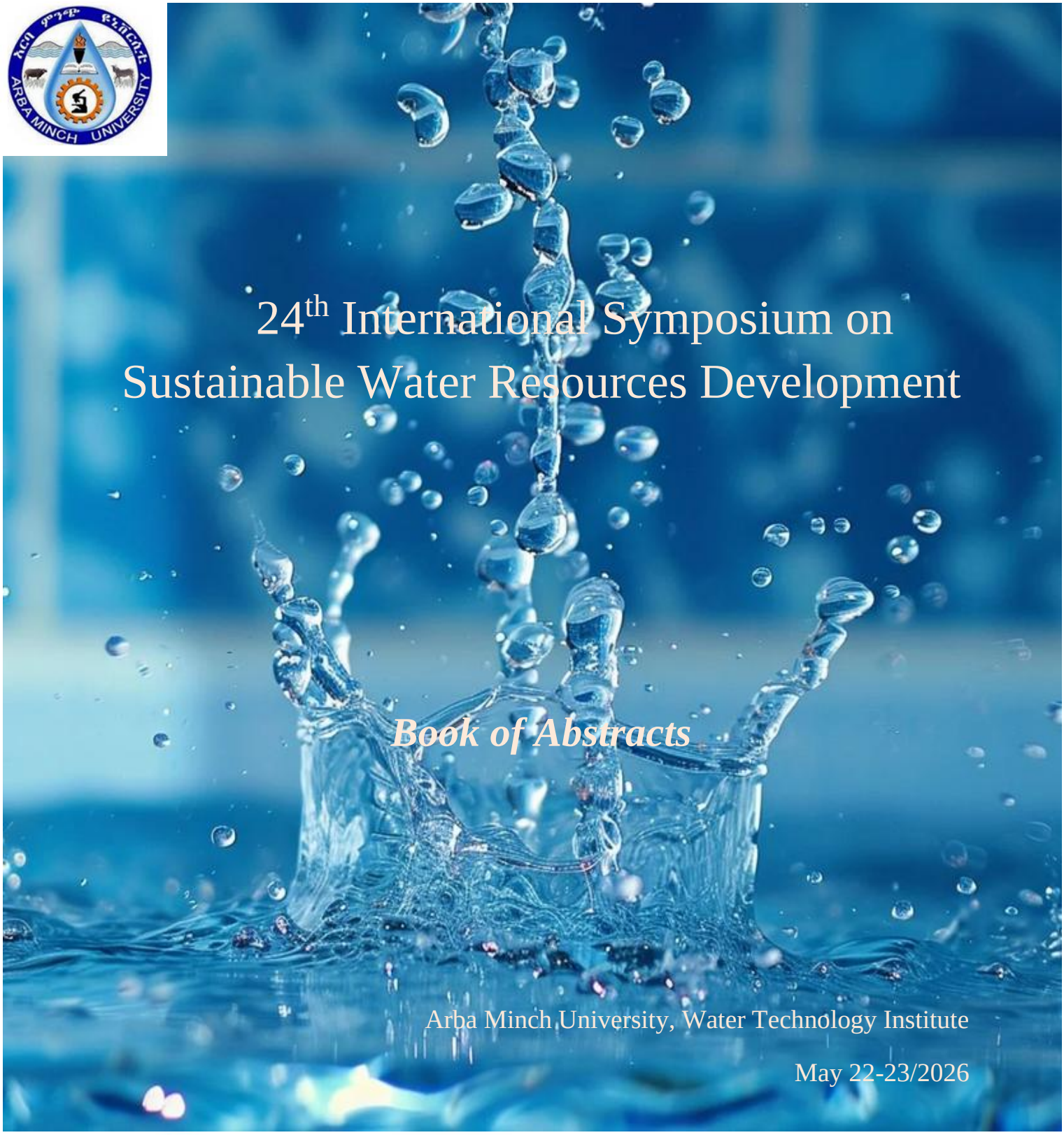

24th International Symposium on Sustainable Water Resources Development

Book of Abstracts

Arba Minch University, Water Technology Institute

May 22-23/2026

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Forward

Arba Minch University, Water Technology Institute, Water Resources Research Center, has been organizing an international symposium on “Sustainable Water Resources Development” for the past twenty-four years.

The symposium aims to provide a platform for professionals, researchers, practitioners, and decision-makers to present research findings, share best practices, and exchange innovative ideas on sustainable water resources development.

For the 24th symposium, 94 papers were submitted by authors from across the country and abroad. Following a rigorous selection process, 14 papers have been chosen for oral presentation and 3 papers for poster presentation. All selected papers will be presented in person.

The organizing committee extends its congratulations and warm welcome to the authors whose papers were selected. We appreciate their participation and look forward to their valuable contributions.

We would like to thank each of you for attending our symposium and bringing your expertise to our gathering.

Organizing Committee

Acknowledgement

We would like to express our sincere gratitude to all the organizationss and individuals whose contributions made this symposium possible. We are particularly grateful for the generous support from our sponsors: the Ethiopian Meteorology Institute, Ethiopian Engineering Corporation, Haverim Construction General Contractor, Blue Matrix Consultancey, Empowering Africa through Academic Mobility for Climate Change Mitigation, Adaptation, and Sustainable Development, BRIGHT FUTURE Ethiopia, AMU-IUC, Catholic Caritas Ethiopia, LM international Ethiopia and Drop of Water. Their partnership and commitment were vital to the success of this event. We also extend our deepest appreciation to our distinguished keynote speakers, for sharing their valuable insights and expertise. Special thanks go to all the paper contributors, reviewers, and organizing committee members for their dedication and tireless efforts in ensuring the symposium's success. Without their collective contributions, this event would not have been possible.

Dr. Eng. Elias Gebeyehu Ayele (PhD)

Director, Water Resources Research Center

Message

On behalf of the Arba Minch Water Technology Institute (AWTI) and Arba Minch University, it is my distinct honor and pleasure to welcome you to the **24th International Symposium on Sustainable Water Resources Development**. We are gathered here in the beautiful city of Arba Minch, a place where nature's water resources meet the peak of academic rigor and engineering excellence.

AWTI holds a storied legacy in the history of East Africa's water sector. Established as a premier center of excellence, the Institute has spent decades pioneering water resources teaching, high-impact research, and innovative technology. Our historical commitment to the water sector has not only shaped the careers of thousands of professionals but has also provided the scientific foundation for major national development projects.

This annual symposium has become a highly reputable and sustained academic platform. For nearly a quarter of a century, it has served as a vital crossroads for the exchange of transformative ideas and cutting-edge technologies. This year is no exception; our participants have traveled from various corners of Ethiopia and across the globe, bringing a rich tapestry of international knowledge and multidisciplinary perspectives.

I am confident that every participant will gain invaluable experience and knowledge over the coming days. By bringing together seasoned experts with decades of experience alongside the next generation of researchers, we foster a unique environment of mentorship and discovery. The quality of work presented here is exceptional—every paper included in this Book of Abstracts has undergone rigorous peer review to ensure it meets the highest standards of scientific merit.

Beyond academic discourse, this symposium serves a greater national purpose. It is our firm belief that evidence-based research is the engine behind the country's development and the long-term prosperity of our people. To ensure these contributions reach the global community, selected papers will be published in our official symposium proceedings and AWTI-affiliated journals.

I would like to express my sincere gratitude to all the researchers, scholars, and practitioners who have contributed their work and presence to this event. To our international guests, thank you for bringing the world's expertise to our doorstep.

I wish you all a highly productive symposium and a wonderful stay at Arba Minch University. May your time here be filled with insightful discussions, lasting professional connections, and a deep enjoyment of our hospitality.

Tamru Tesseme Aragaw (PhD., P.E)

Scientific Director, Arba Minch Water Technology Institute (AWTI)

Arba Minch University (AMU)

ORAL PRESENTATIONS

Theme 1

Hydrology and Integrated Water Resources Management

Assessing Spatio-Temporal Groundwater Storage Variability in the Woleka Sub-Basin, Ethiopia, Using GRACE and GLDAS Data.

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Abstract

The GRACE satellite datasets offer a reliable method of measuring groundwater storage (GWS) variations in the absence of direct observations. The temporal and spatial variability of groundwater storage in the study area was assessed using the GRACE-CSR Mascon solutions and GLDAS 2.2 DA CLSM datasets. The modified Mann-Kendall trend test was utilized to analyze the trends. The GRACE-GWSA was calculated using GLDAS TWS components, which included surface moisture, root-zone water storage, and canopy water storage. This study employed a linear regression method to address missing data and applied a 3-month rolling average technique to resolve discrepancies created during the computation of the GWSA. Monthly groundwater level data from 18 wells were collected over a year (March 2024-February 2025) to validate GRACE-GWSA and GLDAS-GWSA with R^2 and NSE metrics. GRACE-GWSA achieved higher R^2 and NSE values (0.60 and 0.79, respectively) than GLDAS-GWSA (0.56 and 0.65). The study found substantial increases in GRACE TWS (14.08 cm) and GLDAS TWS (11.44 cm), with GWSA increases of 13.71 cm and 8.91cm, respectively, at $P < 0.0001$. These findings underscore the need for enhanced watershed management and conservation initiatives to safeguard groundwater supplies in the region.

Key Words*: GLDAS 2.2 DA CLSM, GRACE-CSR, GWS, Mann-Kendall, TWS, and Woleka River Sub-Basi*

Application of Machine Learning Algorithms for Rainfall-Runoff Modelling in Gumara Watershed, Lake Tana Sub-Basin, Ethiopia

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Abstract

Advances in technology and scientific research have significantly enhanced the understanding of Earth's water systems, enabling contributions to their sustainable use and management and ensuring the availability of water for future generations. However, with the impacts of climate change, agricultural intensification, industrialization, and rapid population growth, a surge in water demand has been observed, while rainfall levels remain nearly constant. This mismatch between water supply and demand has made the effective planning and management of water resources more critical than ever. To address this issue, developing and applying data-driven rainfall-runoff models are seen as a viable solution. In this study, daily and monthly rainfallrunoff predictive models were developed and tested using Support Vector Machine, Random Forest, and Artificial Neural Network techniques in the MATLAB 2019b interface for the Gumara Watershed in Lake Tana Sub-basin. Climatic data were used as independent variables, while hydrological data were treated as dependent variables, with uniform watershed characteristics being assumed. Among the models, consistent performance was exhibited by the SVM having R2 values of 0.70,0.87 and 0.70,0.85, the highest accuracy was achieved RF the with the values of R2 0.80,0.90 and 0.72, 0.85 during training and testing for daily and monthly datasets respectively, and the ANN demonstrated intermediate results. While further research incorporating watershed characteristics as input variables is recommended, the RF is a promising solution for water resource planning and management in the Gumara Watershed and other data-scare areas, with benefits for the local community.

Keywords: *Artificial Neural Network, Gumara River, Machine Learning, Rainfall-runoff modeling, Random Forest, Streamflow, Support Vector Machine*

Satellite-Based Optical and Radar Observations Support Coastal Hydrology Studies

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Abstract

Coastal hydrology is an emerging domain of research due to the need of predicting and assessing the impacts of river flooding and drought at land-sea-interface. Satellites now provide a consistent set of observations that are much improved compared to the past. In this work, we present the case-study of Po River in Italy. The Po River in the summer of 2022 experienced the worst drought in 70 years. The lack of rainfall and reduced snowfall, together with rising temperatures, led to a drastic reduction in water levels, The situation was exacerbated by saltwater intrusion into the river, which destroyed crops and made irrigation almost impossible up to 40 km from the estuary. The analysis aimed to assess two aspects: 1) whether satellites were able to monitor the drop in water levels along the river and whether this was also reflected at sea; and 2) whether it was possible to monitor the salt wedge intrusion in the downstream sections of the Po River by satellite. The results of the analysis confirm that the satellite observed the significant increase and decrease in water levels in correspondence of the extreme events. In addition, the analysis of the data in the downstream part of the Po River, together with the data along the tracks crossing the plume closer to the mouth of the river, supported by the optical imagery showed the interaction between the sea and the river.

Keywords: *satellite radar altimetry, hydrology, coastal oceanography*

Theme 2

Renewable Energy

Modeling of Hybrid Renewable Energy System For Southern Ethiopian Remote Rural Village: A Case Study Of Oda Roba

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Abstract

Rural communities of Ethiopia continue to suffer from a shortage of clean energy despite vast renewable energy resources in the country. This study evaluates four scenarios of hybrid renewable energy systems (HRES) for off-grid electrification of Oda Roba village, integrating photovoltaic (PV), wind turbine (WT), battery storage (BT), diesel generator (DG), and converter (CONV). To identify the optimal model, each scenario was evaluated based on technoeconomic, environmental, and social development indexes. Furthermore, five regression machine learning models were employed to forecast levelized cost of energy (LCOE) and CO_2 emission using 1938 simulation datasets. The results show that among the studied configurations, scenario 3 (PV/WT/BTS/DG/CONV) emerged as the most economical and environmentally sustainable solution to electrify the community. This system achieves a LCOE of $0.311/kWh, a 99.4% renewable fraction, a net present cost of $251,306.5, and minimal CO_2 emissions of 1,260.97 kg/year. The system shows a strong economic feasibility with a 1.48-year fast payback period. Moreover, socio-economic analysis revealed that scenario 3 has a job creation index of 0.328 and a human development index of 0.287. Break-even investigation demonstrated the integrated system is more economical than grid extension. The application of machine learning showed that gradient boosting achieved exceptional accuracy in forecasting LCOE, while XGBoost proved to be the best in predicting CO_2 emission. The finding of this research highlights that a properly optimized HRES, by taking into account its technical-economic aspects, environmental situation, and social development index, can provide clean, affordable, and reliable energy for rural communities.

Keywords: *HRES, Levelized cost of electricity, Rural Electrification, Environmental analysis, Technoeconomic evaluation, Renewable energy, Machine Learning*

Theme 3

Irrigation and Drainage

Integrating FAHP and Geo-Hydrological Modeling to Identify Rainwater Harvesting Zones for Irrigation practices in the Upper Tekeze Basin, Ethiopia.

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Abstract

Climate variability, increasing water demand, and persistent food insecurity pose major challenges to sustainable agricultural development in Ethiopia's semi-arid basins. In the Upper Tekeze Basin (UTB), dry-season water scarcity severely constrains irrigation-based livelihoods, highlighting the need for climate-resilient rainwater harvesting and groundwater recharge strategies. This study presents an integrated geo-hydrological and multi-criteria decision-making framework to identify priority zones for rainwater harvesting and irrigation development in support of sustainable water–food systems. Geographic Information Systems (GIS), the Soil and Water Assessment Tool (SWAT), Fuzzy Logic, and the Fuzzy Analytical Hierarchy Process (FAHP) were combined to evaluate key biophysical and socio-economic factors, including rainfall, surface runoff, slope, drainage density, soil texture, lithology, hydrogeology, land use/land cover, NDVI, lineament density, population density, and proximity to infrastructure and water sources. SWAT model performance was satisfactory at the monthly scale, with R^2 and NSE values of 0.77 for calibration and 0.75 for validation, respectively. Suitability mapping indicates that 16.77% of the Upper Tekeze Basin is classified as highly to very highly suitable for surface rainwater harvesting. Surface irrigation land suitability is predominantly marginal (18.3%), reflecting the need for site-specific, integrated planning. The study demonstrates the value of combining hydrological modeling with fuzzy-based decision analysis to support climate resilient irrigation planning, sustainable water resource management, and evidence-based policy formulation, resilience, and community centered development.

Keywords: *• FAHP • Fuzzy logic • UTB • GIS/RS • Rainwater Harvesting • SWAT model • Surface Irrigation*

Integrated Performance and Investment Analysis for Small-Scale Irrigation Projects in Central Part of Ethiopia

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Abstract

Ethiopia's agricultural transformation is based on small-scale irrigation schemes (SSISs), which promote climate-resilient growth, poverty alleviation, and food security. In Central Ethiopia, small-scale irrigation systems (SSISs) function much below their intended capacity. As of 2025-2026 only roughly 2,990 ha (about 33%) of the 9,058 ha of developed irrigable land are in use. In order to measure productivity gaps, revenue losses, and possible benefits from enhanced scheme functionality, management, and institutional capacity, this study combines irrigation performance assessment, scenario-based analysis, and economic evaluation. The cost-benefit analyses of eight major crops maize, wheat, onion, tomato, garlic, potato, carrot, and cabbage as well as technical performance indicators such as conveyance efficiency, water delivery reliability, irrigation efficiency, cropping intensity, and land and water productivity were examined. With high-value horticultural crops, particularly onions, tomatoes, and garlic, contributing maximum profitability and all crops exhibiting benefit-cost ratios above unity, optimal utilization could generate seasonal gross revenue of $83.4 million (ETB 12.42 billion) and net benefits of $67.4 million (ETB 10.04 billion). Scenario simulations show that a 25% increase in irrigation performance increases the effectively watered area to 41%, which results in a decrease in unrealized revenue losses and an annual increase of USD 5.7–5.9 million (ETB 0.85 billion–ETB 0.88 billion). Institutional and administrative improvements, such as supporting Water Users Associations, participatory governance, and energy-efficient water management, are crucial to achieving these gains. The results show that operational optimization, crop prioritization, water-energy efficiency measures, institutional strengthening, and modest, targeted rehabilitation can increase economic returns, improve rural employment, stabilize household incomes, and promote climate-resilient agricultural systems. These results support SDG 2 (Zero Hunger) and national climate resilience goals while being consistent with Ethiopia's Ten-Year Development Plan (2021–2030), which emphasizes irrigation-led agricultural modernization, green growth, and inclusive rural development.

Keywords: *Small-scale irrigation; Irrigation performance; Cost-benefit analysis; Climate-resilient agriculture; Institutional strengthening; Central Ethiopia*

Evaluating Irrigation System Performance using Participatory Field Measurements and RS Approaches in Fura Irrigation Scheme, South Ethiopia Region, Ethiopia

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Abstract

The Fura small-scale irrigation scheme in southern Ethiopia is facing several challenges to achieve sustainable water productivity. The aim of this study was to evaluate irrigation system performance and water productivity using both participatory (citizen science) and remote sensing approaches during the 2025 growing season. Composite soil samples collected across the scheme reaches revealed a mean pH of 7.85, total nitrogen of 0.32%, available phosphorus of 23.16 mg/kg, and organic matter of 1.75%, and ESP (1.34%) values indicating minimal sodicity risk. The Irrigation adequacy (26–64%), dependability (1.0–2.5), and equity (0.66–0.77) indices were poor, reflecting uneven water distribution. Tomato yields varied from 2.2 ton/ha in the upper reach to 15.0 ton/ha in the lower reach, with water productivity ranging between 1.4 and 12.0 kg/m³, while pepper yields were lower at 0.6 ton/ha and 0.9 kg/m³. Household interviews identified input shortages (66.7%), crop disease and pest prevalence (40%), and irrigation water scarcity (86.7%) as the most pressing challenges. The NDVI value of tomato varied from a minimum of 0.13 to 0.70. Generally, this finding identifies poor irrigation equity, water scarcity, and input access as the major challenges that hinder agricultural and water productivity in the Fura irrigation scheme.

Keywords: *Irrigation performance, Soil spatial variability, Crop productivity*

Theme 4

Water Supply and Sanitation

Integrated Assessment of Surface Water and Groundwater Quality with Human Health Risk Evaluation in Addis Ababa's Water Supply Systems: Evidence of Coupled Contamination Dynamics in Fractured Volcanic Aquifers

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Abstract

The prevalent wisdom that directs water infrastructure investment worldwide is that deep groundwater is shielded from surface contamination. Through the combined analysis of 20-year climate records, 36 months of high-resolution bimonthly water quality monitoring across eight production wells (60–600 m depth) and surface water intake, well construction logs, and human health risk assessment, this study tests that assumption in Addis Ababa's Akaki wellfields and Legedadi Reservoir. Climate analysis shows exceptional trends: dry season minimum temperatures decreased 3.2°C/decade ($p<0.001$), reaching 2.4°C in February 2024, while October rainfall increased from 39 mm (2004–2020) to 369 mm (2021–2024; $p<0.001$). A "Cold Accumulation–Warm Flush" process is fueled by this temperature differential: cold, dry seasons inhibit nitrogen intake, which permits nitrate accumulation that is then triggered by intense rainfall. Legedadi Reservoir shows multi-scale climatic responses, including seasonal conductivity fluctuations, cumulative nitrate rise (13.6% over three years to 125 mg/L), and event-scale turbidity and E. coli spikes (2.3× and 5.8× greater in wet season; $r=0.67$ with 0–3 day rainfall lag). Three classes of aquifer vulnerability are identified by groundwater characterization. 550–600 m Type I wells are still in perfect condition. Severe nitrate pollution (80–125 mg/L) in Type II shallow wells exceeds WHO recommendations. Crucially, nitrate concentrations (95–155 mg/L) in Type III deep wells (>300 m) with strong transmissivity (17.9 L/s/m) are statistically identical to those in shallow aquifers, indicating that fracture networks avoid protective overburden. Hazard quotients above 1.0 across susceptible wells suggest that chronic nitrate exposure presents serious risks to human health. Aquifer assimilative capacity has been exceeded, as seen by the post-dilution nitrate rebound (25–36% above baseline after the wettest 12 months on record). This regime shift renders dilution-dependent protection techniques useless.

Keywords: *water quality assessment, human health risk, nitrate contamination, fractured volcanic aquifers, surface water-groundwater interaction, Addis Ababa*

Waste into Resource: Nature-Based Wastewater Treatment at Yimer Ali Integrated Agro-Industry, Kombolcha

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Abstract

Many Flour industries in Ethiopia have no wastewater treatment plant, and they freely release the waste to the environment. Yimer Ali Integrated Agro-Industry at Kombolcha was formerly disposing of the Wheat wash wastewater to the environment without treatment, and it was under major complaints from the community. This project was planned to treat the wastewater released from the Wheat washing section using a Nature-Based Solution (Column Slow Sand Filter). This industry releases bout 40,000 – 60,000-liter water per day. Therefore, the key objectives of this project were (1) to reuse this wastewater for Wheat washing or (2) to use it for agriculture and greenery area development based on the quality of treated water. The final treated water quality test for 7 parameters (pH, electric conductivity (EC), turbidity, total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), nutrient (NO_3) and phosphate (PO_3) analysis) revealed that it is suitable for irrigation and greenery activities according to FAO standard. The result shows that the value of all parameters is safe and acceptable for irrigation practice, except turbidity (pH = 7.67, EC = 1429 < 2250, TSS = 3.28 < 50, COD = 119.7 < 150, BOD = 2.63 < 10, NO_3 = 28.4 < 30, PO_3 = 0.79, and Turbidity = 98 > 10). The recommended allowable turbidity for irrigation is ≤ 10 NTU; however, the result is reduced from 281.8 to 98 NTU (65.2%). Using this Nature – based Solution recycling mechanism, 36,000 liters of treated water per day is conserved, and it is used for irrigation for fruit plants such as Mango, Avocado, coffee, etc., which is used by other nearby industry (Agmas Sponge Industry) and Yimer Ali Industry used the treated water for compound greenery and dust protection of the car park place.

Keywords: *Integrated Agro-Industry, Waste into Resource, Wastewater treatment, Nature-based-solution, Slow sand filter (SSF)*

Assessing Community Waste Management Practices and Their Environmental Impacts on River Water Quality in the Lower Kulfo River Watershed

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Abstract

Rivers are a vital source of fresh water, supporting domestic use, agriculture, recreation, transportation, energy generation and fisheries. The Kulfo River, located in southern Ethiopia, traverses Arba Minch town and drains into Chamo Lake. This study aimed to investigate community knowledge, perception, and daily waste management practice. Also, the study was designated to assess the link between waste management practice of the community with seasonal and spatially river water quality using Spearman correlation analysis. Furthermore, this study analysed river water contamination using the Comprehensive contamination Index (CPI) and Principal Component Analysis (PCA) to identify potential pollution sources. Accordingly, findings revealed that about 58% of the total solid waste in the study area were dumped into drainage system. While the remaining 42% were directly thrown into the river. The compositions of the waste include 43 % of plastic, 21 % organic matter, 20% glass and 16 % metal. The major challenges identified during the study was lack of the community awareness regarding water pollution accounting for 62.6%. The Principal Component Analysis (PCA) identified three major sources of pollution: sediment erosion, urban and residential waste, and agricultural runoff, which together explained 44.5% of the water quality variance during the wet season and 50.75% during the dry season. Household waste dumping had a substantial correlation with phosphate (r=0.914), ammonia (r=0.892), and turbidity (r=0.856). Lack of awareness and the absence of garbage containers also had a substantial positive connection with nutrient contamination, highlighting the clear link between community activities and river deterioration. As per comprehensive pollution index (CPI), during the rainy season the river water was slightly polluted (0.42 to 0.57) for domestic use, clean (0.12 to 0.18) for irrigation, severely polluted (2.65 to 6.27) for aquatic life. Whereas, in the dry season, the water was slightly polluted (0.53 to 0.67) for domestic use, sub clean (0.33 to 0.39) for irrigation, and severely polluted (2.43 to 2.95) for aquatic life. These finding highlights that the urgent need for effective waste management practice safeguard the Kulfo Rive and ensure its sustainable use for various purposes.

Key words: *Community Perception, Awareness, Waste Management, Kulfo River, CPI, PCA*

Theme 5

Climate Change, Variability and Impacts

Spatiotemporal Rainfall Variability and Climate Teleconnections in the Arid Lowlands of Eastern Ethiopia: Implications for Zone-Specific Climate Adaptation

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Abstract

Using CHIRPS v3.0 data (1981–2024), this study analyzes spatiotemporal rainfall variability, trends, drought, and teleconnections across the Afar, Somali, and Dire Dawa regions. The methodology integrates K-means clustering, Modified Mann–Kendall trend tests, Empirical Orthogonal Functions (EOF), and the Standardized Precipitation Index (SPI). Furthermore, teleconnections were assessed using the Oceanic Niño Index (ONI) and Dipole Mode Index (DMI). Clustering identified three distinct regimes: a bimodal southern lowland, a unimodal northern Rift, and a western transition zone. While the leading EOF mode reveals a coherent regional signal (45.5% variance), teleconnections expose a sharp north-south dipole response to global forcing. El Niño events trigger significant drought in the Kiremt-dominant north (r = -0.33) but enhance rainfall in the Belg-dominant south (r = +0.47), where the Indian Ocean Dipole also exerts dominant positive influence (r = +0.61). Trend analysis confirms a significant decline in Belg rainfall (-2.8 mm/year) confirming the "East African Paradox". Impact assessment reveals distinct drought signatures: SPI-3 captured rapid-onset agricultural droughts in the north (e.g., 2015), while SPI-12 revealed cumulative hydrological deficits driving the prolonged 2020–2023 southern drought. These results demonstrate that uniform national policies mask critical sub-regional heterogeneity. To ensure sustainable development, and mitigate impacts, adaptation strategies and early-warning systems has to be tailored to these specific hydro-climatic sensitivities.

Keywords: *Climate Adaptation, Drought Risk, Eastern Ethiopia, Rainfall Variability, Teleconnections.*

Depth-Resolved Soil Moisture Projections under Climate Change Using CMIP6 Climate Models and Machine Learning in the Kulfo Watershed, Ethiopia

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Abstract

This study evaluates depth-resolved soil moisture dynamics in the Kulfo Watershed, Ethiopia, under future climate change scenarios by integrating bias-corrected CMIP6 projections with advanced machine learning approaches. Performance-based assessment identified CMCC-ESM2 as the most strong model for simulating precipitation (R^2 = 0.83, RMSE = 88.99 mm), while FGOALS-g3 exhibited the highest accuracy for maximum and minimum temperatures (Tmax: R^2 = 0.88, RMSE = 0.25 °C; Tmin: R^2 = 0.88, RMSE = 0.10 °C). Machine learning analyses revealed that LSTM and ensemble tree-based models (RF, XGBoost, LightGBM) consistently outperformed ANN and SVR, achieving peak accuracy at shallow (10–30 cm) layers while maintaining robust predictions at deeper (40 cm) soil depths. Long-term projections (2025–2100) reveal strong depth- and emission-dependent responses. Under the high-emission SSP5-8.5 scenario, soil moisture increases by 0.003/year at 10 cm, 0.008/year at 20 cm, 0.012/year at 30 cm, and 0.018/year at 40 cm, reflecting enhanced precipitation and vegetation feedbacks. The medium-emission SSP2-4.5 pathway shows moderate increases at 10 cm (0.002/year), 20 cm (0.005/year), 30 cm (0.007/year), and 40 cm (0.010/year), while the low-emission SSP1-2.6 scenario induces drying trends across all depths, with declines of 0.003/year at 10 cm, 0.010/year at 20 cm, 0.015/year at 30 cm, and 0.020/year at 40 cm, highlighting the higher vulnerability of deep soils. The results demonstrate that deeper soils (20–40 cm) are more sensitive to climate-change emissions, whereas shallow layers (10 cm) show smaller changes. These findings provide crucial guidance for irrigation planning, groundwater recharge assessment, and climate-resilient water resource management in semi-arid Ethiopian watersheds.

Keywords: *Climate Change; CMIP6; Kulfo Watershed; Machine Learning; Soil Moisture Prediction*

Wetland Restoration as Nature-Based Solution for Climate-Resilient Watershed Management: Evidence from the Gojeb River Sub-Basin, Ethiopia

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Abstract

Ethiopia's Climate Resilient Green Economy (CRGE emphasise the restoration of ecosystems as a key strategy to achieve sustainable development and climate-resilient infrastructure. However, the hydrological effects associated with wetland destruction and restoration remain poorly understood at the watershed scale. This study integrated Earth observation, spatial analysis and eco-hydrologic modelling to explore the consequences associated with wetland destruction and assess the wetlands as nature-based infrastructure for the Gojeb River sub-basin. Analysis of multi-satellite data showed that wetland area declined by 26.6% over 2000 to 2024, largely due to agricultural expansion. Model outputs using a calibrated and validated soil and water assessment (SWAT) tool for simulated conditions around a reduced wetland area showed that runoff volumes are increased by 8.5%, sediment loads by 27.7%, with corresponding decreases of 2.3% due to reduced hydraulic residence times for groundwater recharge. Exceedance plots confirm a changeover to more flash runoff patterns with elevated peak discharge by 1.2% corresponding to given probability levels, which forecast enhanced flood dangers. Wetland restoration, on the other hand, significantly increases subsurface water storage, lowers sediment loads, and improves hydrological management. These results provide empirical evidence that, by enhancing ecosystem services, mitigating the risk of disasters, and strengthening water security, wetland restoration directly supports national green development goals. The study highlights a scalable method for incorporating geospatial intelligence into national water and land management policies, demonstrating the revolutionary potential of Earth observation-driven modelling frameworks in supporting environmentally friendly and economically viable infrastructure decisions.

Keywords: *Climate resilience, Earth Observation, green infrastructure, nature-based solution*

POSTER PRESENTATIONS

Next-Generation Membranes for Water and Wastewater Treatment: MOF-based Membranes

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Abstract

About four billion people worldwide are affected by water pollution and the scarcity of safe drinking water, making the production of clean water one of the most pressing global challenges. Membrane-based separation has emerged as a highly selective, energy-efficient, and environmentally friendly technology compared with conventional processes such as distillation. However, conventional polymeric membranes suffer from inherent limitations, including the permeability–selectivity trade-off, chemical instability, and fouling, which restrict their long-term performance. Emerging two-dimensional nanomaterials, such as graphene, offer ultrathin transport paths but often lack structural stability under the high pressures required for industrial desalination and nanofiltration. Metal-organic frameworks (MOFs) offer a superior alternative due to their crystalline rigidity and monodisperse pore apertures. Here, we present highly water-stable and mechanically robust TCPP-MOF nanosheet membranes fabricated on polyethersulfone (PES) substrates via vacuum-assisted assembly. These membranes achieve an exceptional water permeance of 52 L m^{-2} h^{-1} $bar^{-1,}$ and near-complete rejection (~100%) was observed for organic dyes as small as 300 g/mol, alongside promising salt rejection for NaCl (>80%) and Na_2SO_4 (>90%). The membranes demonstrated excellent mechanical and chemical robustness, maintaining separation efficiency over five days of continuous operation without performance decay. The separation mechanism is governed by a dual-channel transport model, highlighting the synergy between steric sieving within ~1 nm pores and Donnan exclusion for charged solutes. These findings position TCPP-MOF membranes as a transformative platform for efficient and sustainable water purification and desalination.

Keywords: *Membrane separation, metal-organic framework, composite, nanofiltration, desalination*

Hydrological Realities and Political Narratives in the Nile Basin: A Data-Driven Analysis of GERD's Filling Impacts on Downstream Reservoirs Using Optical and Altimeter satellite datasets

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Abstract

The filling of the Grand Ethiopian Renaissance Dam (GERD), which commenced in July 2020, has been a central hotspot of tension in Nile's hydropolitics. This study empirically assesses the hydrological impacts of GERD filling on four major downstream reservoirs (Lake Nasser, Toshka, Rosarios, and Merowe) by comparing pre-filling baseline conditions (before July 2020) with post-filling anomalies in surface area and water level using remote sensing data. The analysis reveals a consistent, system-wide trend of positive storage anomalies across the reservoir cascade during the post-filling period. As expected, the GERD reservoir showed the greatest absolute increase in surface area (mean anomaly of +810.53 km²). Critically, contrary to expectations of immediate downstream depletion, Lake Nasser exhibited a mean area increase of 532.15 km² (10.1%) and a water level rise of 2.82 m. The Toshka reservoir, hydrologically connected to Lake Nasser, showed the largest relative expansion (mean area anomaly of +2,414.68 km²; +1,173.1%). Downstream Sudanese reservoirs at Rosarios and Merowe also recorded positive, though more moderate, anomalies (+7.9% and +3.7% in area, respectively). The data-reality disconnect reveals how existential narratives serve political purposes despite contradicting evidence, eroding trust and misdirecting policy. Though reasonable downstream concerns about long-term security remain valid, GERD's filling coincided with downstream reservoirs storage expansion, not contraction. This offers an opportunity for cooperation based on demonstrated mutual benefit-if political leaders admit hydrological reality over rhetoric, with profound implications for regional stability.

Key Words: *Hydrological Reality, Political narratives, remote sensing, reservoir anomaly.*

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