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To,

Dear **Arunima priyadarsini patnaik, and Dr. Bandita Naik**

Subject: (a) Acceptance of Research Paper for ORAL Presentation
(b) Submission of Registration Fee for its publication in Proceedings

Ref.: Paper No. 446 (Impact of Climate Change on Hydrological Parameters)

It is my pleasure to inform you that your above referred research paper has been accepted for ORAL PRESENTATION in the very prestigious International Conference HYDRO-2018-INTERNATIONAL.

You are requested to kindly make online payment of Registration Fee for at least one Author and Co-authors attending the Conference and send the duly filled Registration Form by 25th October 2018. **The research papers are likely to be published in the Proceedings (Springer) only after the receipt of registration fee from the author.** E-poster Template is attached too.

Looking forward to see you in HYDRO 2018 International at NIT Patna.

With kind regards,

(PROF. (DR.) RAMAKAR JHA)

Chair, HYDRO-2018-INTERNATIONAL

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Impact of Climate Change on Hydrological Parameters

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1. Abstract

The increasing rate of global surface temperature is going to have significant impact on local hydrological regimes and thus on water resources, this leads to the assessment of water resources potential resulting from the climate change impacts. Main parameters that are closely related to the climate change are temperature, precipitation and runoff. Therefore, there is a growing need for an integrated analysis that can quantify the impacts of climate change on various aspects of water resources. Quantifying the impacts of land use change and land cover practices on the hydrological response of a watershed has been an area of interest for the hydrologists in recent years as this information could serve as a basis for developing sound watershed management interventions. The degree and type of land cover influences the rate of infiltration, runoff, and consequently the volumes of surface runoff and total sediment loads transported from a watershed. It often results in significant degradation of land resources such as loss of soil by erosion, nutrient leaching and organic matter depletion. However very few studies in India, have used the physically based hydrological models along with the land use / land cover change conditions. Hence in this current work SWAT model has been used to assess the impact of LU/LC changes on daily and monthly streamflow of Mahanadi River Basin of Sambalpur region. The results of the study indicated that the though land use patterns have changed resulting in increase in agricultural, barren and buildup land and decrease in forest cover leading to increase in runoff but changes have not occurred as significantly as the changes in annual stream flow. However the number of days of high intensity rainfall has increased over decade which along with the land use changes explains for the increase in stream flow.

Keywords: *SWAT model, LU/LC changes, daily and monthly runoff*

2. Introduction

2.1 General

Water is the foremost part of all living things, and a major force constantly shaping the human lives on the earth. It is also a key factor in air conditioning of the earth for human existence and in influence the progress of civilization. Among all natural resources water is one of the most important and significant resource found on earth. The redistribution of water through hydrological cycle is also responsible for climate of any place, like daily fluctuations of temperature, precipitation and wind speed and these type of changes in ecosystem affect the hydrological cycle. Over the last 100 years, Odisha is facing an extreme weather condition in the form of natural disasters (flood, drought, heat waves, earthquakes and cyclones). The natural calamities affected 25 of 30 districts of Odisha which results in damages, loss of properties and loss in human lives. Therefore is a necessity to study the impact of climate change on water resource in this region. Increase or decrease in precipitation pattern can result in increase of frequency of flood, droughts and change in water quality. Therefore, it is necessary to carry out analysis to find out calibration and validation of two climatic parameter i.e. temperature and precipitation.

The National Water policy of India (2002) acknowledges that national perspective are needed to regulate the improvement and management of water resources so that the scarce water resources can be developed and conserved in a balance and environmentally sound basis. Impact of land use changes, watershed development to soil loss and growth of population, water quality and quality is among the most worthy topic in a watershed. The hydrological cycle can be distributed due to changes in land use by the alternating the base flow (Wanga*et al.* 2006) and annual mean discharge of the basin (Costa*et al.* 2003). Hydrological model plays an important role in simulating the process of rainfall-runoff, soil erosion, under different situations. Impact of climate change is going to be most serving in the developing countries due to poor capacity.

A hydrological model SWAT (Soil and Water Assessment Tool) model is used in the present analysis. This model is a physically based, continuous-time model, developed by Dr. Arnold for United USDA-ARS (Agricultural Research Service). SWAT model is used to simulate or predict runoff of different basin, sediment yield and pollution loading in watersheds. The model has an ability to use for small watershed as well as the major river basin systems. It is distributed in time interval hydrological model with an Arc GIS interface. Automated model calibration and validation check. Arnold et al. (2000) applied SWAT with addition of a stream flow filter and recession method for regional estimation of base flow and ground water recharge in the upper Mississippi river basin.

2.2 Study area

Mahanadi River is the sixth largest river in India and one of the major interstate east flowing river in peninsular India. The Mahanadi basin lies between latitude of $19^{0}20'$N to $23^{0}35'$N and longitude of $80^{0}30'$E to $86^{0}50'$E.Mahanadi basin is physically surrounded on the north by Central India hills, by the Eastern Ghats in the South and East and by Maikala hill range in the West. The total catchment area of the basin is 141600 sq. km. The river enters in Odisha through Jharsuguda district subsequent to covering about portion of its aggregate length. Before Sambalpur, it meets its tributary Ib. The Ib, which is the third biggest tributary of Mahanadi, ascends in town Pandrapt, Region Raighar (Chhattishgarh) and channels Raigarh region of Chhattisgarh and three district of Odisha, to be specific Sundargarh, Jharsuguda and Sambalpur. After Sambalpur Mahanadi stream take a southerly turn and it is joined by the Ong. The Ong flows towards Sartaipali, Padampur and Bijepur territory of Balangir and Bargarh area of Odisha. Physically, the basin is bounded in the north by the Central India Hills, the Eastern Ghats in the south and east, and the Maikala Hill Range in the west, lying within geographical co-ordinates of 80°30’ E to 86°50’ E and 19°20’N to 23°35’N. Location of study area is shown in Fig-1.

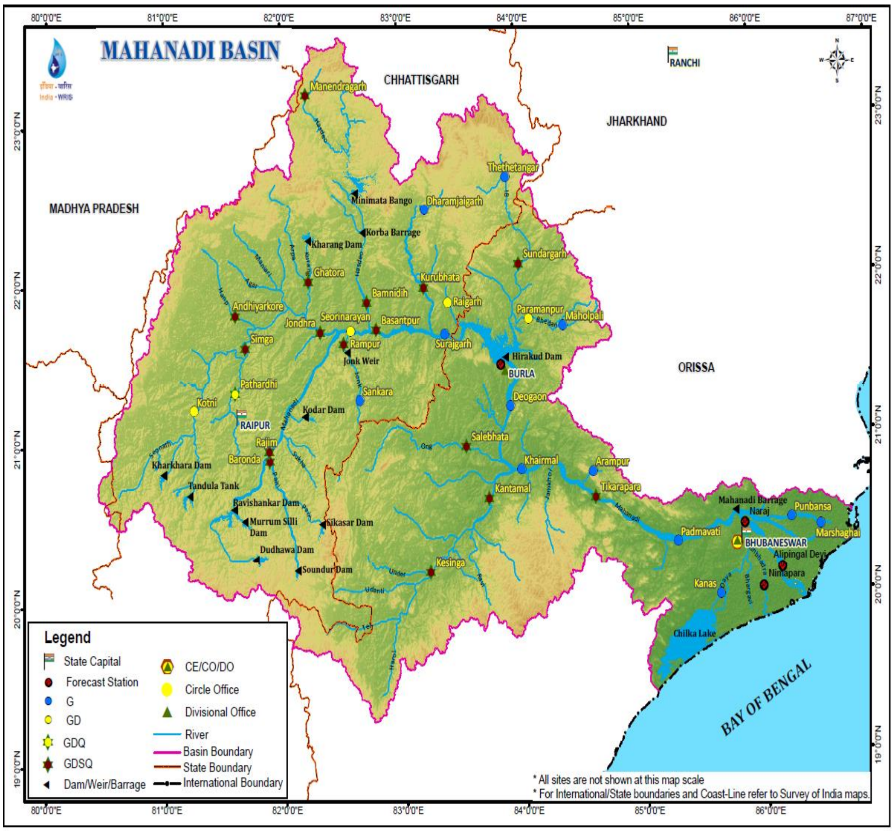

Fig-1: Location of study area (source: India WRIS website)

2.3 Rainfall

Based on the Indian Meteorological Department's (IMD) annual district rainfall figures from 1901–2000, the calculated average rainfall in the Mahanadi basin is 1406 mm. Overall, the Mahanadi basin is a high rainfall region; the lowest annual average being 1080 mm in the Kawardha district of Chhattisgarh, while the Jashpur district of Odisha has the highest annual average rainfall of 1653 mm. The western portion of the basin bordering Maharashtra receives the lowest rainfall. The central part of the basin receives moderate rainfall, while the northern, southern and the delta regions experience the highest rainfall in the basin. Plots the seasonal distribution of rainfall in the basin. Most parts of the basin receives 80–90% of its annual rainfall from the southwest monsoon (i.e. from June to September). However, the amount of rainfall received is dependent on the location in the basin. For example, as compared to the other parts of the basin, the districts located near the delta receive less rainfall (about 60–70% average annual rainfall) between June to September, but receive more rainfall (about 10–22% annual rainfall) from the northeast monsoon (i.e. from October to December). The districts with higher rainfall between October and December also show a marginal increase in the rainfall during March to May as compared to the basin average for this period. Figure 2 shown the Seasonal distribution of rainfall as a percentage of the annual average.

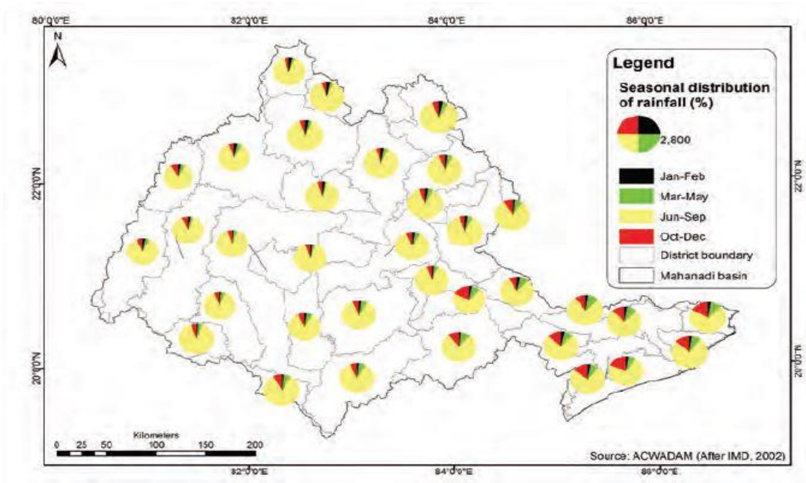

Figure 2: Seasonal distribution of rainfall as a percentage of the annual average

IMD's 100-year district level data was also used to generate trends in the rainfall in the respective districts. Figure 3 shown a map of the linear trends observed on plotting the 112 year (1901–2012) IMD district level data set. Majority of the districts in the basin show a reducing trend computed from the long-term average rainfall. Only two districts each show a constant trend and an increasing trend.

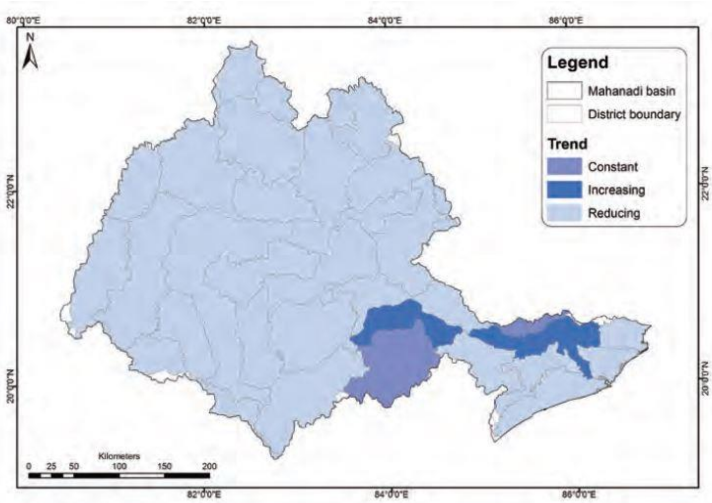

Figure 3: Trends in annual rainfall in the Mahanadi basin
(Source: District level 100 years IMD data)

2.4 Temperature

Daily temperature (maximum, minimum and mean) gridded data (1^0 x $1^{0)}$ for 36 years (1969-2004) collected from IMD has been analyzed. Average monthly temperature variation for 36 years (1969-2004) is given in Figure 4. Three parameters namely minimum, maximum and mean temperature indicates that the December and January are the coldest months with the minimum temperature of 12^0 c. April and May are the hottest months in this region where maximum temperature ranges from 39^0 c to 40^0 c. As compared to eastern portion and delta area, western portion record the lowest and highest temperatures during winter and summer respectively. Highest day temperature recorded in the basin is 50.3^0 c in June, 2003.

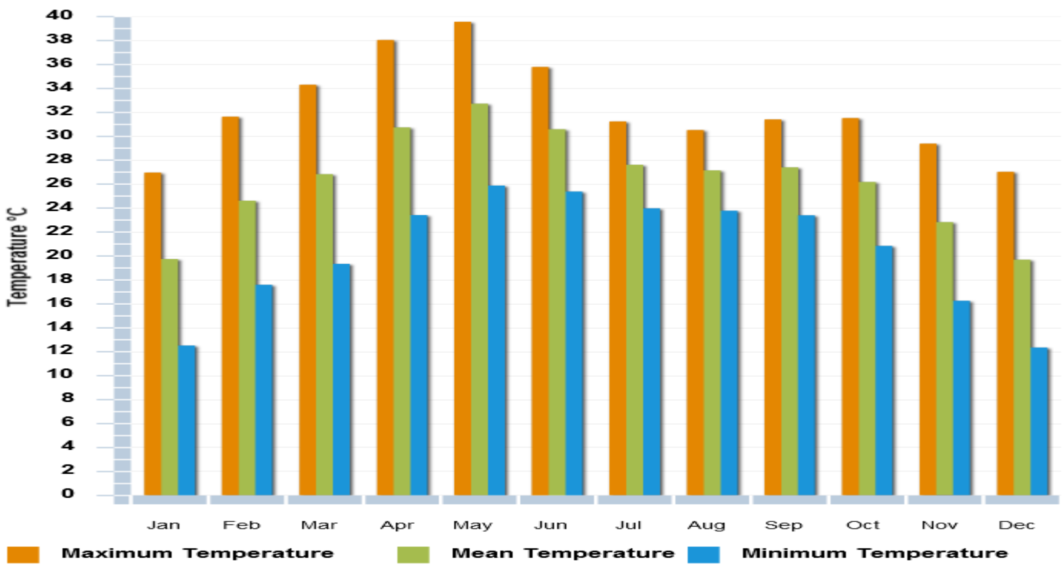

Fig 4: Monthly average temperature (1969-2004) (CWC Report-2014)

2.5 Land Use And Land Cover

Mahanadi valley is the best known for its fertile soil and flourishing agriculture, which preliminary depends on a network of canals that arise from the river. Rice, oilseeds and sugarcane are the principal crops cultivated in Mahanadi valley. The basin has area of about 79,900 km^2 which is about 57% of the basin area and 4% of the total area of country. Except in the coastal plains Odisha, the basin has an extensive area under forests. The sparse vegetation of the highlands contrasts with the moderately luxuriant vegetation of the river valleys. The coastal plains of Odisha, with a high incidence of rainfall, are predominantly rice growth area. The land utilization pattern of Mahanadi river basin comprise of 37.275% forest area, 10.432% cultivated area, 91.137% area with other uncultivated land excluding fallow land, 4.967% fallow land and 38.187% net snow areas as shown in Figure-5. Cultivated area is the total area used for sowing two or more crops in one calendar year. The net snow area is the area snow for each crop but is counted only once. Out of the total annual irrigation water demand of 11km^2 in the basin, the Kharif season utilizes 7km^2 and Rabi season uses 4km^2. Major land use and associated water use changes that have taken place in the basin in the 20th century are related to intensive irrigation of agricultural areas. In the last decade since 2004–05, land cropped in the Kharif season only (i.e. largely rain fed land) has decreased marginally to 30% and land cropped twice or thrice (i.e. irrigated land) has increased substantially, from about 8% to 15%. The largest increases in irrigated land are in the plains of Chhattisgarh, with the development of major irrigation projects in the upper reaches of the Mahanadi and Seonath rivers. Fallow lands in the basin have decreased from about 17% to about 11% (15,507 km2) in the last five years or so. This is in contrast to the MoA data which shows that fallow and cultural wastelands have increased from 7% to about 9% (14,011 km2).

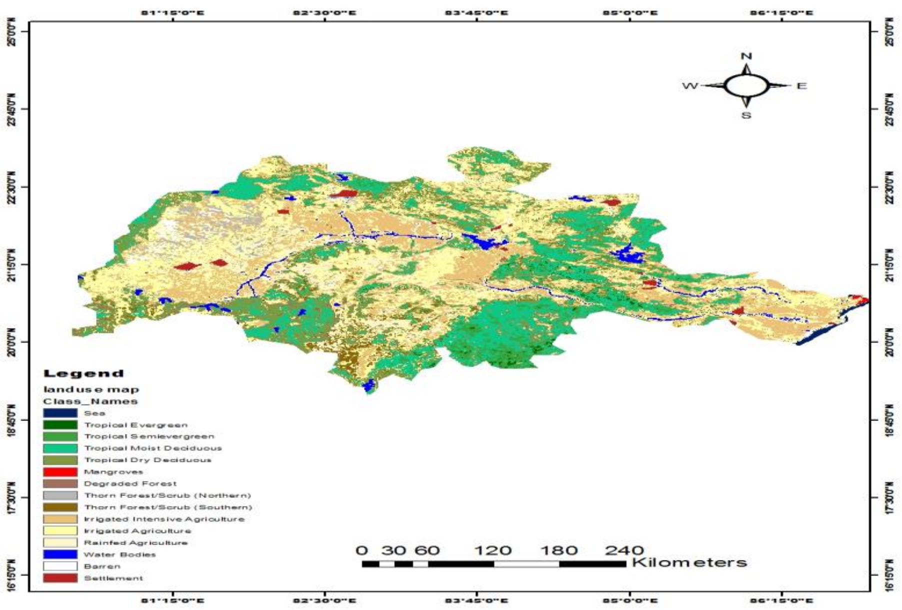

Fig 5: Land use and land cover data for Mahanadi river basin

3 Methodology

3.1 Soil And Water Assessment Tool (SWAT)

The soil and water assessment tool (SWAT) is a continuous, long term, physically based conceptual model. This model operates at basin scale on daily time step (Arnold *et al*. 1998,). SWAT model predicted for impacts of the land use management, sediment and agricultural chemical yield for the development of physically based model. It stimulates the hydrologic cycle in two phase; land phase and routing phase. The land phase aims to control the amount of water, sediment, nutrient and pesticides loading. The routing phase aim to defining the movement of water, sediments etc. through the channel network of the watershed" (Neitsch *et al* 2000). It is a model with Arc GIS interface which has been developed by the USDA-ARS and the Blackland Research and Extension Center (Arnold *et al*. 1998). In this SWAT model, the total catchment is firstly divided into sub-basins or sub-watersheds based on the topographic regions assumed to be lumping further divided into a series of HRUs (Hydrological response units) on the basis of soil, slope and land use combinations. The Green-Ampt infiltration method is one of the options that this model offers to compute excess precipitation at the HRU level, the other one being NCRS curve number method. Simulations are carried out for the components of hydrological cycle, nutrient cycles, sediment yield and aggregate for the sub-basins. The SWAT model can be selected based on the data availability, provides the users with various options when simulation is conducted for the hydrological parameters. The runoff model formed in SWAT is lumped at the sub-basin level, because it computes an average value for spatial varied surface runoff. This one is the limitation of the SWAT model. A SWAT CUP (SWAT Calibration and Uncertainty procedure) model integrate various calibration and uncertainty analysis using the same interface. The SWAT CUP model can run SUFI2 (Abbaspour *et al*., 2007), GLUE (Beven and Binly, 1992) and Parasol (Van Griensven and Meixner, 2006). The SWAT project contains input data and one calibration method to allow user for running a calibration program until convergence is reached. User can save the calibration iteration for the later use. Fig 6 shown the SWAT Model Flow Diagram.

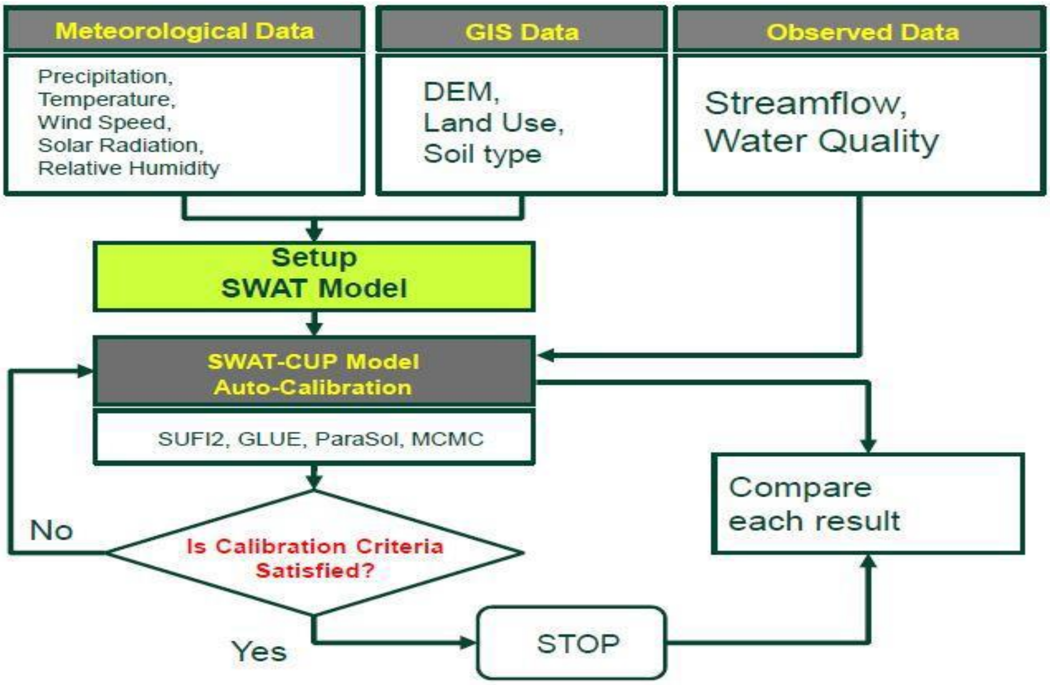

Fig 6: SWAT Model Flow Diagram

4 Result and Discussion

Using Arc SWAT software DEM map, land use map have been represented. By using SWAT-CUP sensitivity analysis of flow parameters, simulated, calibrated and validated results are observed. Monthly calibration and validation for stream flow were performed after conducting sensitivity analysis. The sensitivity analysis performed to determine the optimal parameters best fitted values based upon the observed data collected from study area. Seventeen (2000-2016) year's meteorological and observed stream flow data were used for calibration and validation. Also analysis of land use change and climate change and environmental impact assessment observed and modelled the discharge.Fig 7,Fig. 8 and Fig.9 shown the DEM map, Land use land cover map and Watershed delineation of study area respectively.

4.1 Maps Obtain From Input Data

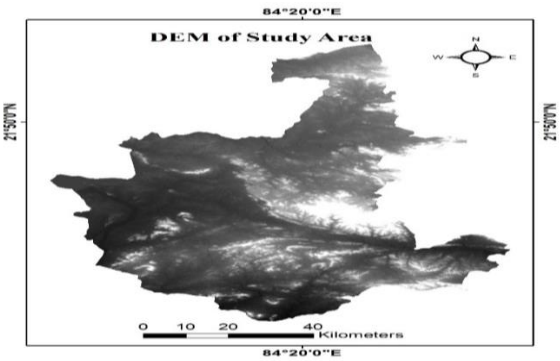

Figure 7:- DEM map

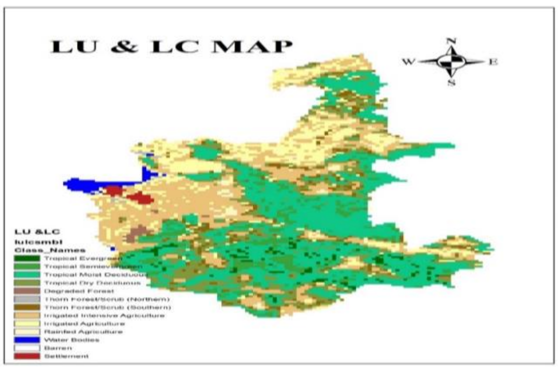

Figure 8:- Land use land cover map

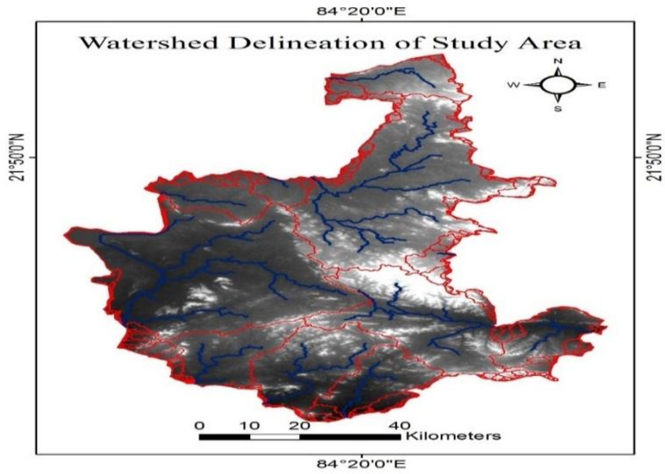

Figure 9:- Watershed delineation of study area

4.2 Sensitivity Analysis

Six parameters were considered for sensitivity analysis to identify the most sensitive parameters. The sensitive parameters which are obtained from the sensitivity were further carried out for calibration. The ranges of various flow calibration were referring to the SWAT CUP from the previously studied journals and user manual. The best fitted values which ranges of the parameter for catchment have been represented in Table 1. Figure 10 shown the Sensitivity analysis of flow calibration parameters**.**

Table 1:- Ranges and best fitted values of flow calibration parameters

SL NO.	FLOW CALIBRATION PARAMETERS	QUALIFIER	MINIMUM	MAXIMUM	FITTED VALUE
1	Curve Number (CN2)	r_	-0.5	0.5	-0.3257
2	Base flow alpha factor (ALPHA_BF)	v_	0	1	0.121564
3	Groundwater delay(days) (GW_DELAY)	v_	30	350	200.01
4	Threshold depth of water(mm) (GWQMN)	v_	0	5000	4219.125
5	Groundwater revap coefficient (GW_REVAP)	v_	0.02	0.3	0.392711
6	Soil evaporation compensation factor (ESCO)	v_	0.01	1	0.512134

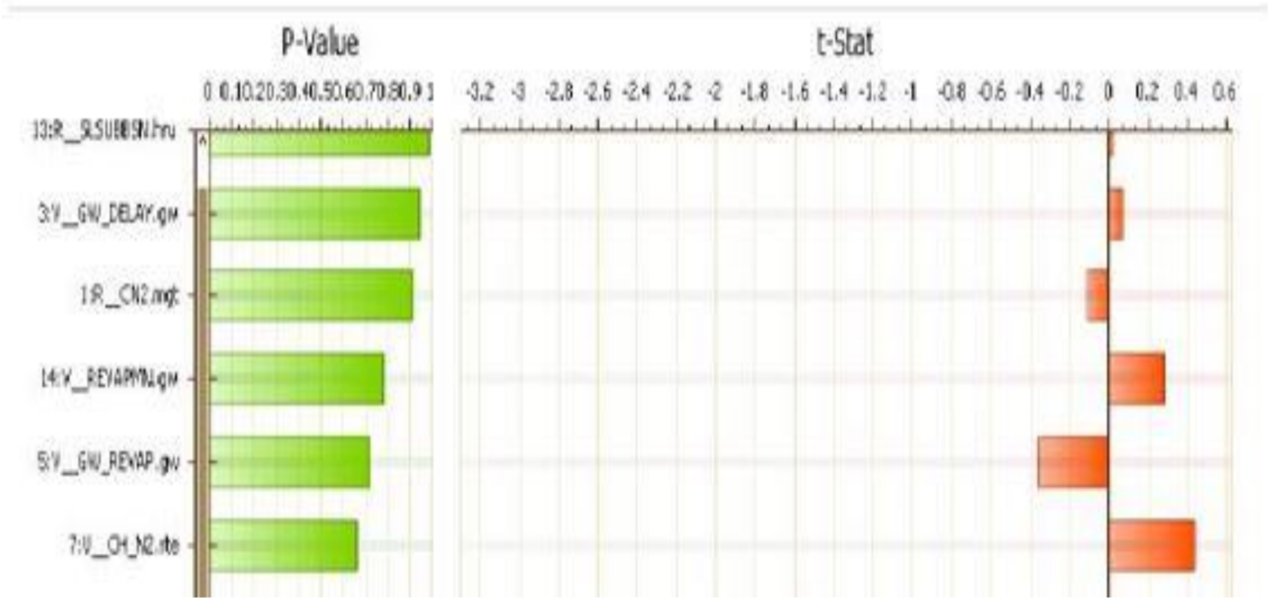

Figure 10:- Sensitivity analysis of flow calibration parameters

5 Conclusion

The study area for the present work is a catchment of Mahanadi river basin. The present study has been conducted for Mahanadi middle basin area of Ib tributary. SWAT model has been used which runs under Arc GIS interface and the model input in the form of runoff discharge for the basin. The simulation discharge value calibrate with the observed discharge for the time period of 2003 to 2011 and validation time period 2012 to 2016.Four sub-basin and five HRUs are found to exist the region from the delineation result from Arc SWAT.For the SWAT-CUP model for six parameters taken for the calibration and validation of model analysis and the flow calibration parameters are considered from literature review and self-interpretation.

6 References

- Abbaspour, K. C., Faramarzi, M., Ghasemi, S. S., & Yang, H. (2009). Assessing the impact of climate change on water resources in Iran. *Water resources research*, *45*(10).
- Beven, K. J., & Kirkby, M. J. (1979). A physically based, variable contributing area model of basin hydrology/Un model a base physique de zone d'appel variable de l'hydrologie du bassin versant. *Hydrological Sciences Journal*, *24*(1), 43-69.
- Devak, M., & Dhanya, C. T. (2014). Downscaling of precipitation in Mahanadi basin, India. *Int. J. Civil Eng. Res*, *5*, 111-120.
- Gosain, A. K., Rao, S., & Arora, A. (2011). Climate change impact assessment of water resources of India. *Current Science*, 356-371.
- Mohapatra, M., & Mohanty, U. C. (2006). Spatio-temporal variability of summer monsoon rainfall over Orissa in relation to low pressure systems. *Journal of earth system science*, *115*(2), 203-218.
- Mujumdar, P. P., & Ghosh, S. (2008). Modeling GCM and scenario uncertainty using a possibilistic approach: Application to the Mahanadi River, India. *Water Resources Research*, *44*(6).

- Qiu, L. J., Zheng, F. L., & Yin, R. S. (2012). SWAT-based runoff and sediment simulation in a small watershed, the loessial hilly-gullied region of China: capabilities and challenges. *International Journal of Sediment Research*, *27*(2), 226-234.