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Proceeding Paper

Evaluating the Impact of the Billion Tree Afforestation Project (BTAP) on Surface Water Flow in Tarbela Reservoir Using SWAT Model †

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Abstract: Khyber Pakhtunkhwa launched the Billion Tree Afforestation Project (BTAP) in 2014. Pakistan also initiated a "10 billion trees in five years" project in 2018. The soil and water assessment tool (SWAT) model was used to forecast the impacts of LULC changes on water yield under three scenarios: before planting, after 1 billion trees planted, and after 10 billion trees planted. Model calibration and validation were undertaken at the Bisham Qila gauging station from 1984 to 2000 and 2001 to 2010. The Tarbela reservoir's mean annual runoff declined from 53.70 mm to 45.40 mm after 1 billion trees planted, while under the third scenario it approximated 35.05 mm.

Keywords: billion tree project; Terbela reservoir; SWAT model; sediment load; water yield

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1. Introduction

Surface runoff with sediment is caused by erosion. Precipitation (snowfall and rain) and land cover affect soil erosion and runoff [1]. Urbanization increases runoff and sedimentation, reducing infiltration [2]. In the Tarbela reservoir, surface runoff has the greatest impact on sedimentation [3]. Land use change affects runoff and sediment flow. Khyber Pakhtunkhwa (KPK) launched the Billion Tree Afforestation Project (BTAP) in 2014 to meet the country's water needs and to mitigate and adapt to climate change. On 3 September 2018, Pakistan's prime minister announced the planting of 10 billion plants across the country, 3 billion of which will be planted in the upper Indus Basin. By 2024, 10 BTAP projects will be completed [4]. We hypothesized that BTAP plantations would reduce the Indus River surface water flow.

There have been no published studies that described the surface runoff at Tarbela reservoir after BTAP planting. We used the SWAT model to calculate the effect of LULC on streamflow. We used three LULC datasets to simulate the SWAT model. Before BTAP planting, stream flow was determined using LULC data. The second scenario used 1 billion trees' LULC data. In the third scenario, LULC was used after 10 billion trees were planted.

2. Materials and Methods

2.1. Study Area

The study area was the Tarbela Dam drainage basin, one of Pakistan's largest reservoirs [5]. Terbela Dam is situated at 34°05′23″ N and 72°41′54″ E on the Indus River in Haripur and Swabi. It is 143 m high [4].

2.2. SWAT Model

To simulate hydrological processes, SWAT needs climate variables, LULC, soil data, and river basin management [6]. SWAT can be discretized by grid or aggregated, in addition to HRU [7]. This study used HRU-based discretization. Figure 1 shows the method's flowchart.

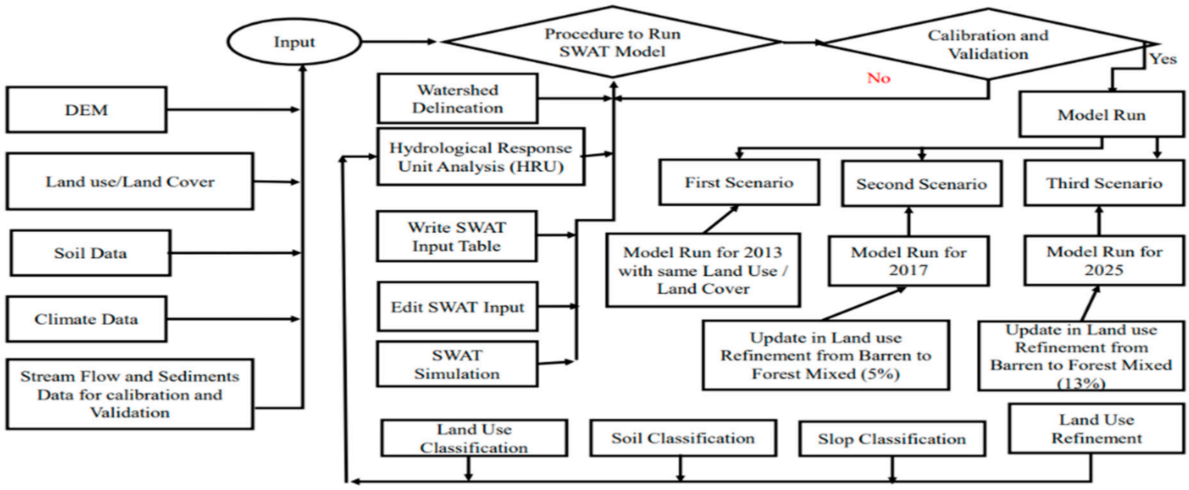

Figure 1. Workflow chart of methodology [8].

2.3. LULC Scenarios

In land use refinement, land use classes were updated according to changes in the study area, from barren to forest cover. After recreating HRU, the entire forest in the study area expanded as land use was updated. In scenarios 2 and 3, this tool changed barren land into forest. The second scenario was considered from after 1 billion trees were planted until 2017. In scenario 3, 10 billion trees will be planted by 2024, of which 3 billion will be in our study area [4]. In the second scenario, after planting 1 billion trees, 5% BARR land became 5% forest mixed, and in the third scenario, 13% barren land became 13% forest-mixed (FRST); these land use percentages were updated, respectively, in land use refinement.

3. Results

3.1. Calibration and Validation

In this study, calibration and validation of the SWAT model were done at Bisham Qila station. Monthly calibration occurred from 1984 to 2000, and monthly validation from 2001 to 2010. SWAT-CUP SUFI2 was used for calibration. The calibration results were promising, indicating a high model performance that can be used to examine land use and land cover effects on sediments and stream flow.

Figure 2 and Table 1 show the calibration and validation results. The calibration and validation values for R2, PBIAS, and NSE ranged from 0.84 to 0.88.

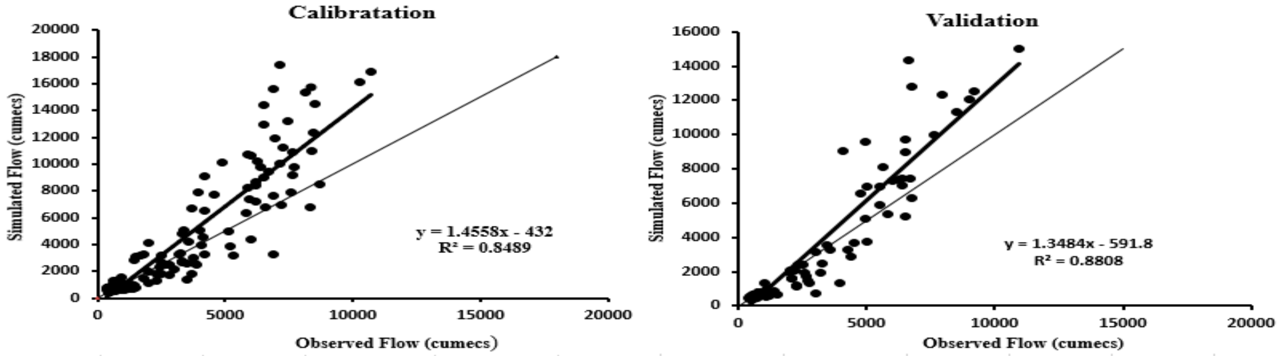

Figure 2. SWAT model calibration and validation results.

Table 1. The calibration and validation values.

Performance Indicator	Calibration	Validation (Water Yield)
R^2	0.85	0.88
PBIAS	11.2	9.4
NSE	0.84	0.86

3.2. Impacts of BTAP on Water Yield

Figure 3 shows SWAT sub-basin water yields for 2013, 2017, and 2025. It includes model-developed water yield components. The first, second, and third sub-basin scenarios yielded 54 mm, 45 mm, and 35 mm of water annually, respectively.

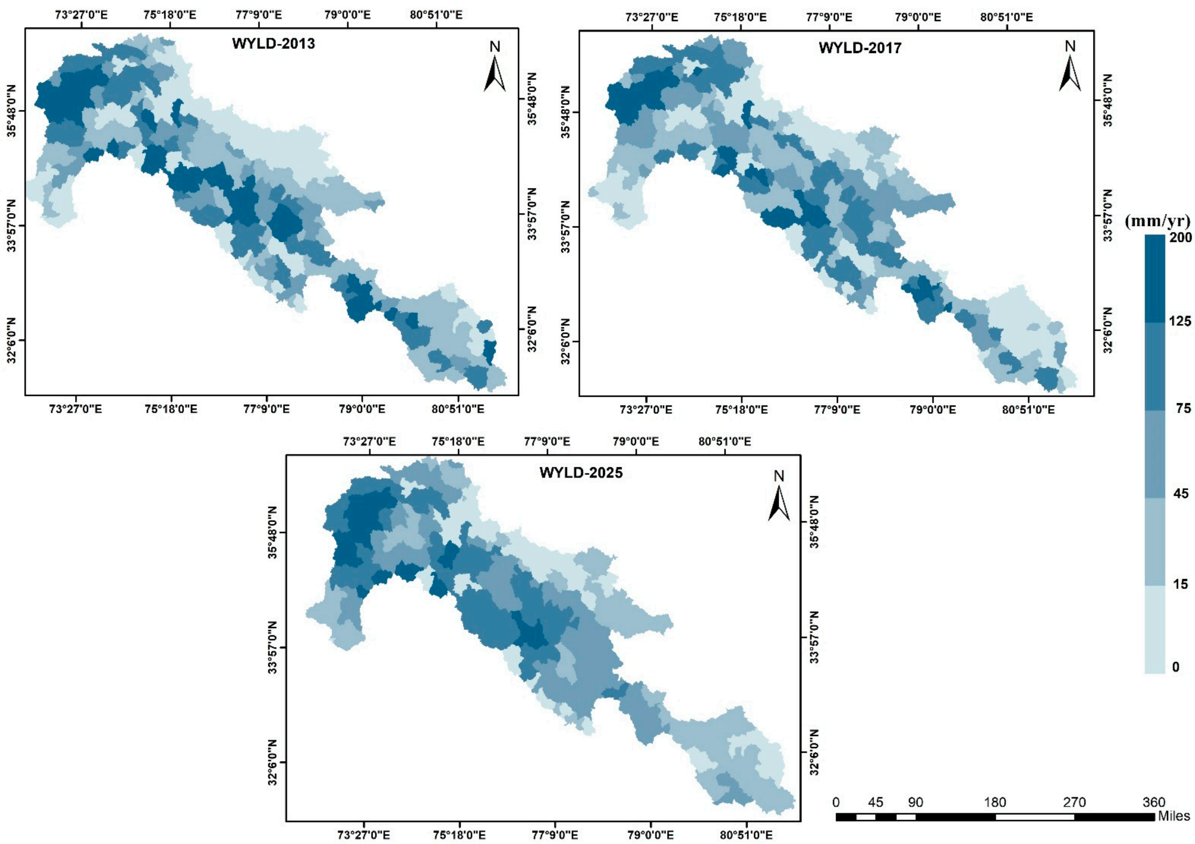

Figure 3. Spatial distribution of water yield for three scenarios (2013, 2017, and 2025) in sub-basins.

Figure 4 shows the model results compared for accumulated water yield at the last sub-basin (300), an inlet of the Tarbela reservoir. After planting 1 billion trees, the peak monthly flow decreased from 14,300 m^3/s (in 2013) to 14,225 m^3/s (in 2017). After 10 billion trees planted, peak flow was reduced by 12,100 m^3/s. Increased forestation from 2013 to 2017 reduced the annual flow by 18%. SWAT evaluation indicates that a 13% rise in forest cover would cause annual flows to drop by 26% from 2013 to 2025.

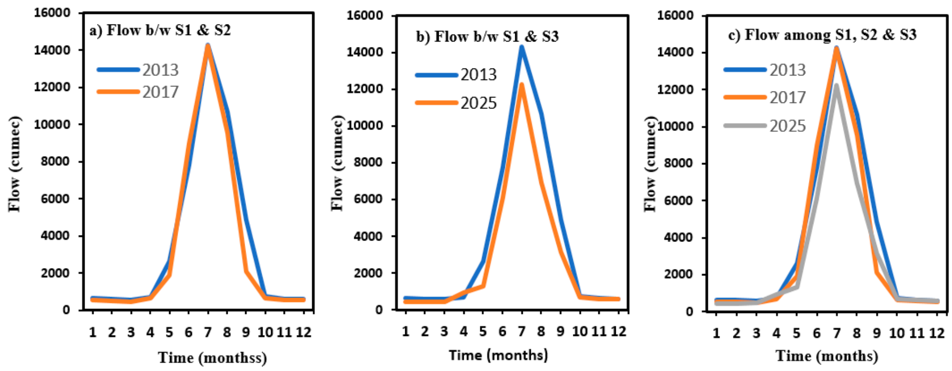

Figure 4. Monthly stream flow comparison between first, second, and third scenarios.

4. Conclusions

Simulations showed that increasing tree planting reduces water flow. A 3% increase in forest cover (after one billion trees) reduced reduce surface water flow by 18%, and a 13% increase (after three billion trees) reduced water flow by 26%, and sediment flow also reduced, respectively. The effect of BTAP on runoff shows that the Tarbela Dam area needs more forest cover. To stop runoff and sediment from getting into reservoirs, it is suggested that the Indus watershed be managed properly.

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