services in the catchment. Further studies are suggested on the expansion of this system in the catchment and similar parts of Ethiopia.

Sahle, M., Saito, O., Fürst, C., Demissew, S., & Yeshitela, K. (2019). Future land use management effects on ecosystem services under different scenarios in the Wabe River catchment of Gurage Mountain chain landscape, Ethiopia. *Sustainability Science, 14*(1), 175-190

Trends in chemical pollution and ecological status of Lake Ziway, Ethiopia: a review focussing on nutrients, metals and pesticides

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Abstract

Aquatic ecosystems contribute to human well-being by delivering ecosystem services, but their protectionhas been given low priority in Africa. Lake Ziway in the Ethiopian Rift Valley basin provides services includingirrigation, drinking water and fish food in the region. This paper reviews the biological resources and spatio-temporal variation of water quality of the lake focussing on nutrients, metals and pesticides. Lake Ziway is underincreasing agricultural and urban pressure and is exhibiting deteriorating trends in several water quality andecological parameters. Nutrients and trace metals, including PO 43−, NO 3−, NH4+, Ca 2+, Cu and Ni of the lake haveshown increasing temporal trends in concentration. Spatially, higher values of major parameters (e.g. NO 3−, NH 4+, K, Na and electrical conductivity) were observed at shoreline sites near floriculture farming. The water quality of the lake exceeded guideline values for drinking water (alkalinity and Fe) and for aquatic life (NH4+, Fe, Cr, Cu andSe). The recently reported pesticides in the lake possibly cause ecological and human health effect. Accordingly, agriculture and urbanisation are affecting water quality of Lake Ziway, with likely negative effects on human healthand the lake ecosystem function unless appropriate interventions are taken. Our results may be useful in assessingother African lakes subject to similar anthropogenic pressures in their catchments.

Keywords: African lakes, agriculture, ecological effect, ecosystem services, spatio-temporal variation, urbanisation, water quality

Merga, L. B., Mengistie, A. A., Faber, J. H., & Van den Brink, P. J. (2020). Trends in chemical pollution and ecological status of Lake Ziway, Ethiopia: a review focussing on nutrients, metals and pesticides. *African Journal of Aquatic Science*, *45*(4), 386-400, ttps://doi.org/10.2989/16085914.2020.1735987.

Socio-ecological vulnerability to climate change/variability in central rift valley, Ethiopia

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Abstract

Climate change/variability and environmental degradation have increased in the central rift valley of Ethiopia, which in turn making the people inhabiting in that ecosystem more vulnerable to the impacts. The purposes of this study were to assess the vulnerability of households and agro-ecosystems to climate change and environmental degradation and the factors determining vulnerabilities in the central rift valley, Ethiopia. Data were collected between November 2014 and May 2015 by interviewing 355 respondents. This has been supplemented with focus group discussions and key informant interviews. The indicator and matrix methods were used to describe socio-ecological vulnerabilities. The results showed that about 9% of the respondents were highly vulnerable to climate change/variability, and environmental degradation. Households in the lowland have the largest proportion of high vulnerable households (60%), while households in highland have the largest proportion of low vulnerable households (30%). In the lowland agro-ecology, the adaptive capacity component has contributed the largest share to household's vulnerability index to the impacts of climate change/variability and environmental degradation. The sensitivity component has higher contribution in highland agro-ecology and the exposure component in the midland agro-ecology. There were variations of income deviation between agro-ecologies that lead to variation in vulnerability of households. Household vulnerability index has shown a very light negative correlation with livelihood diversification index. The poorest households with little share of the total income distribution and with low livelihood diversity index, were the most vulnerable. The results showed that the highest exposure index on ecosystem functions and agricultural performance were in the lowland agro-ecology. This study highlighted the need to assess the social and ecological vulnerabilities in integrated approach as singling out one from the other is difficult. That is, social vulnerability impacts ecological vulnerability and vice versa.

Keywords: Adaptive capacity; Vulnerability; Exposure; Impacts; Ecosystem services; Sensitivity

Mekonnen, Z., Woldeamanuel, T., & Kassa, H. (2019). Socio-ecological vulnerability to climate change/variability in central rift valley, Ethiopia. *Advances in Climate Change Research*, *10*(1), 9-20, https://doi.org/10.1016/j.accre.2019.03.002

Why are Lake Abaya and Lake Chamo so different? A limnological comparison of two neighboring major Ethiopian Rift Valley lakes

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Abstract

Lake Abaya and Lake Chamo are the two largest Ethiopian Rift Valley lakes; they are located close to each other, but have a strikingly different water transparency. We explain key differences in the structure and the functioning of the food web with variation in limnological variables and major pelagic food web compartments within and across both lakes. Data from a detailed comparative investigation of physical and chemical variables and zooplankton community characteristics during the wet and dry season from two consecutive years revealed major differences in key limnological variables between Lake Abaya and Lake Chamo. The most pronounced differences were related to water transparency and the amount of suspended solids in the water column. Lake Abaya is much more turbid, has lower phyto- and zooplankton biomass, and has considerably lower primary production than Lake Chamo. Based on our results, we infer that the profound differences in food web structure between both lakes probably result from differences in sediment load. Finally, our results indicate that conservation programs should focus on reducing sediment inflow from the catchments into the lakes.

Teffera, F. E., Lemmens, P., Deriemaecker, A., Deckers, J., Bauer, H., Gamo, F. W., ... & De Meester, L. (2019). Why are Lake Abaya and Lake Chamo so different? A limnological comparison of two neighboring major Ethiopian Rift Valley lakes. *Hydrobiologia*, *829*(1), 113-124.

Natural resource opportunities and challenges for rural development in marginal grabens – The state of the art with implications for the Rift Valley system in Ethiopia

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Abstract

With increasing global population, the production of more food and fiber has led to an expansion of the areas under cultivation, of which low-lying flat areas (including marginal graben bottoms) are of particular interest. Marginal grabens have been the center of agricultural development around the world. This paper examines the opportunities and challenges related to natural resources in rural development and highlights the knowledge gaps and priorities for the research and development of marginal grabens with specific reference to Ethiopia's Rift Valley marginal grabens, which have sufficient land banks to accommodate irrigated agriculture. Repeated transect walks, focus group discussions and interviews carried out in Northern Ethiopia, have been employed to address these research questions, while content analyses and descriptive statistics have been used to analyze the data. This paper shows that marginal grabens are rich in blue and green waters due to their topographical and geological characteristics, and are fertile plains suitable for irrigated agriculture. However, marginal grabens can reach closing and closed basin status in arid and semi-arid environments. Salinization, waterlogging, incisions and sedimentation also threaten the livelihoods of smallholder farmers in the grabens. Thus, appropriate river basin governance, integrated land management, and wise water allocation is needed to optimize land and water resources during rural development in the (semi)closed marginal grabens of northern Ethiopia and elsewhere in the world with similar geographical settings.

Keywords: Population pressure; Closed basins; Endorheic lakes; Salinization
Northern Ethiopia

Meaza, H., Frankl, A., Poesen, J., Zenebe, A., Deckers, J., Van Eetvelde, V., ... & Nyssen, J. (2017). Natural resource opportunities and challenges for rural development in marginal grabens–The state of the art with implications for the Rift Valley system in Ethiopia. *Journal of Arid Environments*, *147*, 1-16, https://doi.org/10.1016/j.jaridenv.2017.08.003

Implications of land use/land cover dynamics and *Prosopis* invasion on ecosystem service values in Afar Region, Ethiopia

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Abstract

Land use/land cover (LULC) dynamics and the resulting changes in ecosystems, as well as the services they provide, are a consequence of human activities and environmental drivers, such as invasive alien plant species. This study assessed the changes in LULC and ecosystem service values (ESVs) in the Afar National Regional State, Ethiopia, which experiences a rapid invasion by the alien tree *Prosopis juliflora* (Swartz DC). Landsat satellite data of 1986, 2000 and 2017 were used in Random Forest algorithm to assess LULC changes in the last 31 years, to calculate net changes for different LULC types and the associated changes in ESVs. Kappa accuracies of 88% and higher were obtained for the three LULC classifications. Post-classification change analyses for the period between 1986 and 2017 revealed a positive net change for *Prosopis* invaded areas, cropland, salt flats, settlements and waterbodies. The rate of *Prosopis* invasion was estimated at 31,127 ha per year. Negative net changes were found for grassland, bareland, bush-shrub-woodland, and natural forests. According to the local community representatives, the four most important drivers of LULC dynamics were climate change, frequent droughts, invasive species and weak traditional law. Based on two different ESVs estimations, the ecosystem changes caused by LULC changes resulted in an average loss of ESVs in the study area of about US$ 602 million (range US$ 112 to 1091 million) over the last 31 years. With an increase in area by 965,000 ha, *Prosopis*-invaded land was the highest net change during the study period, followed by grassland (−599,000 ha), bareland (−329,000 ha) and bush-shrub-woodland (−327,000 ha). Our study provides evidence that LULC changes in the Afar Region have led to a significant loss in ESVs, with serious consequences for the livelihoods of the rural people.

Keywords: Ecosystem service values; Land use and cover dynamics; Machine learning algorithm; Random forest classifier; *Prosopis juliflora;* Ethiopia

Shiferaw, H., Bewket, W., Alamirew, T., Zeleke, G., Teketay, D., Bekele, K., ... & Eckert, S. (2019). Implications of land use/land cover dynamics and Prosopis invasion on ecosystem service values in Afar Region, Ethiopia. *Science of the total environment*, *675*, 354-366, https://doi.org/10.1016/j.scitotenv.2019.04.220
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Land use and land cover dynamics and ecosystem services values in Kewet district in the central dry lowlands of Ethiopia

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Abstract

A better comprehensive and quantitative analysis of the tempo-spatial dynamics of land use and cover (LULC) in the dry lowlands areas of Ethiopia is crucial for restoring degraded landscapes. This study aimed at analyzing the trends of LULC changes and determine their ecosystem service values in Kewet district central dry lowlands of Ethiopia using multi-temporal satellite imagery for three periods: 1995, 2008, and 2017. Supervised classification, using the maximum likelihood classifier, was applied to quantify LULC changes. Ecosystem Service values were estimated using the modified ecosystem service value coefficients. LULC analysis showed that cultivated land was the most predominant which covered over 41% of the study area in all three periods. Forests showed a net increase of 18.2%. Shrubland occupied the second largest portion in all LULC analysis next to cultivated land, and it showed a net decrease of 29.2%. Open grassland showed a periodic increase. Over the past 20 years, built-up area and bared land grew continuously by 1.80 and 1.01 $km^2\ yr^{-1}$, respectively. However, some degraded land was converted into woody vegetation land through area exclosure, which improved the vegetation coverage of the study area. Ecosystem Service values ranged from US$ 2.37 million for shrubland in 1995 to US$ 22.49 million for forest land in 2008. The total ESVs of the district also continuously decreased over the past two decades. Generally, the LULC in the Kewet district has been dynamic in that some of the LULC classes were expanding, while the others were shrinking through time.

Tesfay, F., Kibret, K., Gebrekirstos, A., & Hadgu, K. M. (2022). Land use and land cover dynamics and ecosystem services values in Kewet district in the central dry lowlands of Ethiopia. *Environmental Monitoring and Assessment*, *194*(11), 1-25.

Spatiotemporal dynamics of soil loss and sediment export in Upper Bilate River Catchment (UBRC), Central Rift Valley of Ethiopia

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Abstract

Soil loss is one of the major challenges for agricultural production in the Ethiopian highlands. The rate and distribution of soil loss (SL) and sediment export (SE) are essential to map degradation "hotspot" areas for prioritizing soil and water conservation measures. The objective of this study was to estimate the dynamics of SL and SE in the Upper Bilate River Catchment of Central Ethiopia. The Sediment Delivery Ratio (SDR) module of the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) model was used to estimate and map SL and SE. The primary input data were rainfall, soil data, land use, and other biophysical parameters of the study area. The model output confirmed that the average total soil loss of the catchment was 36.8 million ton/yr. It is modeled that soil loss doubles within 30 years. The average annual sediment export was about 3.62 ton/ha/yr. The mean annual soil loss of the study area was 23 ton/ha/yr, which exceeded the soil loss tolerance (SLT), estimated to range between (2–18 ton/ha/yr) in Ethiopia. Based on the soil erosion risk level, about 22% of the catchment area was classified as severely degraded, while 62 % was moderately degraded. Severe soil erosion prevails in the sub-watershed (SW)-5, SW-4, and SW-13. Therefore, these sub-watersheds need priority conservation action to restore the ecosystem processes of the study area.

Keywords: Central rift valley; InVEST SDR model; Sediment export; Soil loss; Conservation prioritization

Tamire, C., Elias, E., & Argaw, M. (2022). Spatiotemporal dynamics of soil loss and sediment export in Upper Bilate River Catchment (UBRC), Central Rift Valley of Ethiopia. *Heliyon*, e11220, https://doi.org/10.1016/j.heliyon.2022.e11220

Land-use/cover changes in relation to stream dynamics in a marginal graben along the northern Ethiopian Rift Valley

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Abstract

This paper investigates land-use/cover changes related to river dynamics in northern Ethiopia. Aerial photographs from 1965 to 1986, and SPOT images of 2007 and 2014 were used to extract land units. Land-use/cover changes took place in 48% of the entire landscape around the river across the last five decades. Changes related to swap accounted for 37%, whereas net changes accounted for 11%. The most systematic transitions in terms of gain were from shrubland to farmland, alluvial deposit to settlement, and alluvial deposit to active channel and settlement. Most of these transitions were related to the river dynamics and depict cyclic transitions: farmland → active channel → alluvial deposits → grassland/shrubland → farmland. Human interventions and natural vegetation succession were also very important. The study concludes that river systems have considerable impact on livelihood and need attention in land management undertakings in graben bottoms.

Keywords: Vegetation succession; river; land use/cover; raya graben; land transition; stream dynamics

Demissie, B., Nyssen, J., Billi, P., Haile, M., Vaneetvelde, V., & Frankl, A. (2019). Land-use/cover changes in relation to stream dynamics in a marginal graben along the northern Ethiopian Rift Valley. *Physical Geography*, *40*(1), 71-90, https://doi.org/10.1080/02723646.2018.1458577.

Understanding traditional agro-ecosystem dynamics in response to systematic transition processes and rainfall variability patterns at watershed-scale in Southern Ethiopia

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Abstract

Multi-temporal analysis of land cover dynamics using remote sensing can enable the determination of the spatial extent and average rate of land cover change. With the application of an appropriate change analysis method, it is also possible to distinguish whether a land cover change has occurred by the effect of a random or a systematic process. In connection with this, characterizing rainfall variability and historical meteorological drought events can allow understanding of their effects on agro-ecosystems and vegetation cover dynamics. Therefore, this study has evaluated multi-temporal land cover change in response to the possible impacts of population pressure and rainfall variability on agro-ecosystem dynamics. This was conducted on a traditional agroforestry-dominated landscape in Southern Ethiopia. Using Landsat images acquired in 1985, 2000, and 2018, a post-classification land cover change analysis approach was employed to distinguish between a systematic and random process of inter-category transitions. Assessment of drought events and rainfall variability dynamics were performed using standardized precipitation index (SPI) and rainfall coefficient of variation (CV), respectively. Mann–Kendall test was also applied for the detection of a monotonic rainfall trend. A bias-corrected Climate Hazards group Infrared Precipitation with Stations (CHIRPS) over 1981–2017 was used to calculate the SPI, CV and Mann–Kendall trend test. The analysis showed that above 41% of the landscape has experienced land cover transitions between 1985 and 2018. This has primarily resulted by a systematic and rapid expansion of agriculture, urban areas, and eucalyptus plantations, at the expense of natural vegetation ecosystems. Consequently, over the last 33 years (1985–2018), natural forest, grassland, and wetland have declined by 74.8%, 83.3%, and 78.4%, respectively. Another major land cover change identified in this study was the replacement of open-field crops by agroforestry, mainly in the western part of the catchment. Such expansion of agroforestry has appeared to be spatially correlated with a lower amount of long-term average and more variable rainfall. Perhaps, this could indicate farmers' response to rainfall variability by diversifying agricultural production options (i.e. agroforestry system), by replacing the more risk-prone mono-cropping culture. The observed persistence and further expansion of traditional agroforestry (a combination of perennial crops and scattered trees) have implications in terms of enhancing biodiversity conservation and environmental protection. Overall, the land cover transitions that occurred over the last three decades suggest future conservation priorities for improved landscape management, with more emphasis on the most exposed natural vegetation ecosystems.

Keywords: Agriculture expansion; Deforestation; Traditional agroforestry, Rainfall variability; Remote sensing; Systematic land cover transition

Gessesse, B., Tesfamariam, B. G., & Melgani, F. (2022). Understanding traditional agro-ecosystem dynamics in response to systematic transition processes and rainfall variability patterns at watershed-scale in Southern Ethiopia. *Agriculture, Ecosystems & Environment*, *327*, 107832, https://doi.org/10.1016/j.agee.2021.107832.

Woodland Cover Change in the Central Rift Valley of Ethiopia

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Abstract

Woodlands, which are part of the landscape and an important source of livelihood for smallholders living in the environmentally vulnerable Central Rift Valley (CRV) of Ethiopia, are experiencing rapid changes. Detecting and monitoring these changes is essential for better management of the resources and the benefits they provide to people. The study used a combination of both quantitative and qualitative methods to analyze the extent and pattern of woodland cover changes from 1973 to 2013. Pixel-based supervised image classification with maximum likelihood classification algorithm was used for land cover classification and change detection analyses. Local peoples' perceptions were used to explain the patterns of change and their possible reasons. Four major land cover classes were identified, with an overall accuracy of 88.3% and a Kappa statistic of 0.81 for the latest image. The analysis revealed a major land cover reversal, where woodland (92.4%) was
the dominant land cover in 1973, while it was agriculture (44.7%) in 2013. A rapid reduction inwoodland (54%) and forest (99%) covers took place between 1973 and 2013, with the majority of the conversions being made during the government transition period (1973 to 1986). Agriculture (3878%) and grassland (11,117%) increased tremendously during the 40-year period at the expense of woodlands and forests. Bare land increased moderately (40%). Thus, woodlands are under increasing pressure from other land uses, particularly agriculture, and declining faster. If the current trends of land cover change remain unabated it is likely that woodlands will disappear from the landscape of the area in the near future. Therefore, better forest policy and implementation tools, as well as better woodland management strategies and practices, need to be in place for woodlands to continue providing vital ecosystem goods and services to the local people, as well as to the environment.

Keywords: woodland; land cover change; pattern of land cover change; central rift valley

Mesfin, D., Simane, B., Belay, A., Recha, J. W., & Taddese, H. (2020). Woodland cover change in the Central Rift Valley of Ethiopia. *Forests*, *11*(9), 916, https://doi.org/10.3390/f11090916.

Measuring the Semi-Century Ecosystem-Service Value Variation in Mekelle City Region, Northern Ethiopia

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Abstract

The Mekelle city region is facing severe ecosystem degradation. The study area has experienced unprecedented land-use dynamics over the past 47 years, but the effect of these dynamics on ecosystem-service values remains unknown. Estimating the various ecosystem services from a city region perspective has not been attempted so far. The rationale of this study was to estimate the spatial–temporal ecosystem-service value variations. The methodology employed was land- use/land-cover (LULC) datasets of remotely sensed datasets of the years 1972, 1984, 2001, 2012, and 2019, and ecosystem service value coefficient, expert focus group discussion, and document review were used. The digital satellite images were processed, classified, and analyzed using Earth Resource Development Assessment System (ERDAS) Imagine. Computations of changes in the land-use categories were made using Arc GIS 10.5.1, Eviews for time series data analysis, and XLSTAT analytical tools were used. Over the whole study period from 1972 to 2019, a loss of USD 128.6 million was observed, which is a reduction of 501.9%. The study shows that due to land-use changes, the total ecosystem service value is decreasing annually, suggesting that much more severe ecosystem degradation is due to occur. The results are relevant to policy development and indicate that ecological restoration is the best option in the study area.

Keywords: city region; ecosystem service; land-use dynamics; valuation

Weldegebriel, S. K., & Yeshitela, K. (2021). Measuring the Semi-Century Ecosystem-Service Value Variation in Mekelle City Region, Northern Ethiopia. *Sustainability*, *13*(18), 10015, https://doi.org/10.3390/su131810015.

Land Use Cover changes in the western escarpment of Rift Valley in the Gamo Zone, Southern Ethiopia

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Abstract

LULC changes are caused by natural and human alterations of the landscape that could largely affect forest biodiversity and the environment. The aim of the study was to analysed LULC change dynamics in the western escarpment of the rift valley of the Gamo Zone, Southern Ethiopia. Digital satellite images downloaded from USGS were analyzed using ERDAS Imagine (14) and Arc GIS 10.2 software and supervised image classification was used to generate LULC classification, accuracy assessment and Normalized Difference Vegetation Index (NDVI). Drivers of LULC change were identified and analyzed. Four land classes were identified such as forest, farmland, settlement and water-wetland. Settlement and farmlands have increased by 7.83% and 5.88%, respectively. On the other hand, both forest and water bodies and wetland decreased by aerial coverage of 11.03% and 2.68%, respectively. The overall accuracy of the study area was 92.86%, 94.22% and 94.3% with a kappa value of 0.902, 0.92 and 0.922, respectively. NDVI values ranged between -0.42 to 0.73. Agricultural expansion (31.4%), expansion of settlement (25.7%) and Fuelwood collection and Charcoal production (22.9%) were the main driving forces that jeopardize forest biodiversity of the study area. Integrated land use and policy to protect biodiversity loss, forest degradation and climate changes are deemed necessary.

Keywords: Landsat images, Land use/land cover, Change detection, Rift valley

Dingamo, T. D., Takele, S., Demissew, S., Woldu, Z., Dingamo, T., Demissew, S., ... & Takele, S. (2021). Land Use Cover changes in the western escarpment of Rift Valley in the Gamo Zone, Southern Ethiopia. *bioRxiv*, https://doi.org/10.1101/2021.09.08.

Relationship of Attributes of Soil and Topography with Land Cover Change in the Rift Valley Basin of Ethiopia

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Abstract

Abstract: Understanding the spatiotemporal trend of land cover (LC) change and its impact on humans and the environment is essential for decision making and ecosystem conservation. Land degradation generally accelerates overland flow, reducing soil moisture and base flow recharge, and increasing sediment erosion and transport, thereby affecting the entire basin hydrology. In this study, we analyzed watershed-scale processes in the study area, where agriculture and natural shrub land are the dominant LCs. The objective of this study was to assess the time series and spatial patterns of LCC using remotely-sensed data from 1973 to 2018, for which we used six snapshots of satellite images. The LC distribution in relation to watershed characteristics such as topography and soils was also evaluated. For LCC detection analysis, we used Landsat datasets accessed from the United States Geological Survey (USGS) archive, which were processed using remote sensing and Geographic Information System (GIS) techniques. Using these data, four major LC types were identified. The findings of an LC with an overall accuracy above 90% indicates that the area experienced an increasein agricultural LC at the expense of other LC types such as bushland, grazing land, and mixed forest, which attests to the semi-continuous nature of deforestation between 1973 and 2018. In 1973, agricultural land covered only 10% of the watershed, which later expanded to 48.4% in 2018. Bush, forest, and grazing land types, which accounted for 59.7%, 16.7%, and 13.5% of the watershed in 1973, were reduced to 45.2%, 2.3%, and 4.1%, respectively in 2018. As a result, portions of land areas, which had once been covered by pasture, bush, and forest in 1973, were identified as mixed agricultural systems in 2018. Moreover, spatial variability and distribution in LCC is significantly affected by soil type, fertility, and slope. The findings showed the need to reconsider land-use decision tradeoffs between social, economic, and environmental demands.

Keywords: GIS and remote sensing; spatiotemporal modelling; image processing; land cover change detection; soil spatial variability; soil–land use–slope interaction; kriging

Ayele, G. T., Seka, A. M., Taddese, H., Jemberrie, M. A., Ndehedehe, C. E., Demissie, S. S., ... & Melesse, A. M. (2022). Relationship of Attributes of Soil and Topography with Land Cover Change in the Rift Valley Basin of Ethiopia. *Remote Sensing*, *14*(14), 3257, https://doi.org/10.3390/rs14143257.

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, DOI: 10.4236/nr.2020.1112033.

Wetlands in Ethiopia: Lessons From 20 years of Research, Policy and Practice

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Abstract

Throughout sub-Saharan Africa wetlands provide ecosystem services that are critical to the development needs of many people. Local wetland use, however, is often at odds with broader national policy goals in which narratives of conservation and protection dominate, hence a recurring challenge is how to reconcile these tensions through the development of policies and field practice that deliver sustainable development. In this paper we examine the extent to which this challenge has been achieved in Ethiopia, charting the changes in wetlands policy and discourse over the last twenty years while reviewing the contribution of the multidisciplinary Ethiopian Wetlands Research Programme (EWRP) (1997–2000). Our analysis suggests that despite EWRP having a significant legacy in developing national interest in wetlands among research, government and non-governmental organisations, its more holistic social-ecological interpretation of wetland management remains neglected within a policy arena dominated by specific sectoral interests and little recognition of the needs of local people. In exploring the impacts at the local level, recent investigations with communities in Ilu Aba Bora Zone highlight adjustments in wetland use that famers attribute to environmental, economic and social change, but which also evidence the adaptive nature of wetland-based livelihoods.

Keywords: Ethiopia; Wetland management; Policy; Conservation; Sustainable development

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Socio-Environmental Impacts of Land Use/Cover Change in Ethiopian Central Rift Valley Lakes Region, East Africa

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Abstract

Unregulated land use/cover change (LUCC) has imposed significant local, regional and global impacts on livelihood and environment, particularly in sub-Saharan Africa. Previous studies well documented the extent and drivers of such spectacular LUCC in East Africa. However, data on regional/local impacts particularly that combine its socioeconomic and environmental effects are very scanty currently. Hence, this study is aimed to assess the socio-environmental impacts of LUCC in more dynamic and fragile landscapes of the Ethiopian Central Rift Valley lakes region. We used a combination
of data from Remote Sensing, GIS-based processing, household survey and meteorological stations to quantify and analyze LUCC impacts. Results indicated that a rapid LUCC has occurred in the region over the last three decades which imposed a number of socioeconomic and environment-related impacts. Based on the percentage of respondent farmers, climate change (95%), soil productivity decline (94%), land degradation (92%), shortage of wood (91%), shortage of grazing land (89%), soil erosion (88%),
loss of biodiversity (81%) and lake water retreat (74%), are the principal impacts of LUCC perceived. Such perceived impacts of LUCC are in line with the observed results obtained from comprehensive measured data analysis. Future land use policies need to consider management options that work on reducing anthropogenic-induced pressures on the environment and encouraging livelihood diversification in order to minimize the adverse socio-environmental impacts of spectacular LUCC in the region.

Keywords: anthropogenic, climate change, household, land degradation, perception

Bekele, B., Wu, W., Legesse, A., Temesgen, H., & Yirsaw, E. (2018). Socio-environmental impacts of land use/cover change in Ethiopian central rift valley lakes region, East Africa. *Applied Ecology and Environmental Research*, *16*(5), 6607-6632, DOI:
http://dx.doi.org/10.15666/aeer/1605_66076632.

Random and Systematic Land Use/Land Cover Transitions in Semi-Arid Landscapes of Ethiopian Central Rift Valley Lakes Region (East Africa)

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Abstract

The analysis of land use/land cover (LULC) change has always been a topic of interest in land dynamics research. The majority of previous studies used the conventional method of "net change" analysis to show spatiotemporal LULC transitions. However, such analysis failed to indicate whether the transition is clearly systematic or due to an apparently random process. Hence, this study aimed to identify the most prominent signals of landscape transitions over the last three decades, using the landscapes of East African Rift Valley Region. We used Remote Sensing and GIS to quantify and map the changes in LULC for 1986 and 2016, and then the two maps compared to produce transition matrices. Results show that net change and swap change accounted for 43% and 57% of total change on the landscape respectively. Accordingly, 6% of scattered acacia woodland and 5% of bush land have been converted to agricultural land, whereas 7% and 3% of scattered acacia woodland have been degraded towards grazing land and bush land respectively. These changes were found to be clearly systematic and hence indicate the dominant and prominent signals of landscape transformation. Hence, future land use policies need to consider such prominent signals of LULC change in order to plan an integrated approach to safeguard the fragile ecosystems of the region, while searching for alternative livelihood options.

Keywords: gain, loss, net change, persistence, swap change

Bekele, B., Wu, W., Legesse, A., Temesgen, H., & Yirsaw, E. (2018). Random and systematic land use/land cover transitions in semi-arid landscapes of Ethiopian Central Rift Valley Lakes Region (East Africa). *Applied Ecology and Environmental Research*, *16*(4), 3993-4014, DOI: http://dx.doi.org/10.15666/aeer/1604_39934014.

Evaluation of the WEAP model in simulating subbasin hydrology in the Central Rift Valley basin, Ethiopia

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Abstract

Background

The subbasin hydrologic behaviors have been altered by many natural and anthropologic factors such as climate change and land development activities. Model-based assessment can be used to simulate both natural hydrological processes, human-induced effects, and management strategies on water resources. For the Ketar subbasin, the WEAP (water evaluation and planning) hydrologic model was developed that aimed at (1) evaluating the application of the WEAP model in the Ketar subbasin, (2) evaluating the demonstration of the WEAP model using model efficiency evaluation criteria, and (3) simulating hydrological processes of the subbasin using the WEAP model.

Methods: WEAP-based soil moisture method (rainfall-runoff) hydrology routine is comprised of a lumped, one- dimensional, two-layer soil water accounting that uses empirical functions to designate evapotranspiration, surface runoff, interflow, and deep percolation for a sub-unit at root zone. A catchment is considered as the smallest hydrologic response unit. The catchment's surface hydrological balance is typically estimated by discretizing the catchment into multiple land uses for which water balance is estimated at root zone.

Results: The monthly measured and simulated stream flow statistics showed a positive strong relationship with R2 of 0.82, NSE of 0.80, and IA of 0.95; and with R2 of 0.91, NSE of 0.91, and IA of 0.98 for calibration and validation periods respectively. Similarly, the mean monthly measured and simulated stream flow showed an agreement with R2 of 0.99, NSE of 0.97, and IA of 0.99, and R2 of 0.94, NSE of 0.93, and IA of 0.93 for the periods of calibration and validation respectively.

Conclusion: The model has demonstrated the capability to represent the hydrologic dynamics of the subbasin both at monthly and mean monthly periods. In general, the overall model performance evaluation statistics show a very good agreement between measured and simulated streamflow at the outlet of the subbasin.

Keywords: Hydrologic processes, Model, Soil moisture method

Abera Abdi, D., & Ayenew, T. (2021). Evaluation of the WEAP model in simulating subbasin hydrology in the Central Rift Valley basin, Ethiopia. *Ecological Processes*, *10*(1), 1-14, https://doi.org/10.1186/s13717-021-00305-5.

Climate Change Impacts and Adaptation Actions in Central Rift Valley of Ethiopia

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Abstract

This paper evaluates the climate change impacts and adaptation actions in Central Rift Valley of Ethiopia. The impact of climate change is the common phenomenon of the worldwide even though its vulnerability varies in place and time. Thus, Ethiopia has been considered as one of the countries highly susceptible to climate change. Because of the country's economy heavily depends on traditional rain-fed agriculture within a fragile highland ecosystem, which has been threatened by population pressure and land degradation. Among other regions in the country, the Central Rift Valley has been adversely affected by climate variability and change, which manifested in the frequency and intensity of flood and drought. In addition to these weather extreme events, human activities like land use change and over exploitation of natural resources are also an alarming problem in the area. For example, forest land was decreased by 66.3% whilst agricultural land expanded by 84%, and organic carbon losses were amounted to 60-75% during 1973 to 2006. On one side land degradation, deforestation, overgrazing, soil erosion, flooding, waste disposal and sediment loads are the main threats of the lakes. On the other hand, increasing in temperature and varying in rainfall pattern leads to evaporation, salinity and water shortage; these create higher competition in water use for irrigation projects, floriculture industry, soda abstraction, fish farming, domestic and livestock consumption, which could have an adverse impact on lake quality, level, and river discharges. The prevalence of invasive species, diseases and parasites are also among the significant issues in the area. Meantime, mitigation and adaptation are used as the fundamental global responsive strategies to address climate change. Hence, Ethiopia has identified different adaptation options in Climate Resilient Green Economy Strategy. Watershed based land and water resources management; forest development, energy options, capacity building etc. are among the actions have been used. Beside to this, various potential adaptive activities, including traditional and their effects were examined in the central rift valley. Such as: by adjusting sowing time, applying improved agricultural technologies/inputs, crop rotation, mixed farming system, Agroforestry, afforestation/reforestation, rehabilitation of degraded land, physical soil and water conservation measures, capacity building, enhancing income generation and employment opportunities were among the most actions used to combat climate change impacts in the area. However, the impacts of climate change on the biophysical and social economic of the area were beyond to adaptation capacity. So that, the author recommended that climate change adaptation should be addressed through ensuring the local community needs and participation in integrated approaches like Integrated Watershed Management. It should be also addressed by focusing on highly vulnerable sectors (agriculture and water resources) through effective cropping system, conservational agriculture, effective water application and use, diversification of crop and livestock species, mixed farming system, access to extensional services, access to improved farm technologies and crop varieties, access to information about weather conditions. Generally, any adaptation actions should be enhanced food security and water availability, combating land degradation, reducing loss of biodiversity and ecosystem services.

Keywords: Vulnerability, Climate Change Mitigation and Adaptation, Integrated Watershed Management, Community Participation, Food Security

Chimdesa, G. (2016). Climate change impacts and adaptation actions in Central Rift Valley of Ethiopia. *Journal of Natural Sciences Research*, *6*(3), 84-93.

Evaluation of the impacts of land use/cover changes on water balance of Bilate watershed, Rift valley basin, Ethiopia

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Abstract

Land use/cover change is one of the factors responsible for changing the water balance of the watershed by altering the magnitude of surface runoff, interflow, base flow, and evapotranspiration. This study was aimed at evaluating the impacts of land use/cover change on the water balance of Bilate watershed between 1989, 2002, and 2015. The water balance simulation model (WaSiM) was used to access the impacts of land use/cover change on water balance. The model was calibrated (1989–2003) and validated (2007–2015) using the streamflow of at Bilate Tena gauging station. The result of land-use dynamics showed land use/cover change has a significant impact on the water balance of the watershed: on runoff production, base flow, interflow, evapotranspiration, and total simulation flow. In the study watershed, the change in total simulated flow increased by 77.83%; surface runoff, interflow, and base flow increased by 80.23%, 75.69%, and 87.79% respectively; and evapotranspiration decreased by 6% throughout the study period (1989–2015). The results obtained from this study revealed that the watershed is under land/cover change that shows its impacts on hydrological processes and water balance. Thus, effective information regarding the environmental response of land use/cover change is important to hydrologists, land-use planners, watershed management, and decision-makers for sustainable water resource projects and ecosystem services. Therefore, the policy-makers, planners, and stakeholders should design strategies to ensure the sustainability of the watershed hydrology for the sake of protecting agricultural activities, and urban planning and management systems within the watershed area.

Keywords: Bilate, land use/cover change, WaSiM model, water balance, watershed

Sulamo, M. A., Kassa, A. K., & Roba, N. T. (2021). Evaluation of the impacts of land use/cover changes on water balance of Bilate watershed, Rift valley basin, Ethiopia. *Water Practice & Technology*, *16*(4), 1108-1127, https://doi.org/10.2166/wpt.2021.063.

Modeling the Vulnerability of Livelihood Systems to Drought along Livelihood Zones in the Northwestern Escarpment of the Ethiopian Rift Valley

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Abstract

Drought is becoming a common problem for farmers in the Northwestern Escarpment Ethiopian Rift Valley's three studied livelihood zones (LZs). Droughts wreaked havoc on the community's livelihood systems regularly. It lefts the community food insure and repeatedly disturbs their ecosystems. As a result, the current study used meteorological, spatial, and socioeconomic data from the area to assess the community's drought vulnerability. Each variable of drought vulnerability was normalized as proxy indicators to calculate exposure, sensitivity, and adaptive capacity indexes. From the results, the Raya valley livelihood zone (RVLZ) is relatively more drought vulnerable (0.65) than the Tsirare catchment livelihood zone (TCLZ) (0.63) and Alagie-Ofla livelihood zones (ALOFLZ) (0.60). The RVLZ has a less adaptive capacity than ALOFLZ but more susceptibility and higher exposures to drought risks than the two LZs. Besides, the TCLZ has less adaptive capacity than the two livelihood zones, with more vulnerability and exposure to drought risks than ALOFLZ. The highest levels of exposition and susceptibility synergy with low resilience have aggravated the vulnerability to drought in all study LZs. Livelihood zone-based interventions and climate-smart farming are thus necessary for all LZs to reduce possible drought risks and transfer vulnerable communities into high adaptive capacities.

Keywords: Adaptive capacity; drought vulnerability; exposure; livelihood system; livelihood zone; sensitivity

Ahmed, J. N., Tilahun, E. A., Italemahu, T. Z., Sintayehu, E. G., & Amphune, B. E. (2022). Modeling the vulnerability of livelihood systems to drought along livelihood zones in the Northwestern Escarpment of the Ethiopian Rift Valley. *Papers in Applied Geography*, 1-35, https://doi.org/10.1080/23754931.2022.2068352.

Impact of Land Use/Cover Changes on Lake Ecosystem of Ethiopia Central Rift Valley

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Abstract

Central Rift Valley (CRV) Ethiopia is an important region in terms of its vast ecosystem services (ES)and enriched biodiversity. However, its ES and biodiversity are under terrific pressure from hurried population growth, unsustainable developmental activities, unplanned urbanization, aggressive agricultural expansion, climate change, and the associated changes in land use and land cover (LULC). This study was aimed at analyze LULC changes in the Ethiopia CRV areas from 1985 to 2015 through Geographic Information System (GIS) and Remote Sensing (RS) techniques. Satellite images were accessed, pre-processed and classified. Field observations, discussion with dwellers (elders) were also employed to validate results from remotely sensed data. Major LULC types were detected and change analysis was executed. Consequently, nine LULC changes were successfully evaluated. The classification result revealed that in 1985 the area was covered by 44.34% with small-scale farming followed by mixed cultivated/acacia (21.89%), open woodland (11.96%), and water bodies (9.77%), respectively. Though the area measure varied among land use classes, the trend of share occupied by the LULC types in the study area remained the same in 1995 and 2015. In this research increase in small and large-scale farming, settlements and mixed cultivation/acacia while a decrease in water bodies, forest, and open woodlands is noted. Accordingly, the overall accuracy of this study was 84.46, 86.86 and 88.86 with kapa value of 0.82, 0.84 and 0.87, respectively. Lastly, the DPSIR framework analysis was done and integrated land use and policy reform are suggested as a response for sustainable land use planning and management.

Keywords: Central Rift Valley, Ethiopia, Landsat images, Lake, land use/land cover

Elias, E., Seifu, W., Tesfaye, B., & Girmay, W. (2019). Impact of land use/cover changes on lake ecosystem of Ethiopia central rift valley. *Cogent Food & Agriculture, 5*(1), 1595876, http://dx.doi.org/10.1080/23311932.2019.1595876.

Land use land cover dynamics, its drivers and environmental implications in Lake Hawassa Watershed of Ethiopia

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Abstract

Lake Hawassa watershed is characterized by decades of deterioration with mismanagement of natural resources. Hence, the current study was aimed at assessing the magnitude and transformation patterns of land use land cover categories over the last 45 years, the major drivers of land use land cover changes and the environmental implications of land use land cover dynamics in Lake Hawassa Watershed. The study triangulated data from Landsat images (1972, 1992 and 2017), focus group discussions, interviews and farmers' lived experiences through household survey to evaluate the change and examine the underlying factors and its implications. The land use land cover change detection results revealed significant conversion from shrubland, woodland, and forest to built-up, bare land cultivated land and agroforestry. The proportion of cultivated land and agroforestry increased from 24.2% of the watershed in 1972 to 62% in 2017. These two land uses have gained large parcel of land from naturally vegetated land covers. Overall, about 74.34% of the watershed experienced changes in land cover in 45 years. The changes were driven by proximate and underlying drivers. The identified drivers were expansion of agricultural activities, urban and infrastructure expansion, wood extraction, biophysical factors, demographic factors and land tenure policy. Consequently, the natural resource base of the watershed is degrading. We concluded that unmanaged conversions of land covers were affecting the natural vegetation base and hydrology of the watershed. Hence, it was suggested that integrated lake watershed planning and management has a paramount importance in maintaining economic and ecological benefits.

Degife, A., Worku, H., Gizaw, S., & Legesse, A. (2019). Land use land cover dynamics, its drivers and environmental implications in Lake Hawassa Watershed of Ethiopia. *Remote sensing applications: society and environment*, *14*, 178-190, https://doi.org/10.1016/j.rsase.2019.03.005.

Invasion of Water Hyacinth (Eichhornia crassipes) Is Associated with Decline in Macrophyte Biodiversity in an Ethiopian Rift-Valley Lake—Abaya

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Abstract

Macrophytes play critical ecological role in inland water bodies, especially in shallow systems. Water hyacinth (*Eichhornia crassipes*) is an invasive plant species introduced to Ethiopian water bodies around the mid 20th century with recently exacerbated devastating ecological and economic consequences. Here we report the impact of the invasive plant species on macrophyte species assemblage and biodiversity in Lake Abaya, southwestern Ethiopia. We compared four sites in Lake Abaya, two hyacinth infested and two non-infested, each site consisting of 15 plots. Our results showed that water hyacinth affects the macrophyte community composition, abundance and diversity negatively. Even though some macrophyte species from the Poaceae and Cyperaceae families appear to coexist with the alien plant, the invasive species has reduced macrophyte abundance and diversity at the infested sites, and in some cases changed the community to nearly monotypic flora. Our data affirm that water hyacinth has the potential to alter macrophyte composition, abundance and diversity in the wider Ethiopian aquatic ecosystems. A broad & closer, syste- matic and comprehensive look at the short and long term consequences of its expanding invasion within the framework of specific local environmental, ecological and societal conditions is long-overdue.

Keywords: Macrophytes, Eicchornia crassipus, Composition, Abundance, Wetland

Mengistu, B. B., Unbushe, D., & Abebe, E. (2017). Invasion of water hyacinth (Eichhornia crassipes) is associated with decline in macrophyte biodiversity in an Ethiopian Rift-Valley Lake—Abaya. *Open Journal of Ecology*, *7*(13), 667-681, https://doi.org/10.4236/oje.2017.713046.

Spatiotemporal Analysis of Land-use and Land-cover Dynamics of Adama District, Ethiopia and Its Implication to Greenhouse Gas Emissions

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Abstract

Uncontrolled change in land use and land cover (LULC) enhances the concentrations of greenhouse gases in the atmosphere. This study, therefore, is aimed at the spatiotemporal analysis of LULC dynamics and their implications for the greenhouse gas emissions of the Adama district of Ethiopia. The dry season Landsat image Thematic Mapper (TM) of 1986, Enhanced Thematic Mapper (ETM) of 2000, and Enhanced Thematic Mapper Plus (ETM^+) of 2014 were downloaded from the United States Geological Survey Global Visualization Viewer Website and employed. The hybrid classification approach was performed after the preprocessing of the image. Moreover, observations, key informant interviews, and focus group discussions were used. The analysis was carried out using the image data and survey data. The result indicates that agricultural land and shrub and bush lands covered 80.98%, 76.75%, and 74.42% of the study area during 1986, 2000, and 2014, respectively. Although there were differences in the magnitudes and rates of change during the considered years, the LULC classification results of this study indicated that most natural environments are converted to human-dominated environments, which can be attributed to human-induced activities. Due to this conversion, environmental degradation is aggravated, which again paves the way for the increased concentration of greenhouse gases in the atmosphere. The study concludes that, largely as a result of interventions from the communities living in the area, the study area is being transformed from the natural ecosystem to a managed environment. Hence, the practices of smallholder farmers with respect to protected areas, afforestation, and reforestation must be strengthened and supported by an integrated policy framework.

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Intra- and interspecific niche variation as reconstructed from stable isotopes in two ecologically different Ethiopian Rift Valley lakes

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Summary

1. The concept of species niches has enhanced our understanding of community assembly and food web structure in a variety of ecosystem types. Niche-based species sorting profoundly determines community composition along strong environmental gradients, while interspecific interactions tend to be more important within habitats at local spatial scales. The role of intraspecific niche variation in community assembly and ecosystem functioning has only recently been highlighted.

2. The present study undertakes a quantitative comparison of the trophic structure of fish communities in two iconic Ethiopian Rift Valley lakes, Lake Abaya and Lake Chamo, which are biodiversity hotspots with high societal importance. The lakes differ strongly in ecology: whereas Lake Abaya is turbid due to a very high sediment loading, Lake Chamo is a clear-water lake, which in recent years is, however, rapidly becoming more turbid. Using stable isotopes, we com-pare the structure of the food web in both lakes, and investigate the degree to which differences in trophic structure between the two lakes are mediated by changes in species composition with fixed within-species niches or rather by flexibility in food acquisition within species.3.Different food web compartments, including fish and the main basal sources, were sampled in both lakes. We used Bayesian stable isotope mixing models and Bayesian community-wide metrics for a quantitative comparison of the food web structure between the two lakes.4.We demonstrate that the isotopic niche of the fish community in Lake Abaya is larger and more diversified compared to that in Lake Chamo. Sediment organic material seems to be a major energy source for fish in Abaya, while zooplankton is a dominant source for fish in Chamo. This is consistent with the different ecology of the two lakes, where high turbidity impedes primary and secondary production in Abaya. Differences in trophic structure between the two lakes resulted from intraspecific isotopic niche variation rather than from compositional variation between fish communities.

5. Our results point to the importance of intraspecific variation in feeding ecology of fish communities inhabiting two large Ethiopian Rift Valley lakes with distinct environmental conditions. We anticipate that the approach we used has strong potential to explore large-scale patterns in food web organization in relation to niche variation across different types of ecosystems.

Keywords: community-wide metrics, lake productivity, mixing models, species sorting, species turnover

Lemmens, P., Teffera, F. E., Wynants, M., Govaert, L., Deckers, J., Bauer, H., ... & De Meester, L. (2017). Intra-and interspecific niche variation as reconstructed from stable isotopes in two

ecologically different Ethiopian Rift Valley lakes. *Functional Ecology*, *31*(7), 1482-1492, doi: 10.1111/1365-2435.12852.

Water surface Changes of Lakes in the Central Rift Valley of Ethiopia

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Abstract

Lakes are one of the most important biologically diverse ecosystems. However, extensive human and natural factors contributed to the loss of this ecosystem. Until recently, knowledge on the recent status of rift valley lakes was lacking. The aim of this study was,therefore, to estimate the current extent of selected lakes in the central Rift Valley of Ethiopia using Landsat image. Satellite images of Landsat OLI_TIRS for the year 2018 were used for this study. Selected bands (green, near infrared, shortwave infrared and middle infrared) were selected in calculating automated water extraction index to distinguish water surface from non-water. The result revealed that the extent of water surface was reduced between 2015 and 2018 with an amount of 47.6, 2.4 and 0.9 % for lake Abjata,Shala and Langano, respectively. Such rapid conversions of aquatic ecosystem need urgent management and policy intervention. Furthermore, applied researches are needed to reduce the magnitude of change.

Keywords: LANDSAT, Shala, Langano, Abjata

Kedirkan, N. (2019). Water surface Changes of Lakes in the Central Rift Valley of Ethiopia. *International Journal of Environment and Geoinformatics*, *6*(3), 264-267.

Temporal and spatial variability of suspended sediment rating curves for rivers draining into the Ethiopian Rift Valley

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Abstract

Quantification of suspended sediment dynamics is a proxy for the intensity of soil erosion processes in a catchment. However, direct measurement of suspended sediments is difficult. Long-term-based discharge-suspended sediment relationships often fail to provide sufficiently accurate results due to the temporal variations in sediment supply. This study evaluates temporal variations in suspended sediment-discharge relations for six stations in two selected catchments within the Gamo Highlands in the southern Ethiopian Rift Valley. During a three-year period (2018–2020), discharge was monitored at a 10-min interval using a TD-diver, while 1938 samples of suspended sediment concentration were taken at specific events. Observed suspended sediment concentration varied between 0.04 and 130 $kg\,m^{-3}$ for discharge ranging between quasi-zeros to 339 $m^3\,s^{-1}$. The results show that pooled annual datasets lead to unsatisfying sediment rating curves and large errors in estimated sediment load. However, stratification of the data into three rainy season periods strongly improved the performance of the sediment rating curves. The development of a vegetative cover throughout the rainy season largely controls sediment supply from hillslopes to the river channel and hence the shape of the sediment rating curves. Furthermore, localized bank erosion and gully head dynamics also lead to important interannual changes in sediment rating curves within one river system, as well as between different rivers. Thus, attention should be given to possible errors due to high temporal and spatial variability while using discharge-suspended sediment relations to quantify sediment load.

Tilahun, A. K., Verstraeten, G., Chen, M., Gulie, G., Belayneh, L., & Endale, T. (2022). Temporal and spatial variability of suspended sediment rating curves for rivers draining to the Ethiopian Rift Valley. *Land Degradation & Development*, https://doi.org/10.1002/ldr.4473.

Modeling seasonal and annual climate variability trends and their characteristics in northwestern Escarpment of Ethiopian Rift Valley

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Abstract

Climate variability is a serious threat to the livelihood of smallholder farmers in the Northwestern Escarpment of the Ethiopian Rift Valley. Raya Valley livelihood Zone (RVLZ), Alagie-Offla livelihood Zone (ALOFLZ), and Tsirare Catchment Livelihood Zones (TCLZ) are among the most chronically food-insecure livelihood zones of the area due to climate variability events. This study aimed to analyze the seasonal and annual climate variability trends and their characteristics in the three livelihood zones (LZ). To analyze climate variability trends and variabilities, the monthly Climate Hazards Group InfraRed Rainfall with Station data (CHIRPS), and Enhancing National Climate Service (ENACTS) Maximum (T_{max}) and Minimum (T_{min}) Temperature data from the period 1983 to 2016 at moderate spatial resolution (4km–by–4km) were acquired from the National Meteorological Agency of Ethiopia. The Mann Kendal Test (MKT), Sen's Slope Estimators (SSE), and coefficient of variation (CV) statistical tests were applied to analyze the data. The results uncovered temperature trends in the study area in line with the predicted temperature change across the globe from 0.3 °C in 2016 to 0.7 °C in the year 2035. Annual T_{min} of MKT and SSE indicated minimum temperature increased with statistical significance in all study LZ. The results of MKT annual T_{min} were 0.319, 0.301, and 0.273 °C in ALOFLZ, TCLZ, and RVLZ, respectively. Besides, statistical significance annual T_{max} is rising 0.323 °C per year in the TCLZ and 0.419 °C per year in the RVLZ. The Belg MKT records show that the T_{max} trend increased significantly by 0.301, 0.401, and 0.430 °C in ALOFLZ, TCLZ, and RVLZ, respectively. Besides rainfall trends, only the Kiremt rainfall shows significant trends with SSE magnitudes of 8.081 in the RVLZ and 8.511 in the TCLZ. However, in all LZ, high seasonal and annual rainfall variability was recorded. The Belg rainfall variability (i.e., 64.01, 69.66, and 64.85%) was higher than Kiremt (45.71, 43.95, and 46.31%) and annual (34.4, 35.12, and 31.62%) rainfall variability in ALOFLZ, TCLZ, and RVLZ correspondingly. Analysis of climate variability trends using MKT and SSE and long recorded data from uniformly distributed meteorological grids have high implications for revealed trends and characteristics of climate variability at LZ levels. The combined rapidly warming temperatures with high rainfall irregularities imply possible future effects on agricultural productivities and increasing evapotranspiration demands that will affect the agricultural productivity of smallholder farmers. Thus, agriculture development practitioners and policymakers should consider the seasonal variability of the rainfall at the livelihood zones for future productivity improvement.

Nasir, J., Assefa, E., Zeleke, T., & Gidey, E. (2022). Modeling seasonal and annual climate variability trends and their characteristics in northwestern Escarpment of Ethiopian Rift Valley. *Modeling Earth Systems and Environment*, *8*(2), 2551-2565, https://orcid.org/0000-0002-8421-2232.

Quantifying ecosystem service supply-demand relationship and its link with smallholder farmers' well-being in contrasting agro-ecological zones of the East African Rift

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Abstract

Ecosystem service supply (ESS) has experienced a progressive decline due to degradation and increased ecosystem social demands (ESD). Quantitative studies assessing ecosystem services have mostly focused on ESS with limited attention to ESD and human well-being. To quantify, analyze and map the ESS, ESD, ESDR (Ecosystem Supply-Demand Ratio), weight-based smallholder farmers' well-being (SWB), subjective satisfaction and change-driving factors, questionnaire surveys, semi-structured interviews and focus group discussions were used in contrasting agro-ecological zone (AEZ). The soil loss rate was estimated and mapped using the Revised Universal Soil Loss Equation (RUSLE) to evaluate the role of soil erosion control in regulating ESS. A five point Likert scale was employed to evaluate smallholder farmers' well-being (SWB), subjective satisfaction, and the contribution of ESS to the components of well-being. A radar diagram was used to link ESS, ESD and SWB. The research was carried out between October 1, 2019 and March 30, 2020. The results showed a high supply of provisioning ESS observed in the humid AEZ, whereas low provisioning ESS was observed in the semi-arid AEZ. The observed ESS was not in accordance with ESD, and different change drivers affecting this balance were identified by smallholder farmers. Population pressure was identified as the main driver from smallholder farmers' report and was confirmed by the multiple linear regression model. Due to the undulating topography, a high rate of soil loss was observed in the humid AEZ. Smallholder farmers in humid AEZ attached higher values for soil erosion control than those from the semi-arid AEZ. Of all indicators of SWB, income was assigned the highest weight while receiving low subjective well-being satisfaction levels in both humid and semi-arid AEZs. The overall relative contribution of ESS shows a medium relationship with all components of smallholder farmers' well-being. Therefore, we suggest policies and strategies that would help to recuperate, and the continuous flow of ESS, control population growth, and improve well-being.

Keywords: Agro-ecological zone; Ecosystem service supply; Mismatch; Subjective satisfaction; Well-being indicator; Ecosystem service social demand

Ketema, H., Wei, W., Legesse, A., Wolde, Z., & Endalamaw, T. (2021). Quantifying ecosystem service supply-demand relationship and its link with smallholder farmers' well-being in contrasting agro-ecological zones of the East African Rift. *Global Ecology and Conservation*, *31*, e01829, https://doi.org/10.1016/j.gecco.2021.e01829.

Drivers, farmers' responses and landscape consequences of smallholder farming systems changes in southern Ethiopia

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Abstract

Ethiopia is now the second most populated country in Africa with more than 100 million people and an annual population growth rate of 3%. Here, we assess how the on-going expansion of arable land and urban areas is affecting the availability of common resources, such as forest and grazing land, and the availability of biomass for food, feed, and energy. Taking the Hawassa area in the Rift Valley of Ethiopia as a study case, this study aims at analysing the drivers of change of farming systems, assessing farmers' responses to these drivers and appreciating the consequences for the agricultural landscapes' composition. We found that (i) national-level policies, climate and soil fertility changes, population increase, and urban expansion were major drivers of farming systems change in the Hawassa area, (ii) forests and grasslands have been progressively replaced by cropland and urban areas, and (iii) these changes resulted in fragmentation and diversification of local agricultural landscapes with potential consequences for ecosystem service provision. Farmers responded with the following three main livelihood strategies: consolidation, diversification and specialization. These changes led to more diverse and fragmented agricultural landscapes. This research contributes to the ongoing debate about the viability of small farms.

Kebede, Y., Baudron, F., Bianchi, F. J., & Tittonell, P. (2019). Drivers, farmers' responses and landscape consequences of smallholder farming systems changes in southern Ethiopia. *International Journal of Agricultural Sustainability*, *17*(6), 383-400, https://doi.org/10.1080/14735903.2019.1679000.

Morphometric Change Detection of Lake Hawassa in the Ethiopian Rift Valley

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Abstract

The Ethiopian Rift Valley lakes have been subjected to environmental and ecological changes due to recent development endeavors and natural phenomena, which are visible in the alterations to the quality and quantity of the water resources. Monitoring lakes for temporal and spatial alterations has become a valuable indicator of environmental change. In this regard, hydrographic information has a paramount importance. The first extensive hydrographic survey of Lake Hawassa was conducted in 1999. In this study, a bathymetric map was prepared using advances in global positioning systems, portable sonar sounder technology, geostatistics, remote sensing and geographic information system (GIS) software analysis tools with the aim of detecting morphometric changes. Results showed that the surface area of Lake Hawassa increased by 7.5% in 1999 and 3.2% in 2011 from that of 1985. Water volume decreased by 17% between 1999 and 2011. Silt accumulated over more than 50% of the bed surface has caused a 4% loss of the lake's storage capacity. The sedimentation patterns identified may have been strongly impacted by anthropogenic activities including urbanization and farming practices located on the northern, eastern and western sides of the lake watershed. The study demonstrated this geostatistical modeling approach to be a rapid and cost-effective method for bathymetric mapping.

Keywords: bathymetry; Ethiopian rift; geostatistics; Lake Hawassa; lake morphometry

Abebe, Y., Bitew, M., Ayenew, T., Alo, C., Cherinet, A., & Dadi, M. (2018). Morphometric change detection of Lake Hawassa in the Ethiopian rift valley. *Water*, *10*(5), 625, doi:10.3390/w10050625.

Drivers of Land Use-Land Cover Changes in the Central Rift Valley of Ethiopia

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Pemacu Kegunaan Tanah - Perubahan Liputan Tanah di Lembah Rekahan Tengah Ethiopia

Abstract

Land use-land cover change (LULCC) is driven by the interplay of forcing factors that act at global, regional, and local levels. Previous studies investigated mainly the basic socioeconomic drivers of LULCC. However, these studies less considered climate change vulnerability as a potential driver. Hence, this study is aimed to assess LULCC drivers in more fragile and dynamic landscapes of the East African Rift Valley region for the period of 1986-2016. We used a combination of Remote Sensing, Geographic Information System, logistic regression, and descriptive statistics to quantify and analyze the data. Image analysis results indicated that during the overall study period (1986-2016), grass/grazing land, agricultural land, and bare land have increased by 124%, 42%, and 34% respectively, whereas scattered acacia woodland, bush/shrubland, and swampy/marshy land have declined by 52%, 50%, and 31%, in that order. This image-derived change trend is in line with farmers' perceived results. The top most influential drivers of LULCC includes population growth (95%), fuelwood extraction (93%), agricultural land expansion (92%), charcoal making (92%), climate change/recurrent drought (79%), and overgrazing (71%) in descending order of percentage of respondents. Education level and age of farmers significantly ($p<0.05$) affected their perception towards less perceived drivers. Hence, in order to reduce the adverse socio-environmental impacts of spectacular LULCC in the region, policy and decision makers need to take into account such principal drivers, particularly population growth and climate change.

Keywords: Central Rift Valley; driver; Ethiopia; land use-land cover change; perception

Bekele, B., Wu, W., & Yirsaw, E. (2019). Drivers of land use-land cover changes in the central rift valley of Ethiopia. *Sains Malays*, *48*, 1333-1345, http://dx.doi.org/10.17576/jsm-2019-4807-03.

Typology of the woody plant communities of the Ethiopian Nech Sar National Park and an assessment of vegetation-environment relations and human disturbance impacts

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Abstract

Background and aims

Deforestation and forest degradation have hugely affected the Southern Ethiopian Rift Valley, jeopardizing biodiversity conservation and ecosystem service provisioning. Quantifying the impacts of human activities on the remaining woody plant communities and recognizing vegetation–environment relationships provide the basis for targeted conservation and rehabilitation.

Materials and methods

The study was performed in the Nech Sar National Park (NSNP). Based on a large systematic vegetation survey of 104 plots, we quantified the woody vegetation composition, and we provided a vegetation classification based on Non Metric Multidimensional Scaling, cluster analysis and indicator species analysis. Furthermore, we evaluated vegetation – environment relationships and the effects of human disturbance on community composition and woody plant species richness and diversity.

Key results

Our analyses revealed three very distinct woody vegetation types (Acacia mellifera-Combretum aculeatum; Lecaniodiscus fraxinifolius-Deinbollia kilimandscharica and Acacia polyacantha- Ficus sycomorus) which were significantly differentiated by soil pH, electrical conductivity, available soil phosphorus and organic matter, and by elevation. Human disturbance, as quantified by a compound Human Disturbance Index (HDI) significantly affected community composition, species richness and diversity, and was significantly positively correlated with species richness and diversity. The latter is likely due to intermediate levels of disturbance and encroachment of disturbance affiliated shrubs such as *Dichrostachys cinerea*, *Lantana camara*, and *Acalypha fruticosa*. Furthermore, the demographic structure of key woody species such as *Acacia polyacantha, Acacia tortilis*, *Balanites aegyptiaca*, *Diospyros abyssinica*, *Lecaniodiscus fraxinifolius* and *Terminalia brownii*, showed impacts of human disturbance.

Conclusion

Our results provide a baseline for further conservation actions in the NSNP which should be differentially targeted on the different plant community types. Overall, human disturbance seems not to have resulted yet in species richness declines, although it has started to affect the integrity of the delineated vegetation types and resulted in small scale succession.

Keywords: Deforestation; forest degradation; human disturbance index; Southern Ethiopian Rift Valley; species diversity; species richness; vegetation – environment relations

Utaile, Y. U., Helsen, K., Aydagnehum, S. G., Muys, B., Shibru, S. C., & Honnay, O. (2020). Typology of the woody plant communities of the Ethiopian Nech Sar National Park and an assessment of vegetation-environment relations and human disturbance impacts. *Plant Ecology and Evolution*, *153*(1), 33-44, https://doi.org/10.5091/plecevo.2020.1698
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Review on the natural conditions and anthropogenic threats of Wetlands in Ethiopian

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Abstract

Wetlands are one of the most multifunctional ecosystems of the world that provide a range of economical, biological, ecological, social, and cultural functions and services to human beings. In Ethiopia all types of wetlands except coastal and marine-related wetlands and extensive swamp-forest complexes are found and they are estimated to cover more than 2% of its total surface area coverage. Wetlands deliver a wide range of ecosystem services that contribute to human well-being such as food and feed, construction materials, water supply, water purification, climate regulation, flood regulation and eco-tourism. Wetlands have played a significant role in the growth of human civilizations and cultural development. However, the degradation and loss of wetlands is a worldwide phenomenon and seems to progress faster than in other ecosystems. Despite all those and other indispensable values, these wetlands are under severe pressure and degradation. Due to improper extraction of uses and misconceptions forwarded to wetlands, the health of the wetlands is continuously decreasing from time to time that in doubt their existence in the near future. In order to reverse these emerging problems and conserve these fragile but crucial wetlands, integrated problem solving approach through realizing the collaboration of relevant stakeholders from policy level down to grassroots community is indispensable opportunity to Ethiopian wetlands.

Keywords: Anthropogenic; Management; Natural; Threats and Wetland

Mengesha, T. A. (2017). Review on the natural conditions and anthropogenic threats of Wetlands in Ethiopian. *Global Journal of Ecology*, *2*(1), 006-014.

Building foundations for source-to-sea management: the case of sediment management in the Lake Hawassa sub-basin of the Ethiopian Rift Valley

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Abstract

This article discusses experiences of applying the source-to-sea approach, contextualized to source-to-lake, in the Lake Hawassa sub-basin of the Ethiopian Rift Valley, particularly for the purpose of generating in-depth knowledge on sediment flows, building a geo- graphically relevant comprehensive stakeholder and governance analysis and using this to design impactful interventions that can reduce sediment flux into Lake Hawassa. The source-to-sea approach has proven to be a useful and flexible for evaluating sediment management in the context of a sub-basin such as that of Lake Hawassa.

Keywords: Source-to-sea; source-to- lake; sediment; Lake Hawassa; Ethiopia; Rift Valley

Belete, M. D., Hebart-Coleman, D., Mathews, R. E., & Zazu, C. (2021). Building foundations for source-to-sea management: the case of sediment management in the Lake Hawassa sub-basin of the Ethiopian Rift Valley. *Water International*, *46*(2), 138-156, https://doi.org/10.1080/02508060.2021.1889868.

Landscape-based upstream-downstream prevalence of land-use/cover change drivers in southeastern rift escarpment of Ethiopia

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Abstract

Characterized by high population density on a rugged topography, the Gedeo-Abaya landscape dominantly contains a multi-strata traditional agroforests showing the insight of Gedeo farmers on natural resource management practices. Currently, this area has been losing its resilience and is becoming unable to sustain its inhabitants. Based on both RS-derived and GIS-computed land-use/cover changes (LUCC) as well as socioeconomic validations, this article explored the LUCC and agroecological-based driver patterns in Gedeo-Abaya landscape from 1986 to 2015. A combination of geo-spatial technology and cross-sectional survey design were employed to detect the drivers behind these changes. The article discussed that LUCC and the prevalence of drivers are highly diverse and vary throughout agroecological zones. Except for the population, most downstream top drivers are perceived as insignificant in the upstream region and vice versa. In the downstream, land-use/cover (LUC) classes are more dynamic, diverse, and challenged by nearly all anticipated drivers than are upstream ones. Agroforestry LUC has been increasing (by 25% of its initial cover) and is becoming the predominant cover type, although socioeconomic analysis and related findings show its rapid LUC modification. A rapid reduction of woodland/shrubland (63%) occurred in the downstream, while wetland/marshy land increased threefold (158%), from 1986 to 2015 with annual change rates of - 3.7 and + 6%, respectively. Land degradation induced by changes in land use is a serious problem in Africa, especially in the densely populated sub-Saharan regions such as Ethiopia (FAO 2015). Throughout the landscape, LUCC is prominently affecting land-use system of the study landscape due to population pressure in the upstream region and drought/rainfall variability, agribusiness investment, and charcoaling in the downstream that necessitate urgent action.

Temesgen, H., Wu, W., Legesse, A., Yirsaw, E., & Bekele, B. (2018). Landscape-based upstream-downstream prevalence of land-use/cover change drivers in southeastern rift escarpment of Ethiopia. *Environmental monitoring and assessment*, *190*(3), 1-15.

Effect of Land Use/Cover Changes on Ecological Landscapes of the Four Lakes of Central Rift Valley Ethiopia

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Abstract

The objective of this study was to analyze land use land cover (LULC) changes in the landscape of Central Rift Valley over a period of 30 years (1985–2015). Satellite images of Landsat5 TM (1985), (1995) and Landsat8 OLI (2015) were used. All images were classified using supervised classification technique with ERDAS-13. Change analysis was carried out using post classification comparison in GIS-10.3.1. Twelve LULCCs were successfully captured and the classification result revealed that intensive cultivated land (44.52%), mixed cultivation (18.31%), and woodlands (11.13%), open water (7.99%), large scale farming (7.50%) was dominant LULC types in 1985. In 2015, mixed cultivation (35.90%), large scale farming (14.87%), intensive cultivation (13.99%), open woodland (8.37%) and irrigated land (6.94 %) were the major LULC types followed by others. The change result shows that a rapid increase in irrigable land, large scale farming, and mixed cultivation 8.37%, 14.87%, and 35.90 % occurred between the 1985 and 2015 study period, respectively. Similarly, open water/lake decreased by 2.31%, during the 1985 and 2015 study periods. More specifically, Lake Abijata showed a progressive decline by 25.6%. Analysis of the 30-year change revealed that about 80.79% of the land showed major changes in LULC. Based on the DPSIR framework of analysis, an integrated land use and development planning and policy reform are suggested to encourage the ongoing and planned ecosystem restoration, degraded land rehabilitation, and biodiversity conservation intervention in the Ethiopia Central Rift Valley areas. However, further detailed investigation may be need prior to any recommendation to address the drivers and consequences of land use and land cover changesin the area.

Keywords: CRV, ERDAS, GIS; Image; Landsat TM /Oli, Lake, LULC, RS

Girmay, W., Tesfaye, B., Seifu, W., & Elias, E. (2017). Effect of Land Use/Cover Changes on Ecological Landscapes of the Four Lakes of Central Rift Valley Ethiopia. *Journal of Environment and Earth Science*.

Enset-based land use land cover change detection and its impact on soil erosion in Meki river watershed, Western Lake Ziway Sub-Basin, Central Rift Valley of Ethiopia

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Abstract

Background

Water erosion, upland degradation and deforestation are key environmental problems in the Meki river watershed. The study assessed the land use land cover change (LULCC) for 30 years and it examined the contribution of indigenous Enset-based land use system (EBLUS) to reduce soil erosion and prevent water bodies including Lake Ziway from sedimentation which was not considered in the former studies. GPS based data collected and satellite based LULC analysis using ERDAS Imagine 2014 performed to investigate existing farm management practices and land cover respectively. HEC-GEOHMS, Geo-statistical interpolation and RUSLE were applied to model watershed characteristics, spatial climate parameters and soil loss respectively.

Result: Meki river watershed (2110.4 km2 of area) is dominantly covered by cultivated LUS (41.5%), EBLUS (10.65%), Bush and Chat LUS (25.6%), Forest and plantations LUS (14.14%), built-up (7.4%) and water bodies (0.75%). Soil loss is increasing from 1987 to 2017 and a larger part of the watershed suffers a moderately severe to very severe risk (18 ha−1 year−1 to > 80 t ha−1 year−1) in all sub-watersheds irrespective of the land use systems which shows the watershed is facing sever degradation problem. The mean soil loss of 30.5 t ha−1 year−1 3 and 31.905 t ha−1 year−1 are verified from Enset growing zones and non-Enset growing zones of the watershed respectively.

Conclusion: EBLUS saves significant amount of soil despite the steepness of the slopes of the Enset growing zones of the watershed. Hence, expansion of EBLUS can contribute in sustaining water bodies, including Lake Ziway by reducing soil loss rate and sedimentation problem for the ecological sustainability of the watershed. Therefore, separate land use policy and awareness creation are mandatory for such EBLUS expansion, sustainable watershed management interventions and conservation of the natural environment in the watershed based on its suitability and severity of erosion risk mapping.

Keywords: Enset, Soil-loss, Geostatistics, RUSLE, Land use policy, Meki-river-watershed

Woldesenbet, A. B., Wudmatas, S. D., Denboba, M. A., & Gebremariam, A. G. (2020). Enset-based land use land cover change detection and its impact on soil erosion in Meki river watershed, Western Lake Ziway Sub-Basin, Central Rift Valley of Ethiopia. *Environmental Systems Research*, *9*(1), 1-23.https://doi.org/10.1186/s40068-020-00198-x

Land use land cover change modeling by integrating artificial neural network with cellular Automata-Markov chain model in Gidabo river basin, main Ethiopian rift

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Abstract

Modeling land use land cover (LULC) change is crucial to understand its spatiotemporal trends to protect the land resources sustainably. The appraisal of this study was to model LULC change from 1985 to 2050 owing to the business-as-usual scenario (BAU) in Gidabo River Basin (GRB) located in the Main Ethiopian Rift Valley. Different dependent and independent spatial datasets were used viz, 1985, 2003 and 2021 Landsat imagery; topography features, proximity variables, population density and evidence likelihood. Since the future projection requires the historical land use as a baseline, historical land use trends were detected using hybrid image classification procedure in ERDAS Imagine and nine major land cover classes were identified. Multi-Layer Perceptron Neural Network and Cellular Automata-Markov Chain model built-in TerrSet software were implemented to project the 2035 and 2050 LULC. The study depicts, GRB experienced significant LULC dynamics and will also be extended for the coming several years. Agriculture land, settlement and water body showed significant gains at the expense of forest, shrub and grasslands loss. Land use changes beyond land's capability played a significant role in triggering land degradation. To minimize these adverse consequences of land use change, environmentally-friendly management measures must be implemented. The outcome of this study will be helpful in providing the opportunity to develop adequate land and water resource conservation strategy plan for the future.

Keywords: Artificial-neural-network; Land cover dynamics; Ca-Markov chain; Gidabo

Land degradation; Multi-Layer Perceptron

Girma, R., Fürst, C., & Moges, A. (2022). Land use land cover change modeling by integrating artificial neural network with cellular Automata-Markov chain model in Gidabo river basin, main Ethiopian rift. *Environmental Challenges, 6*, 100419, https://doi.org/10.1016/j.envc.2021.100419

Land Use and Land Cover Change Assessment and Future Predictions in the Matenchose Watershed, Rift Valley Basin, Using CA-Markov Simulation

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Abstract

Land use and land cover change (LULC) is known worldwide as a key factor of environ- mental modification that significantly affects natural resources. The aim of this study was to evaluate the dynamics of land use and land cover in the Matenchose watershed from the years 1991, 2003, and 2020, and future prediction of land use changes for 2050. Landsat TM for 1991, ETM+ for 2003, and Landsat-8 OLI were used for LULC classification for 2020. A supervised image sorting method exhausting a maximum likelihood classification system was used, with the application using ERDAS Imagine software. Depending on the classified LULC, the future LULC 2050 was predicted using CA-Markov and Land Change Models by considering the different drivers of LULC dynamics. The 1991 LULC data showed that the watershed was predominantly covered by grassland (35%), and the 2003 and 2020 LULC data showed that the watershed was predominantly covered by cultivated land (36% and 52%, respectively). The predicted results showed that cultivated land and settlement increased by 6.36% and 6.53%, respectively, while forestland and grassland decreased by 63.76% and 22.325, respectively, from 2020 to 2050. Conversion of other LULC categories to cultivated land was most detrimental to the increase in soil erosion, while forest and grassland were paramount in reducing soil loss. The concept that population expansion and relocation have led to an increase in agricultural land and forested areas was further reinforced by the findings of key informant interviews. This study result might help appropriate decision making and improve land use policies in land management options.

Keywords: land use; land cover; CA-Markov; Matenchose watershed; Rift Valley Basin

Mathewos, M., Lencha, S. M., & Tsegaye, M. (2022). Land Use and Land Cover Change Assessment and Future Predictions in the Matenchose Watershed, Rift Valley Basin, Using CA-Markov Simulation. *Land, 11*(10), 1632. https://doi.org/10.3390/land11101632

Farmers' participation in the development of land use policies for the Central Rift Valley of Ethiopia

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Abstract

Farmers in Ethiopia are elementary for the implementation of land use policies. However, in order to effectively implement these policies, they need to be aware of them, and accept them accordingly. In this study we assess to what extent farmers in the Central Rift Valley are aware of prevailing land use policies in their area, to what extent they participated in the development of these policies, and how they perceive the impacts of these policies, using interviews with local farmers as well as stakeholders from governmental institutions at various levels. Farmers and local governments indicated that there was very little participation in the development of land use policies. Contrary, government informants at higher level indicated the opposite, suggesting a gap between farmers and local governmental institutions on the one side and higher governmental institutions on the other side. The perceived lack of participation of farmers led to a lack of ownership, involuntary participation, and failure to use the local knowledge, all hampering the effective implementation of these policies. The recently introduced land registration and certification process was identified as an exception, as it was the result of a participatory process, generally leading to acceptance upon implementation. Despite their low policy awareness, farmers could identify the impacts of land use policies on land use and land cover change, as well as its impacts on their. Further improvement farmer participation in the development of land use policies could increase ownership and thus yield more effective implementation and avoid social unrest.

Ariti, A. T., van Vliet, J., & Verburg, P. H. (2018). Farmers' participation in the development of land use policies for the Central Rift Valley of Ethiopia. *Land use policy*, *71*, 129-137, https://doi.org/10.1016/j.landusepol.2017.11.051

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

This study aims to perform multi-site calibration and validation of SWAT model using streamflow data, and investigating the responses of water balance components to land use land cover (LULC) change in the Gidabo river sub-basin of rift valley lake basin in southern part of Ethiopia. SUFI-2 algorithm embedded in the SWAT-CUP was employed for sensitivity analysis, calibration, and validation on a monthly basis. The 17 years (1990–2006) streamflow data for three (Aposto, Bedessa, and Measso) gauging stations were used for calibrating the model while 8 years (2007–2014) streamflow data was used for validating the model. The calibrated and validated SWAT model was then used to investigate the response of water balance components to LULC change for three periods (1990, 2005, and 2019) which were performed using ERDAS Imagine 2014 with a maximum likelihood classifier. The most common statistical model performance evaluation indices namely Coefficient of Determination (R^2), Nash-Sutcliffe Efficiency (NSE), and Percent Bias (PBIAS) were used to evaluate performance of the SWAT model in simulating sub-basin hydrology; in addition to physical inspection of observed and simulated streamflow hydrograph. The findings of the multi-site model performance evaluation indicated that the values of R2 ranged from 0.80 to 0.64 and 0.74 to 0.72 during calibration and validation periods respectively. The values of NSE ranged from 0.74 to 0.61 and 0.71 to 0.65 during calibration and validation periods respectively whereas PBIAS ranged from 19.70 to -3.20 and 18.10 to 0.80 during calibration and validation periods respectively. The calibration and validation results indicated that the SWAT model would simulate fairly well the historical streamflow at three gauging stations. The mean annual streamflow response to LULC change for the periods 1990–2005 and 2005–2019 was observed to increase by 2.13% (1.16m^3/s) and 3.62% (2.04m^3/s), respectively and the mean seasonal streamflow was obtained to increase during wet season (April-September) while decreasing trend was observed during dry season (October-March) in all three gauged stations. Results also revealed that there were significant spatiotemporal variations of surface runoff, groundwater flow, lateral flow, and evapotranspiration in the sub-basin. The multi-site calibration and validation together with uncertainty analysis detects spatial variability and simulates the water balance components under changing LULC, which is paramount importance for planning and formulating appropriate integrated land and water resources management and development strategies in the rift valley lake basin of Gidabo river sub-basin in Ethiopia.

Keywords: Multi-site calibration; Sensitivity analysis; SWAT-CUP; Water 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, https://doi.org/10.1016/j.sciaf.2022.e01093

Tempo-spatial land use/cover change in Zeway, Ketar and Bulbula sub-basins, Central Rift Valley of Ethiopia

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Abstract

Understanding tempo-spatial dynamics of land-use/cover (LULC) and its drivers is instrumental in synthesizing knowledge for informed natural resource management planning and associated decisions. The present study investigates tempo-spatial LULC changes, their drivers and the associated impacts in three sub-basins (Zeway, Ketar and Bulbula) in the Central Rift Valley (CRV) of Ethiopia. Satellite imageries of different periods in ArcGIS, field observations, focus group discussions (FGDs) and secondary data were used to analyse the LULC dynamics, their drivers and associated impacts from 1973 to 2014. The overall accuracy of 1973, 2003 and 2014 classification maps was 88.7%, 88.9% and 91.6%, respectively. The analysis results revealed a continuous increase of farmland and town built-up areas at the expense of grasslands, shrub-bush land and woodlands. It further indicated area of open irrigated agriculture, increasing from none to 2.61% of the total area. The FGDs demonstrated agricultural land expansion, resettlement and wood extraction were proximate causes of the observed LULC changes. Population increases, changes in land tenure system and decreased farmland productivity were determined to be the underlying causes of the changes. The FGDs further indicated these changes have negatively affected the natural resources. The present study findings indicate the need to reconsider land-use decision tradeoffs between economic, social and environmental demands, and their implications for other similar areas in Ethiopia and beyond. Quantitative analysis and periodic evaluation of the drivers of such change and the impacts of existing and emerging land-uses in the face of changing climate is recommended to facilitate sustainable use of the fragile ecosystems in the Ethiopian CRV.

Abera, D., Kibret, K., & Beyene, S. (2019). Tempo-spatial land use/cover change in Zeway, Ketar and Bulbula sub-basins, Central Rift Valley of Ethiopia. *Lakes & Reservoirs: Research & Management*, *24*(1), 76-92, https://doi.org/10.1111/lre.12240

Understanding the Impact of Land Use and Land Cover Change on Water–Energy–Food Nexus in the Gidabo Watershed, East African Rift Valley

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Abstract

Land use and land cover (LULC) changes have significant influences on the water–energy–food (WEF) nexus, as the WEF nexus characteristics change naturally due to dynamic LULC changes. However, understanding the WEF nexus' potential and characteristics in the watershed under the influence of LULC changes is less commonly explored. This study used the social network analysis (SNA) model to analyze the interaction between land use (LU) types and water, energy, and food nexus attributes. Moreover, we used regression analysis to analyze the impact of various LU types on the WEF nexus. The LULC maps of 1986, 2000, 2011, and 2019 were prepared by digital classification method with proper accuracy using satellite imagery. The results show that agroforestry is the dominant LU type, accounting for 25.8–53.1% from 1986 to 2019. Further, settlement increased a 100-fold, which shows the dynamic LULC changes. SNA computed the maximum inter-linkage for forest and water access attributes, while agroforestry and food attributes acted as bridge in the network. This shows that there was inter-dependence between LULC changes and the WEF nexus. This result suggests that LU dynamics can exert pressure on the WEF nexus' resource potential, resulting in WEF insecurity. The analysis of impacts of LULC changes on the WEF nexus shows that the changes that occurred in major LUs (i.e., agroforestry, bare land, settlements, and grass land) had significantly impacted hydrological behaviors, energy characteristics, and food production potential. Understanding LULC changes helps us to conserve and manage WEF nexus resources and to resolve the current dilemmas between land, water, energy, and food sector policies and decisions to improve resource productivity, lower environmental pressure, and enhance human wellbeing and security.

Wolde, Z., Wei, W., Likessa, D., Omari, R., & Ketema, H. (2021). Understanding the impact of land use and land cover change on water–energy–food nexus in the gidabo watershed, east African rift valley. *Natural Resources Research*, *30*(3), 2687-2702.

Drivers of land use/land cover changes in Munessa-Shashemene landscape of the south-central highlands of Ethiopia

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Abstract

Understanding drivers of changes in land use/land cover (LULC) is essential for modeling future dynamics or development of management strategies to ameliorate or prevent further decline of natural resources. In this study, an attempt has been made to identify the main drivers behind the LULC changes that had occurred in the past four decades in Munessa-Shashemene landscape of the south-central highlands of Ethiopia. The datasets required for the study were generated through both primary and secondary sources. Combination of techniques, including descriptive statistics, GIS-based processing, and regression analyses were employed for data analyses. Changes triggered by the interplay of more than 12 drivers were identified related to social, economic, environmental, policy/institutional, and technological factors. Specifically, population growth, expansion of cultivated lands and settlements, livestock ranching, cutting of woody species for fuelwood, and charcoal making were the top six important drivers of LULC change as viewed by the local people and confirmed by quantitative analyses. Differences in respondents' perceptions related to environmental (i.e., location specific) and socioeconomic determinants (e.g., age and literacy) about drivers were statically significant ($P = 0.001$). LULC changes were also determined by distances to major drivers (e.g., the further a pixel is from the road, the less likelihood of changes) as shown by the landscape level analyses. Further studies are suggested targeting these drivers to explore the consequences and future options and formulate intervention strategies for sustainable development in the studied landscape and elsewhere with similar geographic settings.

Kindu, M., Schneider, T., Teketay, D., & Knoke, T. (2015). Drivers of land use/land cover changes in Munessa-Shashemene landscape of the south-central highlands of Ethiopia. *Environmental monitoring and assessment*, *187*(7), 1-17.

Land Use and Land Cover Changes and Their Effects on the Landscape of Abaya-Chamo Basin, Southern Ethiopia

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Abstract

This study uses a combination of remote sensing data, field interviews and observations, and landscape indices to examine the dynamics of land use and land cover (LULC), identify their driving forces, and analyze their effects on the landscape of Abaya-Chamo Basin (ACB) between 1985, 1995, and 2010. The results reveal that the landscape of ACB has changed considerably during the past 25 years between 1985 and 2010. The main changes observed imply a rapid reduction in shrubland (28.82%) and natural grassland (33.13%), and an increase in arable land (59.15%). The basin has become more fragmented and formed less connected patches in 2010 compared to 1985. Rapid population growth, internal migration, policy shifts, and regime change were identified as the key driving forces of LULC changes in ACB. The LULC changes and related trend of increasing landscape fragmentation in the basin increased soil erosion, the volume of surface runoff, and sediment transport in the landscape and, consequently, affected the levels and water quality of the lakes found in the rift floor. Furthermore, the destruction and fragmentation of shrubland and natural grassland led to the decline of wild plants and animals previously prominent in the basin. Therefore, protective measures that take into consideration the economic, social, and ecological dynamics of the basin are urgently needed to save the aquatic and terrestrial ecosystems of the basin from further damage.

Keywords: land use/land cover changes; Abaya-Chamo Basin; land management; landscape change; remote sensing

WoldeYohannes, A., Cotter, M., Kelboro, G., & Dessalegn, W. (2018). Land use and land cover changes and their effects on the landscape of Abaya-Chamo Basin, Southern Ethiopia. *Land*, *7*(1), 2, doi:10.3390/land7010002

Land cover changes as impacted by spatio-temporal rainfall variability along the Ethiopian Rift Valley escarpment

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Abstract

Magnitudes of land cover changes nowadays can be assessed properly, but their driving forces are subject to many discussions. Next to the accepted role of human influence, the impact of natural climate variability is often neglected. In this paper, the impact of rainfall variability on land cover changes (LCC) is investigated for the western escarpment of the Raya Graben along the northern Ethiopian Rift Valley. First, LCC between 2000 and 2014 were analysed at specific time steps using Landsat imagery. Based on the obtained LCC maps, the link was set with rainfall variability, obtained by means of the satellite-derived rainfall estimates (RFEs) from NOAA-CPC. After a correction by the incorporation of local meteorological station data, these estimates prove to be good estimators for the actual amount of precipitation ($\rho_{RFE1.0} = 0.85$, $p = 0.00$, $n = 126$; $\rho_{RFE2.0} = 0.76$, $p = 0.00$, $n = 934$). By performing several linear regression analyses, a significant positive relationship between the precipitation parameter DIFF 5Y (i.e. the at-RFE pixel scale difference in five-year average annual precipitation for the two periods preceding the land cover maps) and the changes in the woody vegetation cover was found (standardised regression coefficient $\beta = 0.23$, $p = 0.02$, $n = 108$). Despite the dominance of direct human impact, further greening of the study area can be expected for the future concomitantly to a wetter climate, if all other factors remain constant.

Annys, S., Demissie, B., Abraha, A. Z., Jacob, M., & Nyssen, J. (2017). Land cover changes as impacted by spatio-temporal rainfall variability along the Ethiopian Rift Valley escarpment. *Regional Environmental Change*, *17*(2), 451-463.

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.

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*, 1-21.

Expansion of sugarcane monoculture: associated impacts and management measures in the semi-arid East African Rift Valley, Ethiopia

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Abstract

The study examined the expansion of sugarcane monoculture over the period 1957–2010 and its implications for land degradation and land management measures in the semi-arid northern Main Ethiopian Rift Valley. It used multi-scale and multi-temporal imageries aided by qualitative surveying to investigate the dynamics of land use and cover changes. The study applied both a pixel-based supervised classification and feature extraction methods at subclass levels and merged them into major compatible and comparable land use and cover groups. The results indicated a substantial transformation in the landscape over 53 years (1957–2010), which is attributed to expansion of sugarcane plantation, saline lake water, and smallholder farmland and settlements. The land use and cover changes culminated in reduction of native vegetation cover and biodiversity loss, encroachment of non-native species, and occurrence of soil salinity. Major causes that justify the changes include (1) macro-economic changes and policy shifts towards agricultural development, (2) change in underground hydrology, (3) population growth, and (4) sedentarization of the traditional pastoral community. Proper measures should aim at addressing the trade-off between economic development and environmental sustainability. Moreover, management opportunities should base on the understanding of socioeconomic and biophysical settings and balance the sustenance of the local people and ecological function of the area.

Beza, S. A., & Assen, M. A. (2017). Expansion of sugarcane monoculture: associated impacts and management measures in the semi-arid East African Rift Valley, Ethiopia. *Environmental monitoring and assessment*, *189*(3), 1-14.

Hydrologic responses to climate and land-use/land-cover changes in the Bilate catchment, Southern Ethiopia

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Abstract

The likely effects of climate and land-use/land-cover (LULC) changes on hydrologic processes in Bilate catchment, Ethiopia were evaluated. The study emphasizes the evaluation of individual and combined impacts on hydrologic responses of climate and LULC changes. Climatic scenarios included a downscaled regional climate model from CORDEX-Africa. The CA–Markov model was used to project LULC. The results revealed that distinct changes on hydrologic responses occurred which follow the direction of climate and LULC changes. A 30.87% decline in rainfall resulted in about 4.09, 1.43 and 3.57% decline in runoff, groundwater and water yield, respectively. A rise in mean temperature by 1.3 °C resulted in a 7 and 0.8% increase in potential and actual evapotranspiration, respectively. Runoff, groundwater and water yield are projected to decrease by 11.24, 12.54 and 11.54%; however, potential and actual evapotranspiration are projected to increase by 19 and 14.7%, respectively, under combined climate and LULC changes. The joint effects of climate and LULC changes on hydrologic responses in the forthcoming were higher than the variation trend of climate or LULC change alone. Climate change compared with LULC change has a higher impact on hydrologic responses. The results obtained provide further insight into future water balance, and assistance in water resources planning and management.

Keywords: Bilate catchment, climate change, LULC change, SWAT model, water balance

Kuma, H. G., Feyessa, F. F., & Demissie, T. A. (2021). Hydrologic responses to climate and land-use/land-cover changes in the Bilate catchment, Southern Ethiopia. *Journal of Water and Climate Change*, *12*(8), 3750-3769.doi: 10.2166/wcc.2021.281

Dynamics of land use/land cover: implications on environmental resources and human livelihoods in the Middle Awash Valley of Ethiopia

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Abstract

Quantifying the recent LULC changes and associated impacts on pastoral and agro-pastoral livelihood systems is important since the effects of LULC changes on environmental resources and human livelihood are not fully understood in our study area. This paper analysed the trend of land use/land cover (LULC) dynamics and its implications on natural resources and human livelihood in the Middle Awash Valley, Central Ethiopian Rift Valley. For the purpose, Landsat imageries of thematic mapper (1987), enhanced thematic mapper (2002) and operational land imager and thermal infrared sensor (2016) were employed and analysed using Remote Sensing and Geographic Information System (GIS) software and techniques, and qualitative data analysis had been performed as well. The results showed that cultivated land expanded at a rate of 2.6% year^{-1}, whereas forestland and grassland shrunk at a rate of 1.2% year^{-1} and 2.4% year^{-1}, respectively. The invasive *Prosopis juliflora* has been expanded from 3.7% in 1987 to 37.9% in 2016 at a rate of 1.2% year^{-1}. The introduction of both small- and large-scale commercial irrigation farming and the implementation of villagization programme focused on transforming pastoralists into sedentary lifestyles. Consequently, irrigation farming, launching of villagization, climate variability as in series of droughts, construction of water dam and the rapid expansion of *Prosopis juliflora* were the major drivers of LULC changes in the study area. Although we found some positive developments such as improvement on infrastructural and social services (e.g. school and domestic water supply), income diversification and ecological benefits from *Prosopis juliflora* (e.g. saline soil treatment, carbon sequestration and soil erosion control), there were a range of negative impacts resulting from LULC changes in the study area. LULC changes reduced quality of rangeland resources as the ecologically and economically valuable indigenous tree and grass varieties were significantly degraded. As a result, the traditional pastoral livelihood system has been much vulnerable with the LULC dynamism of the study area. Furthermore, the implementation of the villagization programme has brought socioeconomic impacts on the community and challenges on the ecology, e.g. changing productive rangeland to irrigation crop farms. Our research results, thus, suggest the urgent need for relevant policy interventions in support of the pastoral livelihoods and landscapes with the modification in the implementation of villagization as well as irrigation farming programmes and its better management and controlling *Prosopis juliflora* expansion in the study area.

Abebe, M. T., Degefu, M. A., Assen, M., & Legass, A. (2022). Dynamics of land use/land cover: implications on environmental resources and human livelihoods in the Middle Awash Valley of Ethiopia. *Environmental Monitoring and Assessment*, *194*(11), 1-22.

Effect of land use–land cover change on the regimes of surface runoff—the case of Lake Basaka catchment (Ethiopia)

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Abstract

In this study, the effect of land use–land cover change (LULCC) on surface (direct) runoff was estimated for Lake Basaka catchment using the soil conservation services—curve number model in the geospatial information system (ArcInfo), assisted by remote sensing. The result indicated that Lake Basaka catchment experienced a significant LULCC. About 86% of forest coverage and 46% of grasslands were lost over the study period (1973–2015), which were shifted to open bushy woodlands, farms, lake water and wetlands. The runoff responses were observed to be increasing since 1970s, especially after the inception of large-scale irrigation schemes to the region. The highest increase of surface runoff was observed to occur after mid-1980s, which is in line with the significant LULCC and the corresponding increment of lake level in that period. The reduction in vegetation cover has resulted in an increase of runoff coefficient (r_c) from 0.07 in the 1960s to about 0.23 in 2000s. The sensitivity analysis result indicated that about 70% of the increase runoff rate in the lake catchment is attributed to LULCC, and the remaining proportion is due to rainfall. However, the effect of extreme rainfall on runoff process could not be underemphasized since it has significant impact especially during extreme events (observed r_c of 0.33 in 2008). Overall, when predicting the runoff response of the lake catchment, it is importance to take into account possible future LULCC and evolution.

Dinka, M. O., & Klik, A. (2019). Effect of land use–land cover change on the regimes of surface runoff—the case of Lake Basaka catchment (Ethiopia). *Environmental monitoring and assessment, 191*(5), 1-13.

Spatiotemporal trends of urban land use/land cover and green infrastructure change in two Ethiopian cities: Bahir Dar and Hawassa

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Abstract

Background: The spatiotemporal analysis of urban land use/land cover change (LULCC) helps to understand the dynamics of the changing environment of green infrastructure (GI) on the basis of sustainable city development. There are important links between spatiotemporal land use/land cover and GI change in urban areas. Therefore, the main objective of this study was to examine the spatiotemporal trends of urban land use/land cover and GI changes in Bahir Dar and Hawassa cities for the last four decades (1973–2015). Three different sets of Landsat satellite data were procured from EMA for Bahir Dar and Hawassa from 1973, 2000 and 2015 using Landsat 4 MSS, 7 TM and 8 OLI respectively. Based on this, using ERDAS Imagine (ver. 9.2) and Arc GIS (Ver.10.3) five LULCC classes were identified for analysis purpose.

Result: The results show that vegetation decreased by 30 and 14% in Bahir Dar and Hawassa respectively for the period 1973–2015, while built-up areas expanded by 10 and 24% respectively in the two cities. These land use changes have significant impacts on spatiotemporal trends of GI in urban areas. GI has increased in Bahir Dar and Hawassa in association with built-up area expansion and deliberate activity of city administrations with effective implementation of spatial plans of corresponding cities.

Conclusions: There is a growing concern about GI in cities. Policy makers and stakeholders should also decide on how to use the land at present and in the future. LULCC policymaking processes should aim to balance GI and other types of land use/land cover for sustainable urban development. Urban LULCC has important effects on the urban GI system.

Keywords: City planning, Green infrastructure, GIS, Landsat image, Land use land cover change, Remote sensing, Spatiotemporal

Gashu, K., & Gebre-Egziabher, T. (2018). Spatiotemporal trends of urban land use/land cover and green infrastructure change in two Ethiopian cities: Bahir Dar and Hawassa. *Environmental Systems Research*, *7*(1), 1-15, https://doi.org/10.1186/s40068-018-0111-3

Land use/land cover change effect on soil erosion and sediment delivery in the Winike watershed, Omo Gibe Basin, Ethiopia

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Abstract

Information on soil loss and sediment export is essential to identify hotspots of soil erosion to inform conservation interventions in a given watershed. This study investigates the dynamics of soil loss and sediment export associated with land-use/land cover changes and identifying soil loss hotspot areas in the Winike watershed of the Omo-Gibe Basin of Ethiopia. Spatial data collected from satellite images, topographic maps, meteorological and soil data were analyzed. The land-use types in the study area were categorized into six: cultivated land, woodland, forest, grazing, shrubland, and bare land. The Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) of the sediment delivery ratio (SDR) model was used based on the analysis of land use/land cover and RUSLE factors. The results show that total soil loss increased from 774.86 thousand tons in 1988 to 951.21 thousand tons in 2018 while the corresponding sediment export increased by 3.85 thousand tons for the same period. These were subsequently investigated in each land-use type. Cultivated fields generated the highest soil erosion rate, increasing from 10.02 t/ha/year in 1988 to 43.48 t/ha/year in 2018 when compared with the grazing, shrub, forest, wood land and bare land-use types. This corresponds with the expansion of the cultivated area. This is logical as the correlation between soil loss and sediment delivery and expansion of cultivated area is highly significant ($p < 0.001$). Sub-watershed six (SW-6) showed the highest soil loss (23.17 t/ha/year) while sub-watershed two (SW- 2) has the lowest soil loss (5.54 t/ha/year). This is because SW-2 is situated in the lower reaches of the watershed under dense vegetation cover experiencing less erosion. The findings on the erosion hotspots presented in this study allow prioritizing the segments of the watershed that need immediate application of improved management interventions and informed decision-making processes.

Keywords: InVEST model; Omo Gibe Basin; Sediment delivery; Soil loss; Winike watershed

Aneseyee, A. B., Elias, E., Soromessa, T., & Feyisa, G. L. (2020). Land use/land cover change effect on soil erosion and sediment delivery in the Winike watershed, Omo Gibe Basin, Ethiopia. *Science of the Total Environment, 728*, 138776, https://doi.org/10.1016/j.scitotenv.2020.138776

Assessment of land use and land cover change in South Central Ethiopia during four decades based on integrated analysis of multi-temporal images and geospatial vector data

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Abstract

Agricultural production is the immediate basis for food security and income of the majority of Central Ethiopia′s population. Demographic change has led to ever-decreasing farmland area per household and expansion of agriculture into marginal lands. Climatic extremes have been further aggravating the situation in large parts of the region. Governments and state organizations have been assertive in land use related decisions but effects of land use policies often have become visible only after longer periods. Our study shows changes in land cover, tenure and land use over a period of four decades (1972–2013), reflecting influences of very contrasting political systems.

We used an approach of multi-temporal mid resolution satellite images, combined with visual interpretation and supervised classification, to enhance accuracy of land cover classification and dealing with varying cloud cover, which resulted in improvements of 12–30% over the conventional method.

The combination of enhanced image interpretation and consideration of the specific historical context allowed to draw conclusions on land cover and land use related trends – from collectivization and villagization to recent local techniques of soil conservation through stone bunds – across various agroecological zones of the study region.

Analysis also showed that agriculture nowadays has reached its maximum extension on suitable lands and is expanding more and more into marginal lands threatening biodiversity in forests. Ways of sustainable agricultural intensification are thus urgently needed for land use planning. Without judging the efficacy of past measures, we claim that the enhanced remote sensing-based image analysis technique introduced here can assist in land use planning by identifying areas of success (expansion) and failures (land cover change) of certain practices that only become visible from a greater historical and spatial distance.

Kibret, K. S., Marohn, C., & Cadisch, G. (2016). Assessment of land use and land cover change in South Central Ethiopia during four decades based on integrated analysis of multi-temporal images and geospatial vector data. *Remote Sensing Applications: Society and Environment*, *3*, 1-19, https://doi.org/10.1016/j.rsase.2015.11.005

Estimation of soil erosion using USLE and GIS in Awassa Catchment, Rift valley, Central Ethiopia

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Abstract

In central part of the Main Ethiopian Rift, population increase is forcing farmers to expand their land by clearing forests, bushes and scrubs for crop cultivation, construction purposes and for fuel as energy source. Thus, loss of agricultural lands is increasing in the catchment. Therefore, estimation of soil erosion in Awassa catchment, Ethiopia is very important to make sound environmental management strategies and land use planning. In this context, Universal Soil Loss Equation (USLE) has been adopted to estimate soil erosion for sheet, rill and inter-rill. All these thematic layers were prepared in a Geographical Information System (GIS) using various data sources and data preparation methods. The soil erosion map was prepared by GIS layers over lapping method which ultimately estimated soil erosion rate of study area. The study revealed that 97% of the study area is characterized by 0–10 t ha^{-1} $year^{-1}$ soil erosion rate, whereas 3% of the study area is characterized by 10–202 t ha^{-1} $year^{-1}$ soil erosion rates. When estimated for soil erosion, it was found that out of the whole catchment, 30 km^2 was under high to extremely high soil erosion rate (91–202 t ha^{-1} $year^{-1}$). The outcome of research also showed that the study areas having six ordinal classes of soil erosion risk zone, e. g., extremely high risk (91–202), extreme risk (55–91), very high risk (30–55), high risk (10 − 30), moderate risk (5–10) and low risk (0–5) with corresponding percentage of area falling, 0.18, 0.26, 0.43, 1.62, 2.68, and 94.83, respectively. From the level of soil tolerance limits, it appears that the amount of soil loss is tolerable at its current situation.

Keywords: Soil Erosion; USLE; Remote Sensing; GIS; Ethiopia

Ali, S. A., & Hagos, H. (2016). Estimation of soil erosion using USLE and GIS in Awassa Catchment, Rift valley, Central Ethiopia. *Geoderma Regional*, *7*(2), 159-166, https://doi.org/10.1016/j.geodrs.2016.03.005

Monitoring land use/land cover change impacts on soils in data scarce environments: a case of south-central Ethiopia

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Abstract

To monitor land-use/land-cover (LULC) change and assess its impact on the soil property, the availability of benchmark data is indispensable, which is hardly available in the intensively cultivated regions of developing countries. Our study attempts to solve this problem by generating a benchmark soil data through the development of modified spatial analogue (MSA) method in the context of the Upper Dijo River catchment, south-central Ethiopia. The magnitude and patterns of LULC changes were extracted from air photos and satellite imageries, along with the acquisition of soil samples from the reference and target sites through ground survey. Analysis of digital image processing shows significant LULC changes in a period that spanned three decades. The impact of LULC change on soil quality was assessed by comparing the soil physico-chemical properties sampled from the reference and target sites. The result shows a decline in total nitrogen, organic matter, available potassium and pH levels in soils collected from target sites, which conforms to results reported by studies conducted in data-rich environment. With careful validation, MSA could be useful for monitoring soil property changes in data-scarce environment and generate soil-related parameters for agro-ecological models.

Keywords: Ethiopia; land-use/land-cover change; reference soils; data-scarce environment; soil quality change; modified spatial analogue method

Mengistu, D. A., & Waktola, D. K. (2016). Monitoring land use/land cover change impacts on soils in data scarce environments: a case of south-central Ethiopia. *Journal of Land Use Science*, *11*(1), 96-112http://dx.doi.org/10.1080/1747423X.2014.927011

Land use and land cover dynamics in the Keleta watershed, Awash River basin, Ethiopia

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Abstract

Unprecedented pace and magnitude of land use/land cover (LULC) change in the Ethiopian highlands is a key problem threatening the natural ecosystem and creates vulnerability to an environmental hazard. A combination of remote sensing, field observations and focus group discussions were used to analyze the dynamics and drivers of LULC change from 1985 to 2011 in the Keleta watershed, Ethiopia. Supervised image classification was used to map LULC classes. Focus group discussions and ranking were used to explain the drivers and causes linked to the changes. The result showed rapid expansion of farmland and settlement (36%), shrublands cover shrinking by 50%, while the size of degraded land increased by 45%. Rapid population growth, rainfall variability and soil fertility decline, lack of fuelwood and shortage of cultivation land were ranked as the main causes of LULC change in the watershed according to the focus group discussion. Further effort is needed to improve the creation of new job opportunity, promotion of improved technologies to boost productivity and soil fertility, provide credit facility, extra push on irrigation infrastructure development and soil, water and natural ecosystem conservation practices. Generally, better community-based land resource management will need to ensure sustainable rural livelihoods.

Keywords: Land use/land cover dynamics; land degradation; drivers and causes; Awash River basin; remote sensing; Ethiopia

Bekele, D., Alamirew, T., Kebede, A., Zeleke, G., & Melesse, A. M. (2019). Land use and land cover dynamics in the Keleta watershed, Awash River basin, Ethiopia. *Environmental Hazards*, *18*(3), 246-265, https://doi.org/10.1080/17477891.2018.1561407

Dynamics of land use land cover and resulting surface runoff management for environmental flood hazard mitigation: The case of Dire Daw city, Ethiopia

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Abstract

Study region

This study was conducted in Dire Dawa city, Ethiopia.

Study focus

This study aims to explore the hydrological impacts of land use land cover changes using rational method. As to perform land use analysis, four decade based satellite imagery were analyzed using ERDAS imagine. The hydrological effect of land cover change and respective surface runoff was calculated using rational method.

New hydrological insights for the region

The trend of land use land cover analysis shows that the city has been experiencing significant decrease in forest land with continuous concomitant increases in bare land and settlements through the study period. In response of land use changes, the trend of surface runoff showed continuous increasing trend. The result of focus group discussion confirms that land use change has significantly affected the trend of surface runoff generation. The study also found out that the amount of surface runoff was positively sensitive to forest land and negatively to bare land and settlement classes. To demonstrate the future effect of surface runoff, the study developed worst and best case scenarios. The worst case showed that if the current land use continuous in the coming years, the watershed could receive more surface runoff that threaten the existence of the city. The best case scenario suggested rehabilitation of bare land cover and rooftop rainwater harvesting as promising condition to drop the amount of surface runoff. The output of the study provides environmental friendly surface runoff mitigation strategies that can be adopted at household and community levels.

Keywords: Environmental friendly; Flood mitigation; Land use; Rational model; surface runoff

Erena, S. H., & Worku, H. (2019). Dynamics of land use land cover and resulting surface runoff management for environmental flood hazard mitigation: The case of Dire Daw city, Ethiopia. *Journal of Hydrology: Regional Studies, 22,* 100598, https://doi.org/10.1016/j.ejrh.2019.100598

Quantitatively Assessing the Future Land-Use/Land-Cover Changes and Their Driving Factors in the Upper Stream of the Awash River Based on the CA–Markov Model and Their Implications for Water Resources Management

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Abstract

Despite the rapid economic and population growth, the risks related to the current dynamics of land use and land cover (LULC) have attracted a lot of attention in Ethiopia. Therefore, a complete investigation of past and future LULC changes is essential for sustainable water resources and land-use planning and management. Since the 1980s, LULC change has been detected in the upper stream of the Awash River basin. The main purpose of this research was to investigate the current dynamics of LULC and use the combined application of the cellular automata and the Markov chain (CA–Markov) model to simulate the year 2038 LULC in the future; key informant interviews, household surveys, focus group discussions, and field observations were used to assess the consequences and drivers of LULC changes in the upstream Awash basin (USAB). This research highlighted the importance of remote sensing (RS) and geographic information system (GIS) techniques for analyzing the LULC changes in the USAB. Multi-temporal cloud-free Landsat images of three sequential data sets for the periods (1984, 2000, and 2019) were employed to classify based on supervised classification and map LULC changes. Satellite imagery enhancement techniques were performed to improve and visualize the image for interpretation. ArcGIS10.4 and IDRISI software was used for LULC classification, data processing, and analyses. Based on Landsat 5 TM-GLS 1984, Landsat 7 ETM-GLS 2000, and Landsat 8 2019 OLI-TIRS, the supervised maximum likelihood image classification method was used to map the LULC dynamics. Landsat images from 1984, 2000, and 2019 were classified to simulate possible LULC in 2019 and 2038. The result reveals that the maximum area is covered by agricultural land and shrubland. It showed, to the areal extent, a substantial increase in agricultural land and urbanization and a decrease in shrubland, forest, grassland, and water. The LULC dynamics showed that those larger change rates were observed from forest and shrubland to agricultural areas. The results of the study show the radical changes in LULC during 1984–2019; the main reasons for this were agricultural expansion and urbanization. From 1984 to 2019, agriculture increased by 62%, urban area increased by 570.5%, and forest decreased by 88.7%. In the same year, the area of shrubland decreased by 68.6%, the area of water decreased by 65.5%, and the area of grassland decreased by 57.7%. In view of the greater increase in agricultural land and urbanization, as well as the decrease in shrubland, it means that the LULC of the region has changed. This research provides valuable information for water resources managers and land-use planners to make changes in the improvement of future LULC policies and development of sub-basin management strategies in the context of sustainable water resources and land-use planning and management.

Keywords: land-use/land-cover dynamic; CA–Markov model; geographic information system; remote sensing; water resource; upper stream Awash basin

Daba, M. H., & You, S. (2022). Quantitatively assessing the future land-use/land-cover changes and their driving factors in the upper stream of the Awash River based on the CA–markov model and their implications for water resources management. *Sustainability*, *14*(3), 1538, https://doi.org/10.3390/su14031538

Mapping of land-use/land-cover changes and its dynamics in Awash River Basin using remote sensing and GIS

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Abstract

Understanding the dynamics of land-use and land-cover change at a basin scale, including its driving causes, is vital for the development and planning of appropriate environmental management policies and strategies. The aim of this research was to analyse and understand the long-term dynamics of land-use/land-cover changes and population growth in the Awash River Basin (ARB) using remote sensing and Geographic Information System (GIS). Landsat images for 1988, 2002, and 2018 were processed, classified and analysed. The accuracy assessment showed that the classification was relatively acceptable and effective in detecting the long-term land-use changes in ARB. Cropland increased by 12% between 1988 and 2002, and by 2018 it had increased by 15%. Similarly, the built-up area expanded by 52 km^2 (184%) between 1988 and 2002, and by 2018 it had reached 225%. The analysis showed that the cropland and built-up area expanded at the expense of forest and shrubland, with shrubland and forest reducing by 4% and 25% respectively over the 30 year study period. Higher levels of deforestation, combined with population growth, urbanization and cropland expansion, have impacted on the available water resources and runoff in the area. The findings from this study can help in the design of sustainable environmental management strategies and practices to ensure the sustainability of the ecosystem and natural resources. The results can also be used to address food security issues in the ARB since we see an increasing trend in population growth with a commensurate decrease in agricultural land, thereby increasing food security concerns.

Tadese, M., Kumar, L., Koech, R., & Kogo, B. K. (2020). Mapping of land-use/land-cover changes and its dynamics in Awash River Basin using remote sensing and GIS. *Remote Sensing Applications: Society and Environment, 19*, 100352, https://doi.org/10.1016/j.rsase.2020.100352.

Spatiotemporal detection of land use/land cover change in the large basin using integrated approaches of remote sensing and GIS in the Upper Awash basin, Ethiopia

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Abstract

Assessment of the changing environmental conditions is essential for planning the wise use of natural resources. The main objective of this paper is to analyze the historical and future modeled LULC changes using multi-temporal Landsat images in the Upper Awash basin, Ethiopia. The supervised image classification method was used to determine the historical LULC changes based on Landsat 1 MSS 1972, Landsat 5 TM 1984, Landsat 7 ETM + 2000, and Landsat 8 OLI TIRS 2014. The future LULC change was predicted using the machine-learning approaches of Land Change Modeler (LCM). The LULC change detection analysis exhibited significant increment in the areal extent of the cropland and urban areas, and decreasing trends in the pasture, forests and shrubland coverage. Mainly, the LULC change matrices indicated that larger conversion rate was observed from shrubland to cropland area. The urban area found to increase by 606.2% from the year 1972 to 2014 and cropland has also increased by 47.3%. Whereas, a decreasing trend was obtained in the forest by − 25.1%, pasture − 87.4%, shrubland − 28.8% and water − 21.0% in the same period. The modeled future LULC change scenarios of the year 2025 and 2035 have exhibited significant expansion of cropland and urban areas at the expense of forest, pasture and shrubland areas. The study has revealed the extent and the rate of LULC change at larger basin and subbasin level which can be useful for knowledge-based future land management practice in the Upper Awash basin.

Shawul, A. A., & Chakma, S. (2019). Spatiotemporal detection of land use/land cover change in the large basin using integrated approaches of remote sensing and GIS in the Upper Awash basin, Ethiopia. *Environmental Earth Sciences*, *78*(5), 1-13.

Dynamics of land use and land cover changes in Huluka watershed of Oromia Regional State, Ethiopia

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Abstract

Background

Land use and land cover changes in urbanized watersheds of developing countries like Ethiopia are underpinned by the complex interaction of different actors, driving forces, and the land itself. Land conversion due to residential development, economic growth, and transportation is identified as the most serious environmental pressure on urbanized landscapes of the world. It results in the degradation of natural vegetation and significant increases in impervious surfaces. The purpose of the study was to analyze spatio-teporal changes in land use and land cover in the Huluka watershed with implications to sustainable development in the watershed.

Results

Forest land, cultivated land, urban built-up, bush/shrub land, bare land, grassland, and water body were identified as the seven types of land use and land cover in the Huluka watershed. Forest land decreased by 59.3% at an average rate of 164.52 ha/year between 1979 and 2017. Bush/ shrub land decreased by 68.2% at an average rate of 318.71 ha/year between 1979 and 2017. Grassland decreased by 32.7% at an average rate of 228.65 ha/year between 1979 and 2017. Water body decreased by 5.1% at an average rate of 1.06 ha/year between 1979 and 2017. Urban built-up area increased by 351% at an average rate of 16.20 ha/year between 1979 and 2017. Cultivated land increased by 105.3% at an average rate of 692.76 ha/year between 1979 and 2017. Bare land increased by 41.9% at an average rate of 4.00 ha/year between 1979 and 2017. Infrastructural and agricultural expansion, increased demand for wood, local environmental and biophysical drivers, rapid human population growth, economic drivers, technological drivers, policy and institutional drivers, and local socio-cultural drivers were perceived by residents as drivers of land use and land cover changes. Increased flooding risk, increased soil erosion, increased sedimentation into water resources like lakes and rivers, decrease in soil fertility, loss of biodiversity, loss of springs, decrease in annual rainfall, and increase in heat during the dry season were perceived by residents as negative local effects of land use and land cover changes.

Conclusions

Changes in land use and land cover in the study water shade imply the need for integrating sustainable watershed planning and management into natural resources management strategies. In other words, practices of appropriate land use planning and management, family planning, participatory planning and management, appropriate environmental impact assessment (EIA), and proper planning and

management of development projects and programmes are of paramount importance to promote sustainable development in the Huluka watershed and beyond.

Ogato, G. S., Bantider, A., & Geneletti, D. (2021). Dynamics of land use and land cover changes in Huluka watershed of Oromia Regional State, Ethiopia. *Environmental Systems Research*, *10*(1), 1-20.

Land-use and land-cover changes and their drivers in rangeland-dependent pastoral communities in the southern Afar Region of Ethiopia

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Abstract

The present study was conducted in the southern Afar Region in Ethiopia to analyse the trends of land-use and land-cover changes and their drivers in the period 1985 to 2015 using remote sensing, field observation, focus group discussions and semi-structured interviews. A substantial loss of grassland cover (64.5%), moderate decline of cultivated land (24%) and a considerable increase in bush and shrub land cover (114.3%) occurred between 1985 and 2015. Consequently, pastoralist's access to rangeland resources and farmlands was highly restricted, thus putting the pastoral production system under increasing threat. A 13.3% decline of bare land was also observed during the same period. The results further indicated that policy, climate change, and variability, biotic factors including population growth, overgrazing, *Prosopis juliflora* seed dispersal via livestock's fecal droppings and seed germination potential of *P. juliflora* under moisture stress were the most important drivers of land-use and land-cover changes. Therefore, policy and strategies should be developed to control *P. juliflora* and give pastoralists full rights to their grazing land. Furthermore, there should be a strategy to strengthen the customary institution for effective management of rangeland resources.

Keywords: grassland; land cover; land use; pastoralists; *Prosopis*

Mekuyie, M., Jordaan, A., & Melka, Y. (2018). Land-use and land-cover changes and their drivers in rangeland-dependent pastoral communities in the southern Afar Region of Ethiopia. *African Journal of Range & Forage Science*, *35*(1), 33-43, https://doi.org/10.2989/10220119.2018.1442366

An Alternative Empirical Model to Estimate Watershed Sediment Yield Based on Hydrology and Geomorphology of the Basin in Data-Scarce Rift Valley Lake Regions, Ethiopia

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Abstract

Physical-based soil erosion models are playing an important role in the assessment of soil erosion, transportation, and deposition in the watershed. Most of these models were developed for data-rich areas of the world and they need a measured data to calibrate and validate their results. To apply such physical-based models, the main factor hindering is the lack of measured sediment data. The amount of sediment in the fluvial systems is the result of hydro-geomorphological processes of a watershed and the nature of stream flows. Therefore, this study aims to develop an alternative empirical model that generates the observed sediment data based on the hydro-geomorphology and nature of stream flows for Ziway Lake basin in the rift Valley of Ethiopia. By applying Soil and water Assessment Tool (SWAT), the lake basin was divided in to two sub-basins (Maki and Katar) with 26 of the watersheds within Maki. The SWAT model was calibrated and validated for both stream and sediment flow by using SUFI-2 program and its performance was assessed by using model evaluation statistics. With calibrated sediment flow rates of 26 Maki sub basins, an empirical model was developed by using its respective drainage area, average sub-basins slope, surface runoff, soil erodibility factor, stream flow rate, and average rive slopes. The applicability of the newly developed alternative model was tested by using model evaluation statistics and validated inside of Katar sub-basin. It is recommended to test the developed model in other basins to incorporate with SWAT CUP program to calibrate and validate the sediment yield at data scared area.

Keywords: SWAT; hydro-geomorphology; alternative empirical model; Lake Ziway

Aga, A. O., Melesse, A. M., & Chane, B. (2020). An alternative empirical model to estimate watershed sediment yield based on hydrology and geomorphology of the basin in data-scarce rift VALLEY lake regions, Ethiopia. *Geosciences*, *10*(1), 31., doi:10.3390/geosciences10010031

Impact of Land-Use Changes on Sediment Load and Capacity Reduction of Lake Ziway, Ethiopia

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Abstract
Land-use change has been a factor that alters the hydrologic response of the watersheds leading to influencing on sediment yield changes. This study is mainly focusing on the assessment of the impacts of the land-use changes on sediment load and lake depth reduction on Lake Ziway, Ethiopia using an in- tegrated approach of Remote Sensing (RS), GIS and SWAT model. ERDAS IMAGINE 14 model was used to generate land-use maps from Landsat TM, ETM+, and Ls8 acquired, in 1988, 2002 and 2015 as representative for the periods of (1988-1998), (1998-2008) and (2008-2018), respectively. The maxi- mum likelihood algorithm of supervised classification applied to classify the basin land-use into seven land-use classes. The SWAT hydrological model with ArcGIS interface setup for the basin to evaluate the flow and sediment load with calibration and validation performance of the model range R 2 (0.71 - 0.89) and NSE (0.57 - 0.87). As a result, the total average annual sediment yield from the sub-basins estimated as 3.59 t/ha/yr, 4.36 t/ha/yr, and 4.89 t/ha/yr for three consecutive decadal periods 1988-1998, 1998-2008, and 2008- 2018 respectively. The increasing trend of sediment yield in the Lake Ziway watershed through one period to another justified as due to land-use. Similarly, the net sediment volume deposited in the lake also showed incremental trained with the land-use changes as 1.5 mcm/yr, 1.81 mcm/yr, and 2.033 mcm/yr for the period of 1988-1998, 1999-2008, and 2009-2018, respectively. The depth and water holding capacity of the lake reduced by 4.3 m and 25.76 mcm, respectively, from the depth and capacity recorded on the 2006 bathy- metric survey, which was the effect of deposited sediment over the last 12 years.

Keywords: Land-Use Changes, Watersheds, Sediment Yield, Lake Depth, Lake Ziway, Ethiopia

Kalsido, T., & Berhanu, B. (2020). Impact of Land-Use Changes on Sediment Load and Capacity Reduction of Lake Ziway, Ethiopia. *Natural Resources*, *11*(11), 530-542.DOI: 10.4236/nr.2020.1111031

Effects of long-term deforestation and remnant forests on rainfall and temperature in the Central Rift Valley of Ethiopia

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Abstract

Background
Some evidence suggests that forests attract rain and that deforestation contributes to changes in rainfall and temperature. The evidence, however, is scant, particularly on smaller spatial scales. The specific objectives of the study were: (i) to evaluate long-term trends in rainfall (1970–2009) and temperature (1981–2009) and their relationships with change in forest cover, and (ii) to assess the influence of remnant forests and topographical factors on the spatial variability of annual rainfall.

Methods: This study investigated the forest-rainfall relationships in the Central Rift Valley of Ethiopia. The study used 16 long-term (1970–2009) and 15 short-term (2012–2013) rainfall and six long term (1981–2009) temperature datasets. Forest and woodland cover decline over the past 40 years (1970–2009) and the measured distances between the remnant forests and rainfall stations were also used. The long-term trends in rainfall (1970–2009) and temperature (1981–2009) were determined using Mann-Kendall (MK) and Regional Kendall (RK) tests and their relationships with long-term deforestation were evaluated using simple linear regression. Influence of remnant forests and topographical variables on the spatial variability of rainfall were determined by stepwise multiple regression method. A continuous forest and woodland cover decline was estimated using exponential interpolation.

Results: The forest and woodland cover declined from 44% in 1973 to less than 15% in 2009 in the Central Rift Valley. Annual rainfall on the valley floor showed an increase by 37.9 mm/decade while annual rainfall on the escarpments/ highlands decreased by 29.8 mm/decade. The remnant forests had a significant effect (P-value <0.05, $R2 = 0.40$) on the spatial variability of the number of rainy days observed over two years (2012–2013), but had little effect on the variability of rainfall distribution. For the total annual rainfall, slope was the best predictor which explained 29% of the rainfall variability in the Central Rift Valley. For the annual number of rainy days, both slope and elevation explained most of the variability (60%) of annual number of rainy days.

Conclusion: This study did not find a significant correlation between long-term rainfall trend and forest and woodland cover decline. The rift valley floor warmed significantly due to long-term deforestation in the Central Rift Valley. Topographic factors play a significant role than forest cover in explaining the spatial variability of annual rainfall in the long-term and short term time scale in the Central Rift Valley. But, the short-term rainfall data indicated that the remnant forest had a significant effect on the spatial variability of the number of rainy days.

Keywords: Deforestation, Elevation, Forest, Rainfall, Slope, Temperature

Muluneh, A., van Loon, E., Bewket, W., Keesstra, S., Stroosnijder, L., & Burka, A. (2017). Effects of long-term deforestation and remnant forests on rainfall and temperature in the Central Rift Valley of Ethiopia. *Forest Ecosystems*, *4*(1), 1-17, DOI 10.1186/s40663-017-0109-8

Identifying sustainability challenges on land and water uses: The case of Lake Ziway watershed, Ethiopia

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Abstract

This paper firstly analyzes the land use - land cover (LULC) in Lake Ziway watershed (Ethiopia) and quantifies the changing patterns from 1973 to 2014 using Landsat images. Secondly, the paper estimates sediment yields using the Soil and Water Assessment Tool (SWAT model). It also assesses and estimates water abstraction from Lake Ziway using survey data. The study shows that the conversions from woodlands into agricultural lands and settlement areas are the major detected LULC changes. Of the total area of the watershed, agricultural lands and settlement areas together increased from 57% in 1973 to 75% in 2014 at the expense of woodlands whose areas decreased from 26.16% to 6.63% in the study periods. The study also shows that water abstraction and sediment loads are increasing at Lake Ziway watershed. The major driving forces behind these LULC changes and the impacts on the lake natural condition are anthropogenic factors such as population growth, land policy changes and deforestation. Increasing demands for more land and water resources, i.e., land for settlements and cultivation, wood for fuel and charcoals, and water for irrigation and municipal water supply, are the underlying causes for the observed changes on the watershed resources. Thus, if the existing scenarios of human pressures are left neglected without management interventions, severe watershed degradations will continue to further affect the watershed's resources including the hydrology. Therefore, responsible government institutions should start mobilizing the local communities along with providing financial and material supports for watershed rehabilitation through afforestation and soil and water conservation activities. Additionally, the free-access practices for water use should be replaced by user-charge policy to regulate water abstractions in order to adequately sustain the water level of Lake Ziway and its feeder rivers. In this respect, this study provides firsthand information to policy makers and planners to put in place a comprehensive land and water use plan and regulations against the unruly human actions in the watershed before irreversible losses might happen to Lake Ziway and its watershed resources.

Keywords: LULC; Watershed; Water abstraction; Human impacts; Sediment yield

Lake Ziway

Desta, H., Lemma, B., & Gebremariam, E. (2017). Identifying sustainability challenges on land and water uses: The case of Lake Ziway watershed, Ethiopia. *Applied Geography*, *88*, 130-143, https://doi.org/10.1016/j.apgeog.2017.09.005

Assessment of Land Use Land Cover Change Drivers and Its Impacts on above Ground Biomass and Regenerations of Woody Plants: A Case Study at Dire Dawa Administration, Ethiopia

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Abstract

Understanding land use land cover (LULC) change drivers at local scale is vital for development of management strategies to tackle further decline of nat- ural resources. In connection to this, a study was conducted in Dire Dawa administration, Ethiopia to investigate the drivers for change in land use land cover and its impact on above ground biomass and regenerations of woody plants. A total of 160 respondents were selected randomly to collect data on drivers of LULC change. A multistage stratified cluster sampling was used for above ground biomass assessment. Nine sample plots of 10 m × 10 m size in each cluster and a total of 36 sample plots in all clusters were randomly estab- lished. In all sample plots, woody plants having >5 cm diameter were measured for their diameter at breast height (DBH), and biomass estimated using allometric equation. The study revealed that, cutting of woody plants for fuel wood and making charcoal, population growth, expansion of cultivated land, drought, settlement areas and livestock ranching are the major six important drivers of LULC change. The study also revealed that, the mean above ground biomass of woody plants in Dire Dawa Administration was 4.94 ton/ha, with maximum and minimum above ground biomass of 6.27 ton/ha and 3.90 ton/ha, respectively. The number of regenerants of tree species was low and only 36% of the plots had tree regenerants. Thus, proper woodland management strategies implementation, land use planning, afforestation and reforesta- tion activities are recommended to minimize unprecedented LULC change in the study area.

Keywords: Land Use Land Cove Change, Drivers, Above Ground Biomass, Regeneration

Milkias, A., & Toru, T. (2018). Assessment of land use land cover change drivers and its impacts on above ground biomass and regenerations of woody plants: A case study at Dire Dawa administration, Ethiopia. *Atmospheric and Climate Sciences*, *8*(01), 111, DOI: 10.4236/acs.2018.81008

Detecting Trends in Landuse and Landcover Change of Nech Sar National Park, Ethiopia

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Abstract

Nech Sar National Park (NSNP) is one of the most important biodiversity centers in Ethiopia. In recent years, a widespread decline of the terrestrial ecosystems has been reported, yet to date there is no comprehensive assessment on degradation across the park. In this study, changes in landcover were analyzed using 30 m spatial resolution Landsat imagery. Interannual variations of normalized difference vegetation index (NDVI) were examined and compared with climatic variables. The result presented seven landcover classes and five of the seven landcover classes (forest, bush/shrubland, wooded grassland, woodland and grassland) were related to natural vegetation and two landcover types (cultivated land and area under encroaching plants) were direct results of anthropogenic alterations of the landscape. The forest, grassland, and wooded grassland are the most threatened habitat types. A considerable area of the grassland has been replaced by encroaching plants, prominently by *Dichrostachys cinerea*, *Acacia mellifera*, *A. nilotica*, *A. oerfota*, and *A. seyal* and is greatly affected by expansion of herbaceous plants, most commonly the species of the family Malvaceae which include *Abutilon anglosomaliae*, *A.bidentatum* and *A.figarianu*. Thus, changes in vegetation of NSNP may be attributed to (i) degradation of existing vegetation through deforestation and (ii) replacement of existing vegetation by encroaching plants. While limited in local meteorological station, NDVI analysis indicated that climate related changes did not have major effects on park vegetation degradation, which suggests anthropogenic impacts as a major driver of observed disturbances.

Fetene, A., Hilker, T., Yeshitela, K., Prasse, R., Cohen, W., & Yang, Z. (2016). Detecting trends in landuse and landcover change of Nech Sar National Park, Ethiopia. Environmental management, 57(1), 137-147.

Land Use/Land Cover Dynamics in the Central Rift Valley Region of Ethiopia: Case of Arsi Negele District

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Abstract

The objective of this research paper was to assess the spatial and temporal Land Use/Land Cover Changes (LU/LCC) in Arsi Negele District. Rapid population growth, agricultural expansion, environmental fluctuations, degradation of natural resource and loss of biodiversity are the most visible socio-economic and environmental problem in the study area. Satellite imagery, ground control point data and household level socioeconomic survey were used to produce land cover maps and explaining the historical trends of the study area. ERDAS Imagine and ArcGIS software was used to accomplish the analysis. The analysis result showed that in 1973 most of the study area had been covered by dense acacia woodland and shrub land. Between 1973 to 1986, cultivated grass and bare land increased by 8.98, 33.9, and 36.5 ha respectively. While, shrub and acacia woodland decreased by 6.17 and 73.21 ha, respectively. Between 1986 and 2010, cultivated acacia woodland and land increased by 15.38, 4.63, and 38.52 ha. However, bare and grass land decreased by 19.23 and 39.3 ha, respectively. Furthermore, the trend and magnitude of LU/LCC between 1973 to 2010 acacia woodland and land decreased by 22.72 and 13.58 ha, but shrub land and cultivated land increased by 22.82 and 13.14 ha. Socio-economic survey result revealed that acacia woodland and shrub land decreased, but cultivated land land and grass land increased in the derg regime. However, currently, natural resource conservation activity has got a great emphasis, thus spatial coverage of acacia woodland has increased. Expansion of agricultural land, population growth and the associated demand for land were the major driving forces for the observed LU/LCC changes in the study area. Therefore, loss of biodiversity, soil degradation, and environmental deterioration are largely the results of LU/LCC. Hence, land resources management practices, utilization of alternative energy sources and family planning education are some of the appropriate interventions to reduce this dramatic change.

Keywords: Remote sensing, GIS, land use/land cover changes (LU/LCC), accuracy, landsat, imagery

Mikias, B. M. (2015). Land use/land cover dynamics in the central rift valley region of Ethiopia: Case of Arsi Negele District. *African Journal of Agricultural Research*, *10*(5), 434-449, DOI: 10.5897/AJAR2014.8728

Model-Based Characterization and Monitoring of Runoff and Soil Erosion in Response to Land Use/land Cover Changes in the Modjo Watershed, Ethiopia

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Abstract

The Modjo watershed has experienced significant land use/land cover (LULC) change and soil erosion. This study examines changes in surface runoff generation and soil erosion in response to the LULC dynamics. To simulate runoff and sediment yield, the geographic information system-interfaced Soil and Water Assessment Tool (SWAT) model was used. Model sensitivity, calibration and validation analyses were carried out, and the efficiency of the model was evaluated using simulated and measured discharge data. The two scenario model simulation goodness-of-fit measures verified that the SWAT model performed very well during calibration and validation periods for daily and monthly time steps (Nash–Sutcliffe efficiency $> 0{\cdot}79$ and root mean square error–observation standard deviation ratio $< 0{\cdot}4$). Although the computed values of per cent bias fulfilled a satisfactory standard (greater than $-11{\cdot}8\%$), the model results tended to overestimate discharge. Consequent to the LULC change, an overall increase in the amount of surface runoff (14·2%) and sediment yield (37%) was observed relative to the baseline (1973) simulation scenario. Mean annual soil loss rate was estimated at $24{\cdot}2\ \mathrm{Mg\,ha^{-1}\,y^{-1}}$. Nearly 95·2% of the watershed is experiencing moderate to severe soil loss rates ranging from 14·7 to $37{\cdot}5\ \mathrm{Mg\,ha^{-1}\,y^{-1}}$. In the remaining parts of the watershed, soil loss rates range from 4·4 to $14{\cdot}7\ \mathrm{Mg\,ha^{-1}\,y^{-1}}$. Surface runoff generation and soil erosion varied widely by soil, LULC types and slope positions. The observed environmental change would lead to further land degradation, with negative implications on the livelihoods of local people unless appropriate conservation measures are implemented.

Gessesse, B., Bewket, W., & Bräuning, A. (2015). Model-based characterization and monitoring of runoff and soil erosion in response to land use/land cover changes in the Modjo watershed, Ethiopia. *Land degradation & development*, *26*(7), 711-724, https://doi.org/10.1002/ldr.2276.

Soil erosion risk assessment in the Chaleleka wetland watershed, Central Rift Valley of Ethiopia

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Abstract

Background: Increased flooding and newly formed rills and gullies were observed in the Cheleleka wetland watershed, over the past three to five years. These events are due to problems related to land use changes and are adversely affecting land productivity. This study was conducted to quantify, analyze and map soil erosion risk areas using the Revised Universal Soil Loss Equation.

Results: Only 13.6 percent of the study area has a soil loss value less than 10 ton per hectare per year with the remaining area experiencing a higher soil loss value. A large area, 53.6 percent of the watershed, is under severe to extremely severe soil loss (>45 ton per hectare per year). Another 17.3 percent of the study area has annual soil loss of 20–45 ton per hectare.

Conclusion: A significantly large area of the Cheleleka wetland watershed has non-tolerable soil erosion that threatens annual crop production, land productivity, and hydrological functioning of the area. From the conservation perspective, a large proportion of the watershed needs immediate watershed management intervention.

Keywords: Conservation priority; Land use change; Topography; Soil erosion

Wolka, K., Tadesse, H., Garedew, E., & Yimer, F. (2015). Soil erosion risk assessment in the Chaleleka wetland watershed, Central Rift Valley of Ethiopia. *Environmental Systems Research*, *4*(1), 1-12.DOI 10.1186/s40068-015-0030-5

Susceptibility of soil to wind erosion in arid area of the Central Rift Valley of Ethiopia

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Abstract

Background
In Central Rift Valley (CRV) of Ethiopia, renewable land resources are under pressure. Acacia woodland clearance, frequent cultivation, crop residue removal and mono-cropping are among the major land mis-management practices in the area. This has largely been affecting the soil quality. The current study is aimed at assessing the impact of Acacia woodland conversion, and the subsequent mis-managements on selected soil physical properties, and their relation to the prevailing wind erosion in the area. For this study, four land use/land cover types, namely protected woodland (PWL), managed pastureland (MPL), parkland agroforestry (PAF) and treeless cropland (TLCL) were considered.

Results: Higher ($P < 0.001$) macro-aggregates (>0.25 mm) fraction of soil was found under PWL and MPL while higher fraction of micro-aggregates (0.053–0.25 mm) of soil was found under PAF and TLCL. Soil under PAF and TLCL had higher ($P < 0.001$) proportion of aggregates of < 1 mm, implying potential susceptibility of the soil to wind erosion. Higher soil bulk density (BD) was found in the most top layer (0–15 cm) of TLCL and PAF, and this could be attributed to the trampling effect by animals freely released to these land use types.

Conclusion: In the study area, conversion of native woodland to PAF and TLCL and the subsequent mismanagements negatively affected some soil physical properties, thereby enhancing severity of soil erosion by wind. In contrast, although not commonly practiced by smallholder farmers, soil under MPL is more stable and less susceptible to wind erosion.

Keywords: Andosols; Dry aggregation stability; Land degradation; Crop residue removal

Biyensa, G., Demissie, A., & Lemma, B. (2015). Susceptibility of soil to wind erosion in arid area of the Central Rift Valley of Ethiopia. *Environmental Systems Research, 4*(1), 1-9.

Impact of the productive safety net program on farmers' investments in sustainable land management in the Central Rift Valley of Ethiopia

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Abstract

This study assesses the impact of the Productive Safety Net Program (PSNP) on farmers' investments in sustainable land management (SLM) practices in the Central Rift Valley (CRV) of Ethiopia. Primary data were collected using a structured and pre-tested questionnaire for a sample of 159 households (82 PSNP participants and 77 non-participants) in four kebeles (the lowest administrative unit in Ethiopia) of two weredas (districts). Using a cross-sectional household survey, propensity score matching (PSM) was used to assess the impact of PSNP on households' investments in soil erosion control and soil fertility management. The PSM results show that the *control* group of households (non-participants in PSNP) invested more in soil erosion control measures as compared to the *treated* group of households (participants in PSNP). On the contrary, however, the *treated* group of households significantly invested more in soil fertility management practices (e.g. inorganic fertilizer and compost) as compared to the *control* group of households. The negative impact of PSNP on households' investments in soil erosion control in the treated group of farmers is related to their high labor investment in public works, which is not the case for the non-participants in PSNP. This implies that PSNP should pay more attention to capacity building and awareness raising, which requires a restructuring of the program that would benefit long-term and more sustainable impact on reducing food insecurity and enhancing natural resources in the CRV of Ethiopia.

Adimassu, Z., & Kessler, A. (2015). Impact of the productive safety net program on farmers' investments in sustainable land management in the Central Rift Valley of Ethiopia. *Environmental Development*, *16*, 54-62, https://doi.org/10.1016/j.envdev.2015.06.015

Soil property variations in relation to exclosure and open grazing land use types in the Central Rift Valley area of Ethiopia

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Background

Land degradation and unsustainable management practices have resulted in soil organic carbon and nutrient depletion, hydrological instability, reduced primary productivity, and low biological diversity. In response to these problems, communities in the Central Rift Valley area of Ethiopia have started to establish exclosures about three decades ago. This study has investigated the variations in selected soil properties (soil textural fractions, bulk density, soil moisture content, pH (H_2O) and soil organic carbon content) under two land use types: open grazing land and exclosures in the Central Rift Valley of Ethiopia.

Results

Results showed that soil organic carbon varied significantly with land use types ($p = 0.040$), soil depths ($p = 0.010$) and the interaction effect ($p = 0.039$). The soil moisture content showed significant variation ($p < 0.0001$) only with soil depth.

Conclusion

Exclosure land use type has shown an improvement in soil organic carbon against the findings by Mekuria et al. [International Conference on Advances in Agricultural, Biological & Environmental Sciences (AABES-2014), Dubai (UAE) 2014]. Thus, highly degraded open grazing should be designated as exclosure land management zone to restore and rehabilitate severely degraded landscape in the fragile environment of the rift valley area of Ethiopia.

Keywords: Land use, Exclosure, Grazing land, Soil physical properties, Soil chemical properties, Ethiopia

Yimer, F., Alemu, G., & Abdelkadir, A. (2015). Soil property variations in relation to exclosure and open grazing land use types in the Central Rift Valley area of Ethiopia. *Environmental Systems Research*, *4*(1), 1-10, DOI 10.1186/s40068-015-0041-2.

Characterization of Water Level Variability of the Main Ethiopian Rift Valley Lakes

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Abstract

In this paper, the water level fluctuations of eight Ethiopian Rift Valley lakes were analyzed for their hydrological stability in terms of water level dynamics and their controlling factors. Long-term water balances and morphological nature of the lakes were used as bases for the analyses. Pettit's homogeneity test and Mann–Kendall trend analysis were applied to test temporal variations of the lake levels. It is found that the hydrological stability of most of the Ethiopian Rift Valley lakes is sensitive to climate variability. In terms of monotonic trends, Lake Ziway, Hawassa, Abaya and Beseka experienced significant increasing trend, while Ziway, Langano and Chamo do not. In addition, homogeneity test revealed that Lake Hawassa and Abaya showed significant upward shift around 1991/1992, which was likely caused by climate anomalies such as the El Niño / Southern Oscillation (ENSO) phenomena. Lake Abiyata is depicted by its significant decreasing monotonic trend and downward regime shift around 1984/1985, which is likely related to the extended water abstraction for industrial consumption.

Keywords*:* Ethiopian Rift valley lakes; water level fluctuation; climate variability

Belete, M. D., Diekkrüger, B., & Roehrig, J. (2015). Characterization of water level variability of the main Ethiopian rift valley lakes. *Hydrology*, *3*(1), 1, https://doi.org/10.3390/hydrology3010001.

Indigenous claims and conflicts in managing the Abijata-Shalla Lakes National Park, Ethiopia Fekadu Teferra & Fekadu Beyene

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Abstract

This paper examines claims and conflicts in the management of the Abijata-Shalla Lakes National Park in the Central Rift Valley of Ethiopia. We used data from households, key informants (elders, park managers), and focus group discussions. Poor wildlife policy resulting in space competition between wildlife and humans (other forms of land use), limited means of revenue generation for insiders and centralized benefits from tourism have accumulated grievance and then conflict between national park authority and local communities. Contested land tenure and overlapping claims generated by ill-defined property rights, as interrelated factors, sustained the conflicts. Weak information sharing, rising demographic pressure and conservation policies, giving more priority to global and national than local interests, contributed to the conflict. The result implies that efforts in revitalizing customary authorities and institutions and introducing a co-management strategy canimmensely provide an avenue to manage conflicts between communities and park managers.

Keywords: conflict; national park; customary institutions; co-management; claims

Teferra, F., & Beyene, F. (2014). Indigenous claims and conflicts in managing the Abijata-Shalla lakes National Park, Ethiopia. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *10*(3), 216-227, DOI:10.1080/21513732.2014.942372.

Land Use-Land Cover dynamics of *Huluka* watershed, Central Rift Valley, Ethiopia

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Abstract

Land Use-Land Cover (LULC) dynamic has of human kind age and is one of the phenomenons which interweave the socio economic and environmental issues in Ethiopia. *Huluka* watershed is one of the watersheds in Central Rift Valley of Ethiopia which drains to Lake Langano. Few decades ago the stated watershed was covered with dense acacia forest. But, nowadays like other part of Ethiopia, it is experiencing complex dynamics of LULC. The aim of this research was thus to evaluate the LULC dynamics seen in between 1973–2009. This was achieved through collecting qualitative and quantitative data using Geographic Information System (GIS) and Remote Sensing (RS) technique. Field observations, discussion with elders were also employed to validate results from remotely sensed data. Based on the result, eight major dynamic LULC classes were identified from the watershed. Of these LULC classes, only cultivated and open lands had shown continuous and progressive expansion mainly at the expense of grass, shrub and forest lands. The 25% and 0% of cultivated and open land of the watershed in 1973 expanded to 84% and 4% in 2009 respectively while the 29%, 18% and 22% of grass, shrub and forest land of the watershed in 1973 degraded to 3.5%, 4% and 1.5% in 2009 respectively. As a result, land units which had been used for pastoralist before 1973 were identified under mixed agricultural system after 2000. In the end, this study came with a recommendation of an intervention of concerned body to stop the rapid degradation of vegetation on the watershed.

Keywords: GIS; RS; Land use; Land cover

Gebreslassie, H. (2014). Land use-land cover dynamics of Huluka watershed, Central Rift Valley, Ethiopia. *International Soil and Water Conservation Research*, *2*(4), 25-33, https://doi.org/10.1016/S2095-6339(15)30055-1

Disentangling the impacts of climate change, land use change and irrigation on the Central Rift Valley water system of Ethiopia

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Abstract

The Central Rift Valley (CRV) of Ethiopia is a closed basin where claims on land and water have strongly increased over the past decade resulting in over-exploitation of the resources: a clear symptom is the declining trend in the water level of the terminal Lake Abyata. In this paper, we quantify the plausible recent impacts of climate change, land use change and irrigation water abstraction on water availability of Lake Abyata. We examined trends in lake levels, river discharges, basin rainfall, temperature and irrigation development (ca. 1975–2008), and computed the additional evapotranspiration loss resulting from temperature change and irrigated land. We also analysed land use change (1990–2007) and estimated the subsequent change in surface runoff. Temperature has increased linearly over 34 years ($p < 0.001$) whereas rainfall has not changed significantly. Consequently, increased evapotranspiration consumed 62 and 145 Mm^3 of additional water from lakes and land surface, respectively, during 1990–2007. Furthermore, an estimated 285 $Mm^3\ yr^{-1}$ of water was abstracted for irrigation in 2009 of which approximately 170 $Mm^3\ yr^{-1}$ is irrecoverable evapotranspiration loss. In addition, surface runoff has increased in the upper, and decreased in lower sub-basins of the CRV associated with extensive land use change (1990–2007). However, insight in the impact of the net increase in runoff of 260 $Mm^3\ yr^{-1}$ on the water availability for Lake Abyata remains partial because of data and methodological limitations. We conclude that the potential for agricultural intensification and its hydrological implications should be considered jointly to prevent further deteriorating Lake Abyata.

Getnet, M., Hengsdijk, H., & van Ittersum, M. (2014). Disentangling the impacts of climate change, land use change and irrigation on the Central Rift Valley water system of Ethiopia. *Agricultural Water Management, 137*, 104-115, https://doi.org/10.1016/j.agwat.2014.02.014

Impact of Land Cover Change on Water Quality and Stream Flow in Lake Hawassa Watershed of Ethiopia

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Abstract

Quantifying the hydrologic response of land use/land cover change (LULCC) is of paramount importance to improve land management. This study was carried out to analyze the effect of LULCC on water quality and quantity. LULCC of the watershed in 1986, 1999 and 2011 was analyzed from Landsat satellite images using supervised classification. Time series and point data were collected from the upper and lower sections of Wedesa, Wesha and Hallo Rivers. Water quality parameters (turbidity, suspended solid (SS), total dissolved solid (TDS), pH, electric conductivity (EC), total organic carbon (TOC), ammonia, nitrate and phosphate) were analyzed in the laboratory. A considerable decline in forest and an increase in woodland were observed in the watershed during the indicated periods. Turbidity, SS, TDS and EC were significantly higher ($P < 0.05$) in the lower section of the rivers compared to the upper ones. Ammonia, nitrate and phosphate were higher in the lower section of some rivers compared to the upper ones. In general, water quality in the upper watershed of the three rivers was better than the lower one with respect to considered parameters, which might be related to the observed LULCC. Most water quality parameters varied ($P < 0.05$) seasonally in both the upper and lower sections of the rivers. Despite the irregular rainfall pattern and increased water consumption from the catchment, the annual discharge of the Tikur-Wuha River to Lake Hawassa shows an increasing trend. We concluded that the discharge is not only related to the upstream LULCC but also to the management of the Cheleleka wetland. However, further investigation is required to determine the dominant factors affecting inflow discharge to Lake Hawassa.

Keywords: Discharge; Ethiopia; Lake Hawassa; Water Quality; Wetland

Kebede, W., Tefera, M., Habitamu, T., & Alemayehu, T. (2014). Impact of land cover change on water quality and stream flow in lake Hawassa watershed of Ethiopia. *Agricultural Sciences*, *2014*.http://dx.doi.org/10.4236/as.2014.58068

Land use, land cover and climate change impacts on the bird community in and around Lake Zeway, Ethiopia

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Abstract

This study aimed to show impacts of land use and land cover change (LULCC) and climate on waterbird community structure of Lake Zeway and the surrounding areas. Purposive sampling techniques were used to collect primary data. Based on the purposive sampling techniques, 12 key informants and 12 focus group discussants were selected. A semi-structured questionnaire prepared in English and translated into Afan Oromo was used to interview the focus groups. The key informants participated in the interview under close inspection of the researcher. Field observations and literatures searches were also carried out on the impacts of LULCC, climate changes, lake hydrodynamics and biodiversity. Most (92%) of the discussants indicated decreases in the level and width of Lake Zeway during the last 3-4 decades. The lake water withdrawal for irrigated agricultural activities in the surrounding areas was themain reason for decreases. Eleven groups (92%) reported temperature increases and lower and unpredictable rainfall patterns as cause for the decreases. These changes reportedly resulted in decreased waterbird species diversity and abundance and changed distribution patterns across the lake and the surrounding areas. The FGD identified fish production and irrigated farm and bird habitat as the three most important values of the lake. The discussants also reported the combination of land- use and climate, or climate changes, as important drivers that altered the lake water level, wetland habitats and bird community structure. Urgent conservation measures that could reduce the impacts are needed to conserve the bird species at the lake.

Keywords: Bird community; climate; changes; impacts; irrigated agriculture; land use

Girma, M., Afweork, B., Gail, F., & Yosef, M. (2014). Land use, land cover and climate change impacts on the bird community in and around Lake Zeway, Ethiopia. *International Journal of Biodiversity and Conservation*, *6*(3), 256-270, DOI: 10.5897/IJBC2013.0635

GIS based mapping of land cover changes utilizing multi-temporal remotely sensed image data in Lake Hawassa Watershed, Ethiopia

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Abstract

Classifying multi-temporal image data to produce thematic maps and quantify land cover changes is one of the most common applications of remote sensing. Mapping land cover changes at the regional level is essential for a wide range of applications including land use planning, decision making, land cover database generation, and as a source of information for sustainable management of natural resources. Land cover changes in Lake Hawassa Watershed, Southern Ethiopia, were investigated using Landsat MSS image data of 1973, and Landsat TM images of 1985, 1995, and 2011, covering a period of nearly four decades. Each image was partitioned in a GIS environment, and classified using an unsupervised algorithm followed by a supervised classification method. A hybrid approach was employed in order to reduce spectral confusion due to high variability of land cover. Classification of satellite image data was performed integrating field data, aerial photographs, topographical maps, medium resolution satellite image (SPOT 20 m), and visual image interpretation. The image data were classified into nine land cover types: water, built-up, cropland, woody vegetation, forest, grassland, swamp, bare land, and scrub. The overall accuracy of the LULC maps ranged from 82.5 to 85.0 %. The achieved accuracies were reasonable, and the observed classification errors were attributable to coarse spatial resolution and pixels containing a mixture of cover types. Land cover change statistics were extracted and tabulated using the ERDAS Imagine software. The results indicated an increase in built-up area, cropland, and bare land areas, and a reduction in the six other land cover classes. Predominant land cover is cropland changing from 43.6 % in 1973 to 56.4 % in 2011. A significant portion of land cover was converted into cropland. Woody vegetation and forest cover which occupied 21.0 and 10.3 % in 1973, respectively, diminished to 13.6 and 5.6 % in 2011. The change in water body was very peculiar in that the area of Lake Hawassa increased from 91.9 km^2 in 1973 to 95.2 km^2 in 2011, while that of Lake Cheleleka whose area was 11.3 km^2 in 1973 totally vanished in 2011 and transformed into mud-flat and grass dominated swamp. The “change and no change” analysis revealed that more than one third (548.0 km^2) of the total area was exposed to change between 1973 and 2011. This study was useful in identifying the major land cover changes, and the analysis pursued provided a valuable insight into the ongoing changes in the area under investigation.

Wondrade, N., Dick, Ø. B., & Tveite, H. (2014). GIS based mapping of land cover changes utilizing multi-temporal remotely sensed image data in Lake Hawassa Watershed, Ethiopia. *Environmental monitoring and assessment*, *186*(3), 1765-1780.

Ecological succession and land use changes in a lake retreat area (Main Ethiopian Rift Valley)

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Abstract

In the semi-arid Main Ethiopian Rift Valley, ecological succession is related to continuous lake retreat. Human activity, through its impact on land use and cover, affects this ecological succession at various degrees. Through a remote sensing study, we explored how the drivers for land use and cover changes (LUCC) have changed over the last decades and which impact this has on ecological succession. Remote sensing data used include a Landsat MSS from 1973, a Landsat TM from 1986 and Landsat ETM+ from 2000; a conventional type of classification was used whereby supervised classification of the 2000 image was supplemented by unsupervised classification of the older images. Due to decreased rainfall and water abstraction for intense irrigated agriculture in its catchment, Lake Abijata lost 46% of its area between 2000 and 2006. On the emerged land, an ecological succession was observed along the environmental gradient of the retreating lake: emerged bare land, grassland, land with few scattered Acacia shrubs and open woodlands. Between 1986 and 2000, LUCC tendencies were totally reversed and woody vegetation decreased strongly, indicating increased human impact. This land degradation took place in a context of instable political situation, fuelwood extraction, higher population density and better communications.

Keywords: Deforestation; Ethiopia; Lake Abijata; Lake retreat; Landsat imagery Remote sensing; Successional trend

Temesgen, H., Nyssen, J., Zenebe, A., Haregeweyn, N., Kindu, M., Lemenih, M., & Haile, M. (2013). Ecological succession and land use changes in a lake retreat area (Main Ethiopian Rift Valley). *Journal of Arid Environments*, *91*, 53-60, https://doi.org/10.1016/j.jaridenv.2012.12.001.

Drought vulnerability drives land-use and land cover changes in the Rift Valley dry lands of Ethiopia

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Abstract

The Ethiopian Rift Valley is a dry land zone where for a long time pastoral communities have made their living from acacia-based woodlands. But many pastoralists have changed from a pastoral way of life to mixed farming over time. The aim of this study was to evaluate land-use and land cover (LULC) changes in the Central Rift Valley dry lands of Ethiopia, and determine the role of drought vulnerability as a driver. A combination of GIS/remote sensing techniques, drought vulnerability analyses, field observation and surveying were employed. Because drought vulnerability is linked more closely to the types of land-uses and social contexts rather than only climatological events, it was examined based on locally perceived criteria of drought. Accordingly, the pastoral way of life was vulnerable to severe drought during 25% of the last 28 years while the mixed farming (livestock and maize farming combined) system was vulnerable to severe drought only during 4% of the years. Over the last 5 decades, cultivated lands increased to threefold while the dense acacia coverage declined from 42% in 1965 to 9% in 2010. The observed LULC changes were driven by the interplay of recurrent drought, socioeconomic and institutional dynamics, access to markets and improved technologies such as early-maturing maize cultivars and better land management. Proper policy and technological interventions are required to develop appropriate drought adaptation strategies and avert the increasing degradation of woodlands in the Rift Valley dry lands where a pastoral way of life is still present.

Keywords: Drought; Dry spell; Land-use change; Land management; Rift Valley

Biazin, B., & Sterk, G. (2013). Drought vulnerability drives land-use and land cover changes in the Rift Valley dry lands of Ethiopia. *Agriculture, ecosystems & environment*, *164*, 100-113, https://doi.org/10.1016/j.agee.2012.09.012

Farmers' Perceptions of Land Degradation and Their Investments in Land Management: A Case Study in the Central Rift Valley of Ethiopia

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Abstract

To combat land degradation in the Central Rift Valley (CRV) of Ethiopia, farmers are of crucial importance. If farmers perceive land degradation as a problem, the chance that they invest in land management measures will be enhanced. This study presents farmers' perceptions of land degradation and their investments in land management, and to what extent the latter are influenced by these perceptions. Water erosion and fertility depletion are taken as main indicators of land degradation, and the results show that farmers perceive an increase in both indicators over the last decade. They are aware of it and consider it as a problem. Nevertheless, farmers' investments to control water erosion and soil fertility depletion are very limited in the CRV. Results also show that farmers' awareness of both water erosion and soil fertility decline as a problem is not significantly associated with their investments in land management. Hence, even farmers who perceive land degradation on their fields and are concerned about its increase over the last decade do not significantly invest more in water erosion and soil fertility control measures than farmers who do not perceive these phenomena. Further research is needed to assess which other factors might influence farmers' investments in land management, especially factors related to socioeconomic characteristics of farm households and plot characteristics which were not addressed by this study.

Adimassu, Z., Kessler, A., Yirga, C., & Stroosnijder, L. (2013). Farmers' perceptions of land degradation and their investments in land management: A case study in the central rift valley of Ethiopia. Environmental Management, 51(5), 989-998.

Analysing decadal land use/cover dynamics of the Lake Basaka catchment (Main Ethiopian Rift) using LANDSAT imagery and GIS

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Abstract

Development of accurate classification methods for rapidly changing catchments like that of Lake Basaka is fundamental to better understanding the catchment dynamics, which were not addressed in previous studies. Thus, the aim of this study was to map the decadal land use/cover (LUC) regimes of the Lake Basaka catchment, utilizing time series of LANDSAT images and to analyse the changes that occurred at different time periods. Both unsupervised and supervised image classification systems were utilized in Earth Resources Data Analysis System (ERDAS) Imagine (9.1). Appropriate pre- and postprocessing also was utilized. Seven major LUC classes were identified in the final land cover maps produced after the supervised (maximum likelihood) classification exercise. The analysis results indicated the Lake Basaka catchment had experienced a drastic change in its LUC conditions over the last 4–5 decades because of rapid increases in human settlement, deforestation, establishment of irrigation schemes and Awash National Park (ANP). Approximately 18 924 ha of forest and 4730 ha of grazing lands were devastated between 1973 and 2008. At the same time, there was a shift in land cover from forests/woodlands to open woodlands, shrub and grazing lands. The land cover classifications generally were achieved at a very high overall accuracy (84.34%) and overall kappa statistics (0.802), substantiating the value of using the classified LUC in this study as an input to hydrological models. This study results provide an opportunity to better understand and quantify the hydrological response regimes of the lake catchment from the perspective of changing LUC conditions during different hydrological periods and the resulting dynamics of the lake water balance.

Dinka, M. O. (2012). Analysing decadal land use/cover dynamics of the Lake Basaka catchment (Main Ethiopian Rift) using LANDSAT imagery and GIS. *Lakes & Reservoirs: Research & Management*, *17*(1), 11-24, https://doi.org/10.1111/j.1440-1770.2012.00493.x

Exploring determinants of farmers' investments in land management in the Central Rift Valley of Ethiopia

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Abstract

Land degradation, especially water erosion and nutrient depletion, seriously affects agricultural production in the Central Rift Valley of Ethiopia. Farmers' investments to conserve their land are until now however quite limited. The objective of this study is to identify the major factors that determine farmers' decisions *how much* and *where* to invest in land management. Exploratory factor analysis and Pearson correlation were used to analyse the data from 240 households operating 738 plots in three different production domains. The study identified five major factors that influence farmers' decisions *how much* to invest in land management: *(1) households' resource endowments, (2) farming experience and knowledge, (3) access to information, (4) social capital and (5) availability of family labour*. This result implies that extension strategies aiming at sustainable land management should try to enhance households' resources endowments and improve their access to information. Moreover, the influence of social capital and availability of family labour indicates the crucial importance of collective action in land management. Similarly, the study revealed that farmers are more willing to invest in plots that (1) are vulnerable to water erosion, (2) have better soil fertility and (3) are larger. However, the influence of these factors on farmers' investments in land management was highly variable across the considered production domains. Hence, the diversity in social, economic, cultural and biophysical conditions must be taken into account by rural extension programmes. This calls for site-specific land management strategies that can be planned and implemented at micro-level with active participation of farmers.

Keywords: Ethiopia; Factor analysis; Farmers' investments; Sustainable land; management; Extension strategies

Adimassu, Z., Kessler, A., & Hengsdijk, H. (2012). Exploring determinants of farmers' investments in land management in the Central Rift Valley of Ethiopia. *Applied Geography*, *35*(1-2), 191-198, https://doi.org/10.1016/j.apgeog.2012.07.004

Investigation of non-stationarity in hydro-climatic variables at Rift Valley lakes basin of Ethiopia

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Summary

Streamflow, lake level and rainfall data acquired from 11 monitoring stations and 21 grid points at Rift Valley lakes basin of Ethiopia have been analyzed to evaluate short and long term dependence using parametric and non-parametric tests. Temporal variation in land use/cover has also been analyzed to investigate its effect on streamflow. Summer rainfall at Alaba Kulito and Bilate Farm show decreasing trend at 10% significance level. All other events of observed and gridded rainfall and total number of rainy days exhibit insignificant trends. Streamflow and lake level exhibit significant increasing trend for more than three-quarter of events investigated. Extreme wet years are marked with increased positive Sea Surface Temperature (SST) anomalies whereas extreme dry years are characterized by negative SST anomalies. Even though there are such apparent associations between extreme rainfall magnitudes and SST, the frequency of above average total rainfall years to occur is relatively less during the analysis window. The observed trend in streamflow, lake level and rainfall is attributed to the combined effect of global climatic change and variability on local climate and altered catchment condition over the years. Thus, simultaneous analysis of catchment dynamics and hydro-climatic variables using multiple time series models to detect non-stationarity eliminate potential bias of ruling out the effect of catchment dynamics.

Keywords: Non-stationarity; Trend; Streamflow; Lake level; Rainfall; Land use/cover dynamics

Wagesho, N., Goel, N. K., & Jain, M. K. (2012). Investigation of non-stationarity in hydro-climatic variables at Rift Valley lakes basin of Ethiopia. *Journal of Hydrology*, *444*, 113-133, https://doi.org/10.1016/j.jhydrol.2012.04.011.

Dynamics and hotspots of soil erosion and management scenarios of the Central Rift Valley of Ethiopia

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Abstract

Most of the lowland in the central rift valley of Ethiopia is arid or semiarid and in degradation, with frequent occurrence of droughts. Soil erosion by water during the rainy season is a serious problem in the region, leading to declining agricultural production, decreased food security, and a sedimentation risk for water bodies. However, there has been no systematic study of this problem or of possible management solutions. To meet this need, we analyzed soil erosion rates from 1973 to 2006, identified erosion hotspots, and proposed possible soil conservation scenarios. We assessed the soil loss dynamicity using the universal soil-loss equation and geographical information system software, considering the land use change at the following three periods: 1973, 1985 and 2006. We characterized the watershed in terms of the erosion severity, topography, and land use to identify hotspots and proposed, modeled, and evaluated various watershed management scenarios to mitigate the problem. Soil erosion increased markedly from 1973 to 2006, with annual rates of 31, 38, and 56 t ha^{-1} in 1973, 1985, and 2006, respectively, as a result of vegetation degradation and particularly the conversion of thousands of hectares of forest or woodland into cropland. The observed soil erosion rates are far from the tolerable rate of soil loss of the country and hence require urgent soil conservation interventions, especially in the hotspot areas. We proposed eight scenarios for reducing soil losses and evaluated their effectiveness. Rehabilitating degraded land (using exclosures and planted vegetation) and installing stone erosion-control structures (stone bund) in cropland reduced the total soil loss by 12.6% and 63.8%, respectively. Treating hotspot areas with annual soil loss of more than 20 t ha^{-1} by integrated management (erosion-control structures and exclosures) was the most effective approach, reducing soil loss by 87.8%.

Keywords: Environmental rehabilitation; Ethiopia; Land degradation; Soil conservation; Soil erosion; USLE model

Meshesha, D. T., Tsunekawa, A., Tsubo, M., & Haregeweyn, N. (2012). Dynamics and hotspots of soil erosion and management scenarios of the Central Rift Valley of Ethiopia. *International Journal of Sediment Research, 27*(1), 84-99, https://doi.org/10.1016/S1001-6279(12)60018-3.

Environmental factors associated with larval habitats of anopheline mosquitoes (Diptera: Culicidae) in irrigation and major drainage areas in the middle course of the Rift Valley, central Ethiopia

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Abstract

Background & objectives:

Larval control is an integral part of malaria vector management in Ethiopia and elsewhere. For effective larval control, a sound understanding of the factors responsible for spatio-temporal variation in larval production is essential. A study was thus conducted to characterize larval habitats of anopheline mosquitoes in irrigation and major drainage areas between Adami Tulu and Meki towns, in the middle course of the Ethiopian Rift Valley.

Methods: Aquatic habitats were sampled for anopheline larvae and the associated environmental variables (water temperature, turbidity, water current, water pH and other variables) were measured, characterized and analyzed.

Results: Microscopic identification of the late instars (III and IV) of anopheline larvae collected throughout the study period yielded nearly 47.6% Anopheles pharoensis, 32.1% An. arabiensis, 17.1% An. squamosus and only 3.2% of other species (An. coustani and An. cinereus). Larvae of the local malaria vectors, An. arabiensis and . pharoensis were most abundantly sampled from sand pools and natural swamps, respectively. Logistic regression analysis detected four best predictor variables associated with larval abundance of malaria vector species. Thus, relative abundance of An. arabiensis larvae was significantly and inversely associated with aquatic vegetation and water current, whereas the relative abundance of An. Pharoensis larvae was significantly and positively associated with water temperature and the presence of algae in the water bodies.

Conclusion: Dry season anopheline larval habitats such as riverine sand pools that are created and maintained by perennial water bodies and their associated water development projects need to be considered in vector control operations.

Keywords: Anophelines; Ethiopia; irrigation and drainage; larval habitats

Kenea, O., Balkew, M., & Gebre-Michael, T. (2011). Environmental factors associated with larval habitats of anopheline mosquitoes (Diptera: Culicidae) in irrigation and major drainage areas in the middle course of the Rift Valley, central Ethiopia. *Journal of Vector Borne Diseases*, *48*(2), 85.

A Dynamic Simulation Model of Land-Use, Population, and Rural Livelihoods in the Central Rift Valley of Ethiopia

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Abstract

The dynamic interactions between society and land resources have to be taken into account when planning and managing natural resources. A computer model, using STELLA software, was developed through active participation of purposively selected farm households from different wealth groups, age groups and gender within a rural community and some members of Kebelle council. The aim of the modeling was to study the perceived changes in land-use, population and livelihoods over the next 30 years and to improve our understanding of the interactions among them. The modeling output is characterized by rapid population growth, declining farm size and household incomes, deteriorating woody vegetation cover and worsening land degradation if current conditions remain. However, through integrated intervention strategies (including forest increase, micro-finance, family planning, health and education) the woody vegetation cover is likely to increase in the landscape, population growth is likely to slow down and households' income is likely to improve. A validation assessment of the simulation model based on historical data on land-use and population from 1973 to 2006 showed that the model is relatively robust. We conclude that as a supporting tool, the simulation model can contribute to the decision making process.

Garedew, E., Sandewall, M., & Soderberg, U. (2012). A dynamic simulation model of land-use, population, and rural livelihoods in the Central Rift Valley of Ethiopia. *Environmental Management, 49*(1), 151-162.

Soil water property variations in three adjacent land use types in the Rift Valley area of Ethiopia

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Abstract

This study investigated the effects of land use change on infiltration and moisture content of soils in three land use types. A total of 81 soil and core samples (3 replications × 3 treatments × 3 profiles × 3 soil depths) were used to determine parameters that may affect the infiltration properties of soils. The infiltration rate was measured in the field using double-ring infiltrometer with three replicates in each land use type. Results showed that infiltration rates were generally slow in the open grazed and cultivated lands suggesting high potential for runoff, limited percolation, and very low amount of water available in the soil profiles. The accumulated infiltration in soils under cultivation and open-grazing was smaller than the controlled grazing by approximately 57%. Similarly, cultivation and open-grazing had reduced the soil moisture content by 29 and 33%, respectively, compared to the controlled grazing. Surface soil compaction, higher dry bulk density and lower soil organic carbon, appeared to be the principal factors for the low infiltration capacity and moisture content of the soils. Therefore, dry land management, with long term tree cover and well regulated grazing system, is very crucial for the sustainable ecosystem functioning of this environmentally fragile area.

Keywords: Infiltration capacity; Deforestation; Land conversion; Semi-arid; Soil properties; Abernosa

Abdelkadir, A., & Yimer, F. (2011). Soil water property variations in three adjacent land use types in the Rift Valley area of Ethiopia. *Journal of Arid Environments*, *75*(11), 1067-1071.https://doi.org/10.1016/j.jaridenv.2011.06.012

Analysis of the hydrological response of a tropical terminal lake, Lake Abiyata (Main Ethiopian Rift Valley) to changes in climate and human activities

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Abstract

Integrated dynamic water and chloride balance models with a catchment-scale hydrological model (PRMS) are used to investigate the response of a terminal tropical lake, Lake Abiyata, to climate variability and water use practices in its catchment. The hydrological model is used to investigate the response of the catchment to different climate and land-use change scenarios that are incorporated into the lake model. Lake depth–area–volume relationships were established from lake bathymetries. Missing data in the time series were filled using statistical regression techniques. Based on mean monthly data, the lake water balance model produced a good agreement between the simulated and observed levels of Lake Abiyata for the period 1968–83. From 1984 onwards the simulated lake level is overestimated with respect to the observed one, while the chloride concentration is largely underestimated. This discrepancy is attributed to human use of water from the influent rivers or directly from the lake. The simulated lake level and chloride concentration are in better agreement with observed values (r^2 = 0·96) when human water use for irrigation and salt exploitation are included in the model. A comparison of the simulation with and without human consumption indicates that climate variability controls the interannual fluctuations and that the human water use affects the equilibrium of the system by strongly reducing the lake level. Sensitivity analysis based on a mean climatic year showed that, after prolonged mean climatic conditions, Lake Abiyata reacts more rapidly to an abrupt shift to wetter conditions than to dry conditions. This study shows the significant sensitivity of the level and salinity of the terminal Lake Abiyata to small changes in climate or land use, making it a very good 'recorder' of environmental changes that may occur in the catchment at different time scales.

Legesse, D., Vallet-Coulomb, C., & Gasse, F. (2004). Analysis of the hydrological response of a tropical terminal lake, Lake Abiyata (Main Ethiopian Rift Valley) to changes in climate and human activities. *Hydrological processes*, *18*(3), 487-504, **https://doi.org/10.1002/hyp.1334**

Land-Use and Land-Cover Dynamics in the Central Rift Valley of Ethiopia

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Environmental management, *44*(4), 683-694

Abstract

Understanding the complexity of land-use and land-cover (LULC) changes and their driving forces and impacts on human and environmental security is important for the planning of natural resource management and associated decision making. This study combines and compares participatory field point sampling (pfps) and remote sensing to explore local LULC dynamics. The study was conducted in two peasant associations located in the central Ethiopian Rift Valley, which is a dry-land mixed farming area exposed to rapid deforestation. From 1973–2006, the area of cropland doubled at the expense of woodland and wooded-grassland in both of the study sites. Major deforestation and forest degradation took place from 1973–1986; woodland cover declined from 40% to 9% in one of the study sites, while the other lost all of its original 54% woodland cover. Our study concludes that assessing LULC dynamics using a combination of remote sensing and pfps is a valuable approach. The two methods revealed similar LULC trends, while the pfps provided additional details on how farmers view the changes. This study documents dramatic trends in LULC over time, associated with rapid population growth, recurrent drought, rainfall variability and declining crop productivity. The alarming nature of these trends is reflected in a decrease in the livelihood security of local communities and in environmental degradation. Given these dry-land conditions, there are few opportunities to improve livelihoods and environmental security without external support. If negative changes are to be halted, action must be taken, including building asset bases, instituting family planning services, and creating opportunities outside these marginal environments.

Garedew, E., Sandewall, M., Söderberg, U., & Campbell, B. M. (2009). Land-use and land-cover dynamics in the central rift valley of Ethiopia. *Environmental management*, *44*(4), 683-694.

Continuing land degradation: Cause–effect in Ethiopia's Central Rift Valley

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Abstract

The Central Rift Valley (CRV) is one of the most environmentally vulnerable areas of Ethiopia. Most of the lowland in the CRV is arid or semiarid, and droughts occur frequently. We studied the dynamics of land use and cover and land degradation by analyzing Landsat data from 1973, 1985, and 2006 using Geographic Information Systems and remote sensing techniques. The analysis revealed that in the last 30 years, water bodies, forest, and woodland decreased by 15·3, 66·3, and 69·2 per cent, respectively; intensive cultivation, mixed cultivation/woodland, and degraded land increased by 34·5, 79·7, and 200·7 per cent. The major causes of land use and cover change (LUCC) and land degradation in the area were population and livestock growth in regions of limited resources, unsustainable farming techniques, the Ethiopian land tenure system and poverty. Lake level and area decline, and accelerated land degradation are the major environmental impacts of LUCC observed in the CRV. The environmental and socio-economic consequences of LUCC and land degradation are far-reaching. As a result of the expansion of land degradation over time, agricultural productivity has decreased and worsened food insecurity (shortages) and poverty in the Ethiopian CRV. In addition, if current trends in LUCC continue, Lake Abiyata will dry up by 2021. A detailed study of the degradation amount in relation to soil erosion, sediment yield to the lakes and catchment characteristics should be made using adaptable models; so as to guide the implementation of comprehensive and sustainable land use management by giving more attention to erosion prone areas.

Meshesha, D. T., Tsunekawa, A., & Tsubo, M. (2012). Continuing land degradation: cause–effect in Ethiopia's Central Rift Valley. *Land degradation & development*, *23*(2), 130-143, https://doi.org/10.1002/ldr.1061.

Detection and analysis of land-use and land-cover changes in the Midwest escarpment of the Ethiopian Rift Valley

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Abstract

This study detects patterns of land-use and land-cover changes in the last three decades (1972–2004) and analyses its causative factors in the Upper Dijo River catchment, Midwest escarpment of Ethiopian Rift Valley. Data captured through the synergy of an aerial photo satellite image and ground-based socio-economic survey were analysed by GIS and SPSS. The results showed a decline in shrub-grassland and riverine trees at 21.5 and 16.3 ha per year, respectively, and increase in plantation trees, annual crops and bare/open grasslands at 2.8, 12.5 and 24.8 ha per year, respectively. The results are interpreted in the light of population dynamics, socio-economic condition and policy framework. The findings warrant that land-use and land-cover change in the region is very rapid, and unless the existing management of land resources is up-scaled, land ownership is secured, and family planning is mainstreamed in regional and local development plans, the region's fragile ecological balance would collapse irrecoverably.

Keywords: land-use and land-cover change; population pressure; rift valley escarpment; GIS; satellite image; Ethiopia

Mengistu, D. A., Waktola, D. K., & Woldetsadik, M. (2012). Detection and analysis of land-use and land-cover changes in the Midwest escarpment of the Ethiopian Rift Valley. *Journal of Land Use Science*, *7*(3), 239-260, http://dx.doi.org/10.1080/1747423X.2011.562556

Soil property changes following conversion of acacia woodland into grazing and farmlands in the Rift Valley area of Ethiopia

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Abstract

Continued conversion of woodlands into grazing and farmland is seriously undermining the natural ecosystem of the dry and fragile Rift Valley areas of Ethiopia. This study investigated the effects of land-use change on soil organic carbon (SOC), total nitrogen (N), pH, exchangeable bases, cation exchange capacity (CEC) and base saturation (per cent) in three adjacent land-use types: controlled grazing, open-grazing and farmland. A total of 81 soil samples were collected and analysed. Contents of SOC and total N decreased drastically in open-grazing and farmland ($p < 0{\cdot}001$), and were significantly higher in the top 0·2 m than in the subsurface soil layer. Compared with the controlled grazing, reductions in the contents of SOC and total N in the top 1 m soil layer were 22–30 and 19 per cent, respectively, due possibly to the decrease in plant biomass input into the soil and the fast decomposition of organic materials. Long-term cultivation had significantly increased the concentration of exchangeable K. Exchangeable Na was high in the lower layers, while Mg was higher in the top surface soil. CEC also varied with soil depth ($p = 0{\cdot}016$); it was higher in the topsoil than in the subsurface soil, which may be, among others, due to the differences in soil organic matter distribution with depth. Although these semi-arid soils are known to have low organic carbon and CEC levels, the values from the current study area are critically low, and may indicate the further impoverishment of the soils under high agricultural and grazing pressures.

Yimer, F., & Abdelkadir, A. (2011). Soil property changes following conversion of acacia woodland into grazing and farmlands in the Rift Valley area of Ethiopia. *Land degradation & development*, *22*(4), 425-431, https://doi.org/10.1002/ldr.1022.

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

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Summary

This study aims to investigate groundwater recharge and flow patterns in tectonically active rift systems, exemplified by a case study in the Main Ethiopian Rift. The chosen approach includes the investigation of hydrochemical parameters and environmental isotopes (^{3}H, $\delta^{2}H$, $\delta^{18}O$, $\delta^{13}C$-DIC, ^{14}C-DIC, $^{87}Sr/^{86}Sr$). Apparent groundwater ages were determined by radiocarbon dating after correction of ^{14}C-DIC using a modified $\delta^{13}C$-mixing model and further validation using geochemical modelling with NETPATH. Hydrochemical and isotopic data indicate an evolutionary trend existing from the escarpments towards the Rift floor. Groundwater evolves from tritium-containing and hence recently recharged Ca–HCO_3-type water on the escarpments to tritium-free Na–HCO_3 groundwater dominating deep Rift floor aquifers. Correspondingly, rising pH and values coupled with increasingly enriched $\delta^{13}C$ signatures point to hydrochemical evolution of DIC and beginning dilution of the carbon isotope signature by other carbon sources, related to a diffuse influx of mantle CO_2 into the groundwater system. Especially thermal groundwater sampled near the most recent fault zones in the Fantale/Beseka region displays clear influence of mantle CO_2 and increased water–rock interaction, indicated by a shift in $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ signatures. The calculation of apparent groundwater ages revealed an age increase of deep groundwater from the escarpments to the Rift floor, complying with hydrochemical evolution. Within the Rift, samples show a relatively uniform distribution of apparent ^{14}C ages of ~1800 to ~2800 years, with the expected down-gradient aging trend lacking, contradicting the predominant intra-rift groundwater flow described in existing transect-based models of groundwater flow. By combining hydrochemical and new isotopic data with knowledge of the structural geology of the Rift, we improve the existing groundwater flow model and propose a new conceptual model by identifying flow paths both transversal and longitudinal to the main Rift axis, the latter being strongly controlled by faulted and tilted blocks on the escarpment steps. The connection between groundwater flow and fault direction make this model applicable to other active rift systems with similar structural settings.

Keywords: Rift tectonics; Hydrochemistry; Isotope hydrology; Groundwater cycle and dating; $^{87}Sr/^{86}Sr$; ^{14}C

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, https://doi.org/10.1016/j.jhydrol.2011.03.022.

Land-use/cover dynamics in Northern Afar rangelands, Ethiopia

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Abstract

This study uses a combination of remote sensing data, field observations and information from local people to analyze the patterns and dynamics of land-use/cover changes for 35 years from 1972 to 2007 in the arid and semi-arid Northern Afar rangelands, Ethiopia. A pixel-based supervised image classification was used to map land-use/cover classes. People's perceptions and ecological time-lines were used to explain the driving forces linked to the changes. A rapid reduction in woodland cover (97%) and grassland cover (88%) took place between 1972 and 2007. Bushland cover increased more than threefold, while the size of cultivated land increased more than eightfold. Bare land increased moderately, whereas bushy grassland and scrubland remained stable. According to accounts from local people, major events that largely explain the changes include: (1) severe droughts in 1973/74 and 1984/85; (2) increase in dry years during the last decade; and (3) immigration and increased sedentarization of pastoralists. If the present land-use/cover change were to continue, coupled with a drier climate, people's livelihoods will be highly affected and the pastoral production system will be under increasing threat.

Keywords: Afar pastoralists; Agriculture; Drought; Dry-season grazing; Livelihoods

Vegetation cover

Tsegaye, D., Moe, S. R., Vedeld, P., & Aynekulu, E. (2010). Land-use/cover dynamics in Northern Afar rangelands, Ethiopia. *Agriculture, ecosystems & environment*, *139*(1-2), 174-180, https://doi.org/10.1016/j.agee.2010.07.017

Characteristics and quality of gum arabic from naturally grown *Acacia senegal* (Linne) Willd. trees in the Central Rift Valley of Ethiopia

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Abstract

Drylands of Ethiopia, including those in the Rift Valley, host good potential for commercial production of natural gums such as gum arabic. However, little researches have assessed the qualities of these gums for their commercial and industrial promotions. The objectives of this study were to assess the (i) quality of gum arabic collected from naturally grown *Acacia senegal* trees in the Central Rift Valley of Ethiopia and (ii) evaluate these quality characteristics against reported quality attributes of the same kind of gum from known destinations such as the Sudan and with international specifications. Gum samples were collected from randomly identified 10 trees of *A. senegal* in the study area and composited into one big sample by putting all in one plastic bag. The characteristics analyzed included: color, odor, moisture content, ash content, viscosity, pH, specific rotation, N and tannin contents, and concentration of several metals using standard laboratory procedures. The results yielded moisture content of 15%, ash content of 3.56%, intrinsic viscosity of 1.19 ml g^{-1}, pH on 25% solution of 4.04, specific rotation of −32.5, nitrogen content of 0.35%, protein content of 2.31% and with no tannin content. Mineral contents of the gum arabic (g/100 g) are Ca 0.7, Mg 0.2, Na 0.01, K 0.95, Fe 0.001, P 0.6 and non-detectable traces of Pb, Co, Cu, Zn, Ni, Cd, Cr and Mn. These values agree well with values of same quality characteristics of gum arabic reported from Sudan and other exporting countries, and also conform well to international standards in all aspects. Indeed, it is possible to utilize the gum arabic resource of the Central Rift Valley of Ethiopia for commercial and/or industrial purposes.

Keywords: Drylands; International specifications; Physico-chemical characteristics; Industrial application

Yebeyen, D., Lemenih, M., & Feleke, S. (2009). Characteristics and quality of gum arabic from naturally grown Acacia senegal (Linne) Willd. trees in the Central Rift Valley of Ethiopia. *Food hydrocolloids*, *23*(1), 175-180, https://doi.org/10.1016/j.foodhyd.2007.12.008.

Spatial and temporal variation of soil organic carbon stocks in a lake retreat area of the Ethiopian Rift Valley

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Abstract

Land use and cover changes lead to loss of vegetation cover and subsequent change in soil organic carbon (SOC) and soil quality. This study was carried out in a lake retreat area in the Main Ethiopian Rift Valley, to investigate SOC stock build-up in function of duration of land emergence and SOC dynamics in function of land use and cover changes. Based on an analysis of Landsat imagery (1973, 1986 and 2000), coupled with soil and land use studies, determinants for SOC stock were found. Firstly, SOC stock significantly differed between cultivated land and grazing land (3301 and 2626 g m^{-2}) on the one hand, and woodland (4594 g m^{-2}) on the other. Further, only weak relations were found between SOC stock and vegetation index or IR and green band reflectances, which is related to low canopy density (even in woodland) and low leaf density of *Acacia* during the dry season.

The strongest explanation of SOC stock is related to the duration of emergence and hence of pedogenesis. Its proxy, elevation, explains much of the variability of SOC (R^2 = 0.48). There is a non-negligible long-term trend of SOC build-up from < 2000 g m^{-2} (inherited C-rich limnic sediments) to > 4500 g m^{-2} under the climax *Acacia–Balanites* woodland (on land that emerged approximately 4233–4540 BP). Using a multiple regression model involving elevation and presence of forest or woodland, the SOC stock in the study area could be assessed at 3966 (± 1799) g m^{-2} SOC in 2000, against 4319 (± 1835) g m^{-2} in 1986 and 4199 (± 1866) g m^{-2} in 1973, thereby confirming the rapid SOC depletion after removal of vegetation.

Keywords: Deforestation; Ethiopia; Lake Abijata; Lake retreat; Land degradation; Organic C build-up; SOC stock

Nyssen, J., Temesgen, H., Lemenih, M., Zenebe, A., Haregeweyn, N., & Haile, M. (2008). Spatial and temporal variation of soil organic carbon stocks in a lake retreat area of the Ethiopian Rift Valley. *Geoderma*, *146*(1-2), 261-268, https://doi.org/10.1016/j.geoderma.2008.06.007.