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Review of Soil and Water Assessment Tool for Watershed Analysis in India and China: Opportunity and Challenges

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Abstract: Development of water resources and its management on larger scale is done with the help of modelling nowadays. Integrated water management of large areas should be accomplished within a spatial unit (the watershed) through modelling Concerns that motivated the development of extensive hydrological modelling includes climate change, water supply check in arid regions, flooding at larger scales, and land management externalities. A conceptual, continuous time model called SWAT (Soil and Water Assessment Tool) was developed to assist water resource managers in assessing the impact of management on water supplies and non-point source pollution in watersheds and large river basins. This paper attempts to analyse the use of SWAT in India and China on regional basis. A detailed review of literature has been done to fulfil the study. It was found that most of the works are attributed to civil engineers. Geographers are carving out a niche for themselves in the mentioned field. As geographers study about weather, climate, humidity, sunshine, moisture, soil properties etc. which work as inputs for SWAT, they can get familiar with the model and use it in their field. Although, their part has increased in last decade, more awareness is required. The limitations of the model and its applicability in Indian watersheds have also been analysed. Some suggestions have also been provided by the authors.

Keywords: *Hydrologic, Modelling, SWAT, India, China, Review, Geographers*

Introduction: Due to the increasing demand for water resources, the pressure on their prudent use is increasing. Water is not only precious but also a very complex product. The dynamic nature of time and the spatial variability of the landmass contributes to the dynamic behaviour of the watershed response to natural and artificial water inputs. This requirement has led to the formulation of continuous simulation models for water balance with distributed parameters that can provide information on the distribution and use of water in a watershed. By mimicking the prevalent natural processes in the region, they can provide many answers that are not usually readily available otherwise. Investigating the continuous daily flow of precipitation in arid and semi-arid regions is difficult, especially when climate data is limited, time-consuming or unavailable. A calibrated and validated model to simulate hydrological processes will be of great help to the management of the affected watersheds.

A watershed or river basin is an area that integrates various hydrological processes such as precipitation, snowmelt, evapotranspiration, infiltration, surface runoff, and subterranean flow. Hydrological modelling involves the formulation of mathematical models to represent these hydrological processes and their interactions. For example, hydrological modelling takes into account the relationships between soil, water, climate and land use and presents them through mathematical representation (Gosain et al., 2009). This can be difficult as it involves highly non-linear processes, complex interactions and high spatial variability at the pelvic level. From the mid-19th century, the development of hydrological modelling continues with an understanding of physical processes, computational effort, and data recovery capabilities.

In water resource studies, runoff is the most important hydrological variable used. Estimating the direct outflow of non-measured river basins is difficult and time consuming. Traditional models of runoff prediction require extensive hydrological and meteorological data. Many models have been developed for watershed hydrology, but the availability of time and geospatial data has been the major obstacle to implementing these models, especially in developing countries. Remote Sensing and Geographic Information Systems (GIS) and appropriate rainfall runoff models are ideal tools for estimating direct runoff, peak flow, and hydrographs. However, the development of Remote Sensing and Geographic Information Systems (GIS) has influenced and improved the widespread adoption of these models worldwide.

A watershed is a natural physiographic or ecological entity made up of interdependent parts and functions. Information on rainwater is highly relevant given the acceleration of the program for the management of river basins for the conservation and development of natural resources and their management. Knowledge of river drainage gives an idea of what water is available to replenish waters in the water catchment area, which is of great importance to drinking water and agricultural water management. In addition, quantification of runoff, understanding of various hydrological components, and water budgeting provide insights into the possibilities of rainwater harvesting (Welderufael et al., 2009), as well as future plans and options. Management. A hydrological model can build a precipitation-runoff relationship and predict future flow-rate values for hydrological and hydraulic design. Hydrological models are classified into deterministic (physical), parametric (empirical) and mathematical models (Dawson and Wilby, 2001).

Mathematical models are much more popular for assessing runoff because they are less data-based, simpler and less expensive (Fontaine et al., 2002). The deterministic model is based on the physical laws of mass and energy transfer and the empirical model represents simplified hydrological processes. Remote Sensing (RS) and Geographic Information System (GIS) technical development has promoted and improved the increasing use of watershed models around the world. GIS is a suitable instrument for the efficient management of large and complex databases and digital representation of the features of hydrographic basins used in hydrological modelling. It has increased confidence in modelling accuracy by providing a more practical approach to watershed conditions, defining watershed properties, improving the efficiency of the modelling process and increasing the estimation capabilities of the watersheds. hydrological modelling (Bhuyan et al., 2003).

Quantitative hydrological models are useful tools to support the development of new strategies for water resource management and assessment of water quality issues (Beven 2011, Abbaspour et al., 2015). Among these models, the Soil and Water Assessment Tool (SWAT) (Arnold and Fohrer 2005, Arnold et al., 1998) is widely used for water catchment areas around the world (Song et al., 2011, Nerantzaki et al., 2015, Schmalz et al., 2015, Guse et al., 2016, Malago et al., 2016). In recent decades, the integration of modules to assess the effects of various hydrological and chemical processes has continuously improved the SWAT model (Gassman et al., 2007). SWAT is often used by both the global academic community and practitioners. This model has proven to be an effective tool for simulating hydrological processes, pollutant transport, soil erosion, water households and assessing the effects of climate change, land use change and climate change. Water management practices under various environmental conditions (Abbaspour et al., 2007 Guo et al., 2008, Rahman et al., 2013, Baker and Miller, 2013, Dile et al., 2016, Woznicki et al., 2016; et al., 2016).

Advantages of SWAT model: The SWAT model, developed by the Agricultural Research Service (Arnold et al., 1996), simulates the hydrological cycle as well as the growth cycles of plants and roots as well as the daily harvest and decomposition. It also includes routines to simulate the separation of sediments from river basins and their transport through river systems. The SWAT model was developed to transport water and sediment from individual water catchment areas through key water intake systems. Tanks and tanks can be installed both upstream and downstream. Agricultural land can be irrigated with diversions from the sub-basin or from outside the sub-basin. The main advantage of the model is that, unlike other conventional concept simulation models, it does not require much calibration. With the model existing and planned uses as well as water scarcity can be evaluated. The model provides a complete representation of the amounts of water that are: fed to the ground by precipitation; Enter currents as outflow; are used by natural vegetation, agricultural crops and evaporation and returned to the atmosphere; and seep through the root zone and return partly as a contribution of groundwater. The SWAT model has been linked to many platforms. One of the most versatile is the interface to the ArcView GIS system (AVSWAT). AVSWAT (User's Guide, 1999) was used in this study for pre and post processing of SWAT input / output data.

It is expected that climate change will exacerbate water stress in Central Asia in the near future (Siegfried et al., 2012), as the vast majority of arid lowlands in the region rely heavily on glacier meltwater provided by the Tienshan Mountains, known as the "water tower" of Central Asia (Hagg et al., 2007, Sorg et al., 2012, Lutz et al., 2014).

Since the watershed is the fundamental science unit, it requires proper planning and management, which will be of greater benefit to society. The integrated approach to developing watersheds with digital revolution technology has been used over the last decade. In addition, modelling of watersheds using computer models, remote sensing and GIS is being used in several areas. The application of software engineering in the field of civil engineering has yielded more accurate results than other techniques. It has also been used in various applications of water resources engineering, and there are still many areas to discover that can be discovered using soft computing. Watershed modelling is one of the important aspects of water resource engineering where soft computing can play an important role. Modelling of various catchment area parameters such as rainfall, runoff, infiltration, soil erosion will benefit society.

Insights regarding the surveyed Chinese and Indian SWAT literature: Urbanization in China and India have been on an increase which has led to burden on natural resources. To help manage these resources, more research is being conducted. China has published more papers than India using SWAT model. China has explored all aspects of the model and in fields not only related to academic. However, SWAT's popularity and application has increased over the last decade in India. Indian researchers have focussed more on water quality and availability aspect of the model and much of the studies are in the academic domain.

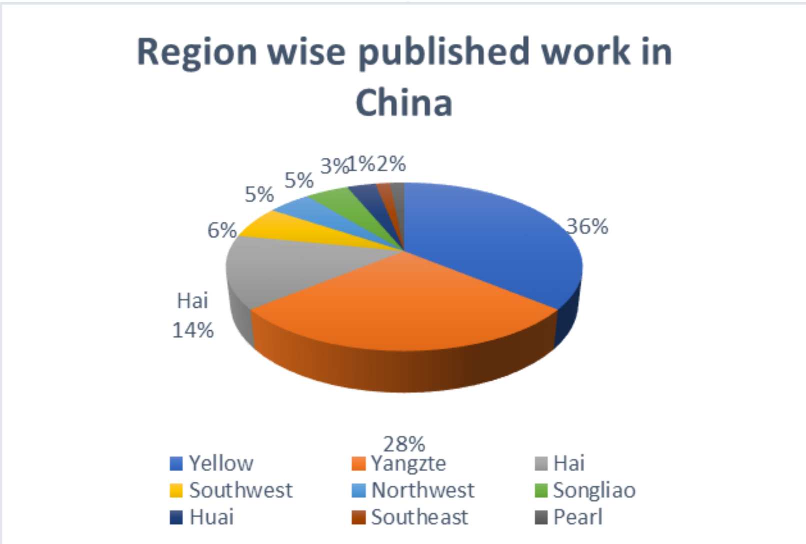

Figure 1: SWAT work in China

Source: SWAT literature database

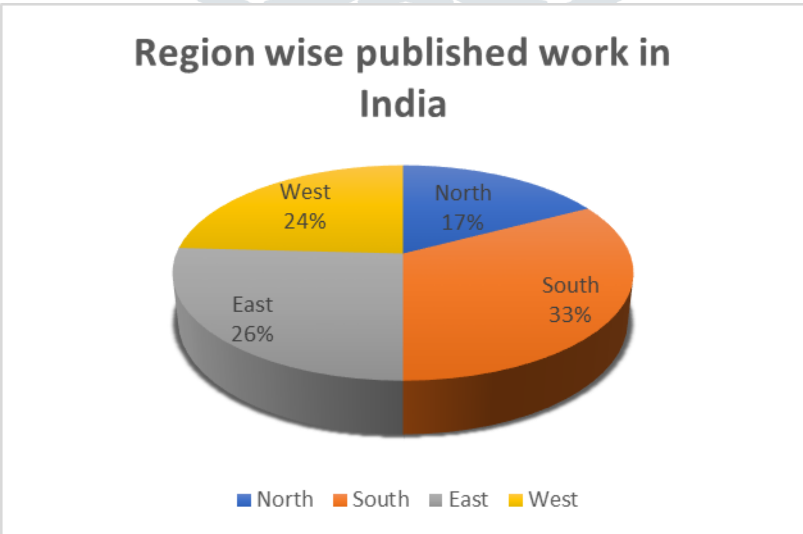

Figure 2: SWAT work in India

Source: Author

Serial number	Basins	Number of Applications	Applied Field
1	Yellow	23	Climate and Land use change
2	Yangzte	18	Pollutant loading
3	Hai	9	Hydrology assessment
4	Southwest	4	Climate and land use change
5	Northwest	3	Climate and land use change
6	Songliao	3	Hydrology assessment
7	Huai	2	Impoundments
8	Southeast	1	Interface
9	Pearl	1	Pollutant loading

Overview of SWAT Applications in China

Hydrological models are nowadays intensively used in developing countries such as China and India to keep a track on water resources in awe of changing climate scenarios. SWAT's use and familiarity is expanding among Asian students, professors and professionals, which has resulted in dozens of hydrological and/or pollutant transport evaluations in these watersheds.

SWAT hydrologic testing: Kaur et al (2003) estimated water and sediment yield data using SWAT in a 92.46 sq km catchment of Damodar-Barakar basin in Hazaribagh district of Jharkhand. Runoff was simulated in Dal watershed (189 sq km) of Kashmir in 2019.

Future outlook : With the advances in data entry and analysis and information technology, the future of hydrology seems even more promising. It is expected that new tools will be made available to hydrology. For example, drones are becoming common place for acquiring geospatial data. Hydrological models will be so easy to use that only little knowledge of hydrology is needed to make them work. Nor does a car engineer have to drive a car or an electrician operate an electrical system. Any model, simple or complex, is linked to a statement about uncertainty. The new frontiers of hydrology will evolve through the use of mobile phones and new information technologies. The hydrological forecasting capacity will multiply.

Watershed modelling includes an in-depth study of pollutant transport based on various surface and subsurface features, including the interfaces between them. Specific research and progress is focused on the subcomponents of water catchment modelling. Other areas to consider include the development of guidelines for determining the minimum data resolution requirements, a better understanding of magnification problems and relationships, and the development of lines of evidence. Guidelines for the emerging area for the development of the transport network.

There will be more interaction between the user and the model and the modeller. This has already begun what today is considered social hydrology. Hydrology will play an increasingly important role in addressing the great challenges of this century, such as: For example, water security, food security, energy security, environmental safety, health security and the link between nutrition, water and energy and sustainable development. These big challenges also require educators to review and adapt the supply of hydrological education to train the leaders of tomorrow who are well-prepared for the needs of tomorrow's society. Similarly, research funding agencies need to reconsider and redefine their funding priorities, taking into account these major challenges and pressing societal needs.

Conclusion : The water and energy cycle plays a vital role in understanding the mechanisms of climate change and environmental change in China and India, as water resources are scarce and water resources are rapidly increasing. Population, resulting in significant anthropological impacts on the climate due to land use and greenhouse gas emissions. Anthropogenic greenhouse gas emissions cause an increase in surface temperatures ("greenhouse effect") and can decisively influence the climate and thus the well-being of society. The increase in the human population and the activities of mankind in the last century, caused by the factor 5, the greenhouse gases and aerosols that arise from the burning of fossil fuels, industrial activities and pollution Land use has changed the atmospheric impact. Composition, so it is not the same as a century ago (Mann et al., 1999).

Geographers and researchers in other disciplines are increasingly using hydrological models to study the potential impacts of future climate change and urban development on basin water quantity and quality. Although modelling is an uncertain and probabilistic process, it is a useful methodology for experimenting with the dynamics that govern complex environmental and social systems and for projecting possible ranges of impacts that may be faced by water resource managers over the next several decades.

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