Simulating Water Yield with Changing Climate and Landscape

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***Abstract*—Water yield reters to the total volume of the water produced or discharge form a particular watershed catchments area or land region over a given period. It represents the amount of water that flow out of an area according for factors like precipitation, evaporation, transpiration, soil erosion, crops, land use -landcover, crop co-efficient factor. Soil type, solar radiation and humidity. Thus, various model developed over time. Tn the recent tin1es the invest sessional water yield (SWY) model as became popular deposit accurately estimates the amount of water yield.**

I. INTRODUCTION

This study looks at how changes in land use, like deforestation and urban growth, affect water availability and river behavior in the Gorgan River Basin (GRB), Tran. Researchers used satellite images from 1990 to 2020 to see how forests, farms, <1nd other land types shifted over time. Then, they used a modeling tool called INVEST different future scenarios: no intervention, strict conservation, or limited land use changes in sensitive areas.

Key findings showed that forests play a crucial role in reducing runoff, preventing soil erosion, and maintaining water supplies, However, expanding agriculture and urban areas are reducing forests and pastures, which worsens water loss and increases runoff The study also highlights that rainfall is a critical factor in1lucncing water availability, to prevent future water shortages, the research recommends balancing land development with strategies to protect forests and natural ecosystems.

1. Gorgan River Basin (Iran): Till· study exammes how changes in land use (like expanding agriculture and urbanization) affect water resources. It uses satellite data and modeling to show that deforestation and land conversion reduce water availability, highlighting the importance of protecting forests to prevent runoff and maintain resources. Different scenarios show how sustainable land management can balance development with conservation.
2. Nepal River Basins: Focuses on how urbanization affects rivers and hydropowcr. More buildings increase runoff but reduce groundwater recharge, impacting seasonal river flows and electricity generation. Sustainable planning is essential for balancing water use and energy needs.
3. Rainfall-Runoff Models (SWAT): Compares two methods for predicting water flow based on land use and rain patterns. Tt shows the importance of considering uncertainties to improve the accuracy of hydrological predictions.
4. Estuaries and Fish Health: Explores how land use and waler quality affect fish populations in estuaries. Well- managed catchments have healthier ecosystems, while urban and farm runoff harms water quality and fish diversity.
5. Min River Watershed (China): Examines how land use changes affect water flow and runoff in a critical biodiversity area. lt uses future scenarios to suggest vegetation restoration for sustainable water management.
6. Coa tal China: Studies how climate and **land** use changes impact runoff in densely populated coastal areas. Precipitation and urbanization arc key factors, emphasizing the need for adaptive waler management strategies.
7. Southern Alps (Europe): Investigates how land use and soil properties affect runoff and erosion. Tt highlights soil conser ation strategies to prevent erosion and maintain hydrological stability.
8. Naeli River Basin (China): Examines climate and land use impacts on water flow in a key agricultural area. Climate change and shifting land use patterns require adaptive management to secure water resources.
9. US Watersheds: Looks at how land cover data impacts water flow models. Resampling methods affect predictions, and the study emphasizes refining these methods to improve

modeling accuracy.

ln essence, all studies underline the critical role 01·sustainable land and water management in maintaining ecosystems and supporting human needs.

II. LITERATURE REVIEW

1. Lucy. A. Goodridge Kainer: This study compared the performance of two rainfall-runoff methods, Curve I umber (CN)and Green and Ampt (G & amp; A), within the SWAT model to simulate stream flow across different land use types. Using a Bayesian uncertainty framework, the study assessed how model parameters, input data, and structure influence predictions, with results showing that C models performed better in agricultural and forested areas, while G & amp; A outperformed CN in urbanized sub watersheds. The G & amp; A method was particularly effective **in** capturing peak flows and the flashier behavior of urban hydrographs, thanks to its better handling of rapid hydrologic responses. In contrast, CN methods struggled in urban settings, tending to overestimate precipitation to simulate high flows. While G & amp; A showed slightly wider uncertainty bands, it provided better coverage of observed strcamflow, especially In developed areas. The study underscores the importance of choosing the right runoff method based on land use, with G & amp; A being more suitable for urbanized regions and Ci better for agricultmal and forested areas.

2. Guo Wenxian, Lonj YU: This study explores how land use changes impact hydrological processes in the Min River Basin, China, by combining land use predictions with hydrological simulations. Using the PLUS model to predict future land use and the SWAT model to simulate runoff, the research compares two scenarios: one with minimal restrictions (inertia clcvclopmcnt) and one focused on ecological protection. The results show that rapid urban expansion increases surface nmoffand reduces groundwater recharge, while promoting woodland growth helps mitigate these effects. The study underscores the importance of managing land use to protect water resources and biodiversity. It also suggests that future research should consider the combined effects of climate change and land use changes on hydrological processes.

3. Ali Tas Dighi, Mazdok Arab: This study explores how land use changes in coastal catchments and water quality affect fish communities in estuaries, focusing on the role of mangroves and other coastal ecosystems. The researchers hypothesize that estuaries with more preserved natural habitats will have better water quality and more diverse fish populations, while those surrounded by urban and agricultural land will show poorer water quality and lower fish diversity. Surveys were conducted in five estuaries in southeast Queensland, Australia, from 2017 to 2020, using underwater video to record fish species and abundance. The study found that fish species richness, abundance, and diversity were higher in areas closer to the estuary mouth with lower chlorophyll-a (Chi-A) concentrations and more natural habitats in the catchment. The analysis also identified key indicator species associated with high and low Chi-A levels which could help inform coastal management practices.

4. liTasdighi: This snidy investigates the performance of two rainfall-runoff methods, the Curve Number (CN) and Green and Ampt (G&A), within the SWAT model, focusing on the uncertainties in sh·camflow simulations. lt evaluates how unccrtaintic • **trom** model parameters, inputs, and structure affect streamtlow predictions at various locations within a mixed-land use watershed. The findings suggest that while both methods performed similarly at the watershed outlet, G&A provided more realistic internal hydrological process simulations, especially in areas with developed land. The study emphasizes the importance of accounting for input data uncertainty and the broader hydrologic regime when selecting runoff models for complex watersheds.

5. Duong Dang Khoi:Thc urban drainage system constantly facing nooding issues in coastal and urban areas. RobLtSt and accurate urban flood management, particularly considering fast-

moving compound floods, is crucial to minimize the impact of flood disasters in coastal cities. Till now, Ho Chi Minh City (HCMC) lacks an effective means of urban flood management because of flood risk communication among residents. Existing nood risk communication tools rely on post-disaster flood model outcomes and data. Therefore, this research proposes a real- time Early Urban Flooding Warning System (EUFWS) integrated with a user-friendly web and app interface.

6. Masoomeh Yaghoobi: This study examines how changes in land use in the Gorgan River Basin, Tran, have impacted water yield services over the past JO years and predicts future trends up to 2040. Using satellite images and models Iike Land Change Modeler and Invest, the research considers three scenarios: continuity, conservation, and mitigation. Results show that agricultural land changes have led to fluctuations in water yields, \Vith a projected I 3.6% increase in water yield by 2040 under the continuity scenario. The findings emphasize the importance of land management strategies to maintain water resources in the basin.

7. Manuele Bettoni: Jn mountain regions like th Onscrnonc Valley in Switzerland, soil is highly vulnerable to erosion, especially due to changes in land use. Abandoning agricultural activities can lead to a decrease in soil maintenance, resulting in unstable terraces and exposed soil, which increases the risk of erosion. However, land use changes significantly affect surface runoff, especially when soil becomes water-repellent, but they do not always lead to significant erosion unless the soil is left exposed. Using rainfall simulators in controlled conditions, the study measures how different land uses and soil properties influence runoff and soil erosion in this area.

8. Alberto Bostno: The paper presents HOTSED, a GTS- based model for identifying hotspots of sediment dynamics at the watershed scale. The model integrates geomorphic data with structural and functional aspects of connectivity to a i;::,s sediment source areas and their hazard potential. It was tested in the Val d' Arda-Mignano watershed in Italy, an area affected by complex gcomorphic processes like landslides and soil erosion. HOTSED provides a comprchcnsivc sediment hazard map that helps in managing watershed and reservoir areas. The study emphasizes the importance of both structural and fi.mctional sediment connectivity for effective watershed management.

9. David M. Barnard: Agriculture in the western U.S. relies heavily on mountain snowpacks and strcamflows, but these water sources are becoming increasingly unpredictable due to wildfire impacts and climate change. Wildfires can disrupt snow accumulation, alter melt timings, and degrade water quality, which complicates water forecasting for irrigation. The challenge is further exacerbated by a lack of integrated research linking source-water systems to agricultural water needs, creating uncertainty in water supply forecasting. To address these issues, researchers advocate for better data collection, advanced modeling, and more flexible irrigation management strategics, emphasizing the need for a systems-level approach to water resource management and agricultural adaptation.

10. Cliarle c. Rhoades: Agriculture in the western U.S. depends heavily on, at r from mountain snowmclt, but climate change and w1ldtire are creating uncertainty in water supply forecasting. Wildfires impact snow accumulation, snowmelt timing, and strearntlow, making it harder to predict water availability for farming. This uncertainty challenges irrigation planning and crop selection, as well as the management of water infrastructure Like reservoirs. To ensure sustainable farming, it's crucial to better understand how changes in mountain watersheds affect water resources and improve forecasting models that account for these changes.

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