Comparative Impact Assessment of Climate Change and Land-Use Alteration on Decadal Water Balance Components: A Case Study on The Baitarani River Basin, Odisha

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Abstract

Water Balance Components (WBCs), the most fundamental processes of a river basin, are getting disturbed by climate change and land-use alterations in the present scenario. These two factors are the major driving force behind the spatio-temporal variation of the WBCs that creates an alarming concern for fulfilling water demand by different sectors. The popular hydrological model Soil and Water Assessment Tool (SWAT) is applied to the Baitarani River basin (12,095 km^2) of eastern India for evaluating the dominance of the above factors on the WBCs deviations at a decadal scale (1980-1989, 1990-1999, and 2000-2009). A quantile regression-based stochastic approach has been used to analyze the uncertainties resulting from different simulations accounting the combined responses of climate change and land-use alterations as well as model parameters. However, such analysis has not been explored more for the present study area. The model performance results reveal that the statistical performance indices (NSE and R^2) are within the acceptable limit. The WBCs in terms of evapotranspiration, surface runoff, lateral flow, water yield, soil moisture storage, and deep aquifer recharge has been quantified at a decadal scale from the simulated model outcomes. The result shows that the water yield component is more (680.36 mm) for mid-decade (1990-1999) as compared to other decades, which is favourable to fulfill sectoral water demand. Further, the uncertainty analysis explains that climate change impact plays a vital role in WBCs variation. The developed approach can portray the variability of WBCs of other river basins that are vulnerable to climate change. The outcomes of this study can be used to maintain an appropriate balance between water availability and demand to avoid water scarcity. Keywords: Water balance components; Climate change; Land-use Alterations, Brahmani; Baitarani

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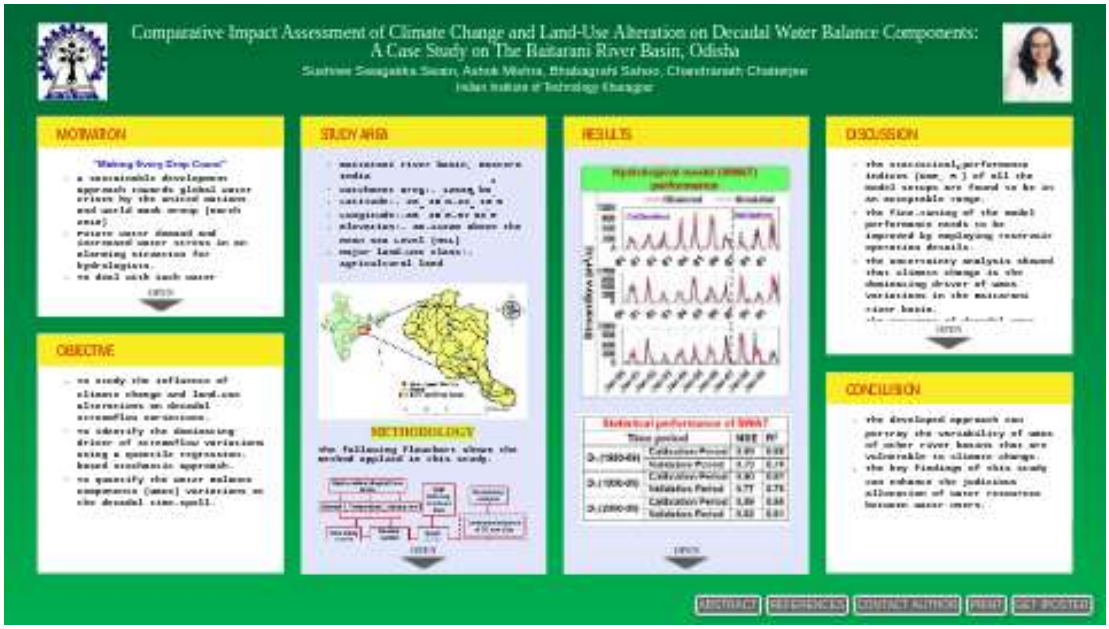

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ABSTRACT

Water Balance Components (WBCs), the most fundamental processes of a river basin, are getting disturbed by climate change and land-use alterations in the present scenario. These two factors are the major driving force behind the spatio-temporal variation of the WBCs that creates an alarming concern for fulfilling water demand by different sectors. The popular hydrological model Soil and Water Assessment Tool (SWAT) is applied to the Baitarani River basin (12,095 km2) of eastern India for evaluating the dominance of the above factors on the WBCs deviations at a decadal scale (1980-1989, 1990-1999, and 2000-2009). A quantile regression-based stochastic approach has been used to analyze the uncertainties resulting from different simulations accounting for the combined responses of climate change and land-use alterations as well as model parameters. However, such analysis has not been explored more for the present study area. The model performance results reveal that the statistical performance indices (NSE and R^2) are within the acceptable limit. The WBCs

in terms of evapotranspiration, surface runoff, lateral flow, water yield, soil moisture storage, and deep aquifer recharge has been quantified at a decadal scale from the simulated model outcomes. The outcome of decadal WBCs analysis reveals that the water yield component is increasing towards the end decade (2000-09), which is favourable to fulfill sectoral water demand. Further, the uncertainty analysis explains that climate change impact plays a vital role in WBCs variation. The developed approach can portray the variability of WBCs of other river basins that are vulnerable to climate change. The outcomes of this study can be used to maintain an appropriate balance between water availability and demand to avoid water scarcity.

Keywords: Water balance components; Climate change; Land-use Alterations, Brahmani; Baitarani

MOTIVATION

"Making Every Drop Count"

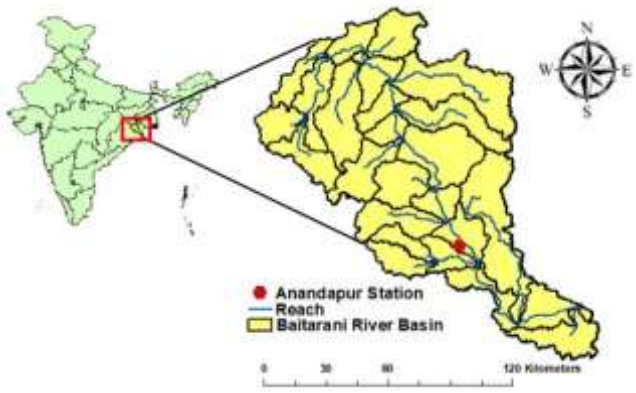
- **A sustainable development approach towards global water crises by the United Nations and World Bank Group (March 2018)**
- **Future water demand and increased water stress in an alarming situation for hydrologists.**
- **To deal with such water conflict issues, it is necessary to study the variations in water availability, its causes, and effect at different time-spell.**

OBJECTIVE

- **To study the influence of climate change and land-use alterations on decadal streamflow variations.**
- **To identify the dominating driver of streamflow variations using a quantile regression-based stochastic approach.**
- **To quantify the Water Balance Components (WBCs) variations at the decadal time-spell.**

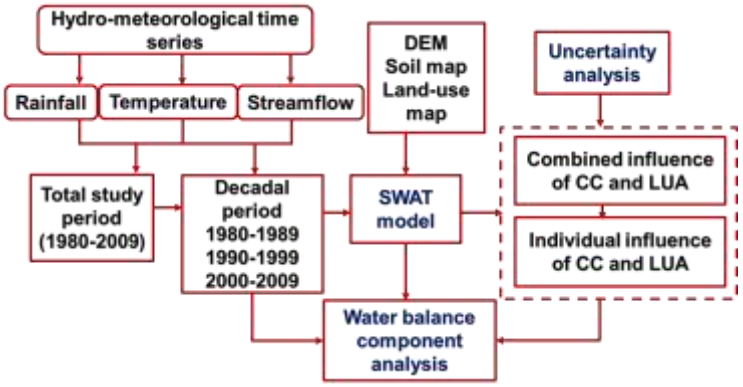
STUDY AREA

- **Baitarani river basin, Eastern India**
- **Catchment area:- 12095 km^2**
- **Latitude:- 20° 35′N-22° 15′N**
- **Longitude:-85° 35′E-87°03′E**
- **Elevation:- 3m-1192m above the Mean Sea Level (MSL)**
- **Major land-use class:- Agricultural land**

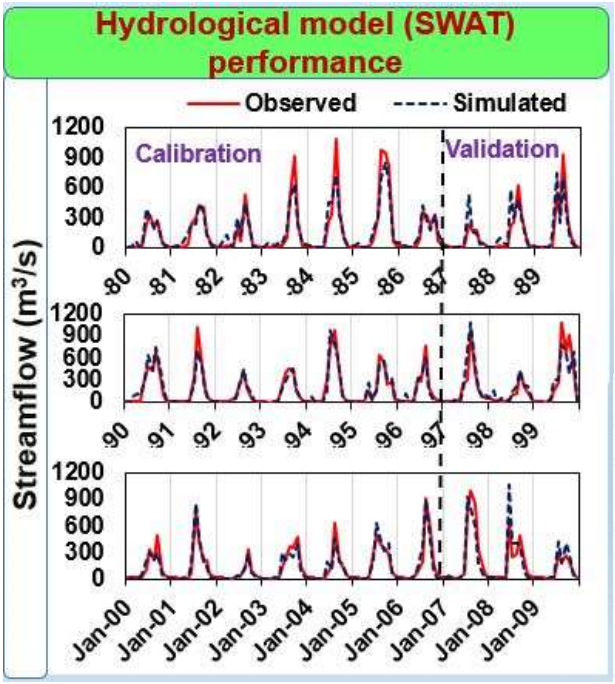


METHODOLOGY

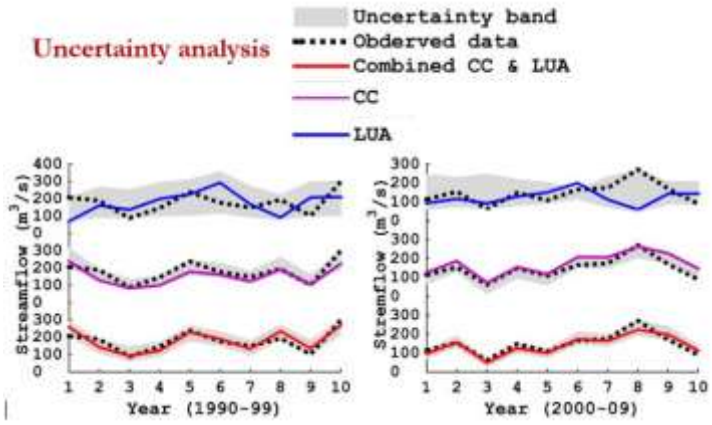
The following flowchart shows the method applied in this study.

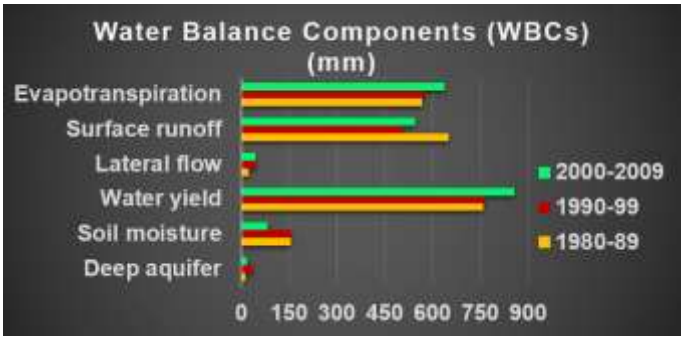


RESULTS



Statistical performance of SWAT			
Time period		NSE	R^2
D_1 (1980-89)	Calibration Period	0.89	0.88
	Validation Period	0.79	0.76
D_2 (1990-99)	Calibration Period	0.90	0.91
	Validation Period	0.77	0.78
D_3 (2000-09)	Calibration Period	0.89	0.90
	Validation Period	0.82	0.81





DISCUSSION

- The statistical performance indices (NSE, R^2) of all the model setups are found to be in an acceptable range.
- The fine-tuning of the model performance needs to be improved by employing reservoir operation details.
- The uncertainty analysis showed that climate change is the dominating driver of WBCs variations in the Baitarani river basin.
- The outcomes of decadal WBCs analysis reveal that the water yield component is increasing towards the end decade (2000-09), which is favourable to fulfill sectoral water demand.

CONCLUSION

- The developed approach can portray the variability of WBCs of other river basins that are vulnerable to climate change.
- The key findings of this study can enhance the judicious allocation of water resources between water users.

REFERENCES

Swain, S. S., Mishra, A., Sahoo, B., & Chatterjee, C. (2020). Water scarcity-risk assessment in data-scarce river basins under decadal climate change using a hydrological modelling approach. Journal of Hydrology, 590, 125260.