CHAPTER 2: REVIEW OF LITERATURE

2.1 General

Review of literature is an indispensable part of any research work. It provides a solution to the problem by previous work done by various scientists and researchers. Soil and water are the most important natural resources of the world, and these are under tremendous stress due to ever-increasing biotic pressure. To understand the watershed, it is required to study surface and undersurface (sub-surface) characteristics of it. The literatures related to the study of the research area are presented in the following sections.

2.2 Introduction

According to objectives in the literature review, the following topics are covered:

1) Morphometric analysis
2) Land Use and Land Cover analysis
3) Soil Erosion models
4) Prioritization of watershed for identifying erosion prone area.
5) Hydrological and sediment yield modeling.
6) Impact of Soil Erosion on climate change and environment.

Basically, the availability and condition of land and water depend upon various characteristics of the watershed like the slope of the area, weathering depth, situated surface and sub-surface water bodies, fractures presence, canals, land use /land cover, etc.

For conserving water and soil resources sustainable development and effective management of watershed are significant. Thus one can say that the watershed-based approach for conserving the natural resources considered to be very effective since the excess rainfall from the basin will be drained to an outlet point and surface runoff will be governed by various basin characteristics and morphological parameters, such as shape, size, slope, soil type, land use/land cover type and relief of basin. In addition to that, there are gully erosion control structures that reduce the length of a slope leading to a decrease in the flow of water by reducing the flow rate.

2.3 Review on Morphometric Analysis

Around the globe many hydro-geologists as Horton, 1945; and Strahler, 1957, 1964; Krishnamurthy et al., 1996 studied the surface drainage characteristics of different watersheds and sub-watersheds using conventional methods, while Nag & Chakraborty, (2003) and Rao et al., (2010) studied morphometric analysis and drainage characteristics using modern techniques such as Remote Sensing and Geographical Information System (GIS).

On morphometric analysis, so much work has been done all over the world by different scientists using various techniques. Some researchers used the conventional method while some used modern techniques as Geomatics techniques. Horton (1945), Miller (1953), Smith (1950), and Strahler (1964) have done excellent work on morphometry. In India, this type of study has been done by researchers (Rastogi and Sharma 1976, Nautiyal 1994, Rudraiah et al., 2008, Magesh et al., 2012a & 2012b, Wilson et al., 2012) on various watersheds.

Various other researchers such as Srivastava (1997) studied the stream characteristics of Jharia coalfield which is situated in Bihar, using RS techniques. Nag (1998) carried out Morphometric analysis of Chaka sub-basin in Purulia district, and after some time in 2003

Nag and Chakraborty studied the influence of rock and their types & structures in the development of stream pattern and their characteristics in hard and stony areas. Recently Srinivasa et al., (2004) have used RS and GIS techniques in the analysis of Morphometric parameters of the basin in Pawagada area of Tumkur district, Karnataka.

Magesh et al., (2013) estimated surface runoff and intensity of the flow of the stream network with the help of associated various morphometric parameters.

Parasiewicz et al., (2017) stated that anthropogenic changes led to widespread changes in the physical structure and behavior of the rivers, living and non-living biotic communities and ecological functioning of aquatic ecosystems worldwide. Morphometric descriptors are relatively simple approaches to describing the processes of the pool and to compare characteristics of the basin.

According to Pike, (2001) the development of watershed depends on several factors such as geomorphology of the river, the geology of the area, structural component, soil type and their characteristics, vegetation cover through which it flows. His studies revealed that measurement and mathematical analysis of the earth's surface could be termed as Geo-morphometry.

Strahler, (1964) proposed that morphometric analysis of the watershed provides a quantitative description of the river drainage system, which is an essential aspect of the watershed.

Strahler, (1957) presented that morphometric studies include assessment of streams by measuring various properties of the streams and drainage characteristics. River basins or watersheds consist of a clear morphological region and are particularly relevant to drainage pattern and geomorphology of the river.

Horton, (1945) suggested a law about stream length and stream order and is called Horton’s law. Horton’s law of stream length suggested a geometric relationship between the stream numbers in successive stream orders and landforms.

Rai et al., (2017) proposed Morphometric assessment requires analysis of various drainage parameters such as, stream order, stream length, area (A), perimeter (P) of watershed, length of drainage networks, drainage frequency (Fs), drainage density (Dd), texture ratio (T), length of overland flow (Lo), bifurcation ratio (Rb) and circulatory ratio (Rc).

Ratnam et al., (2005) also studied various Morphometric parameters using RS and GIS techniques and topographical map.

A detailed description of morphometric parameters of the watershed also requires characterization of linear and areal characteristics of an area, the gradient of stream network and contributing watershed slopes. Detailed analysis of drainage parameters and stream networks are of great help in understanding the impact of drainage morphometry on watershed relief and their characteristics.

Mundia and Aniya, (2005) revealed that Remote Sensing data are capable in effectively assessment of drainage change, land use/land cover change, soil characteristics, relief effect on soil; and GIS techniques provide a flexible environment for manipulation and analysis of spatial information.

Sreedevi et al., (2005) studied drainage/stream characteristics of the Pageru river basin, India using topographical maps and satellite imagery (Landsat images) to find out the potential groundwater zones. Ibrahim Bathis and Ahmed, (2016) implemented Morphometric technique to locate suitable site location for rainwater harvesting structures at the sub-watershed level in Wadi Umm Al Qutffa basin, Jordan.

Agarwal et al., (2013) used this analysis to facilitate in the suitable sites identified for the construction of artificial recharge structures for the Ganga river basin, India.

Pandey et al., (2004) stated that precise understanding of the hydrological behavior of drainage network is an essential aspect for proper sustainable development and management of the watershed. Hence for developing sustainable management plan thorough study of the individual watershed is necessary which requires enormous data. And in the country like India where most of the watersheds are ungauged, and data is not sufficient, the analysis of Morphometric parameters of the watershed can play an important role.

Beside watershed development and management there are other works also which can be done by Morphometric analysis. Narendra and Rao, (2006) adopted Morphometric analysis for the purposes of integrated land and water resources management, Jasmin and Mallikarjuna, (2013) use this technique in groundwater studies, Bagyaraj and Gurugnanam (2011) done soil erosion studies with this, Chen and Yu, (2011) performed landslide analysis and their impact on environment, Altin and Altin, (2011) found it is very useful in tectonic studies and Rawat et al., (2011) studied natural hazard vulnerability and assessment. Thus one can say that Morphometric analysis is an essential technique in any hydrological investigation such as potential groundwater assessment, groundwater management, watershed management, and environmental assessment.

Magesh et al., (2012 a) correlated various hydrological phenomena with the physiographic characteristics of stream pattern such as the slope of the drainage area, shape, and size of the watershed, drainage density, stream frequency, no of streams, size and length of the contributory streams, etc.

Nautiyal (1994); Nag and Chakraborty (2003); Magesh et al., (2012 b) performed Morphometric analysis by measurement of various linear and aerial parameters including relief and gradient of the stream network and slope of the watershed.

Now if one can try to summarize the whole morphometric review, one can say that prioritization of micro-watersheds can be done by various morphometric parameters (Linear as well as shape parameters) even without the availability of soil maps (Biswas et al., 2002). And the result of this analysis was reliable up to some extent.

2.4 Review on Land Use/Land Cover Analysis

Land Use and Land Cover both are almost interrelated terms, and it is difficult to distinguish between them accurately. For example change in land use reflects in the land cover and changes in land cover also reflect in land use. A change in either, however, is not necessarily the product of the other. Changing either, however, is not necessarily a product of the other.

A change in LULC does not necessarily indicate the degradation of the land. However, many changing patterns of land use driven by various social causes, lead to changes in vegetation, which affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to influence the climate and biosphere (Riebsame et al., 1994).

Meyer, (1995) stated that the land cover could be changed, except for man-made forces. Natural phenomena such as flood, fire, climate variability, and weather and ecosystem dynamics may also initiate changes in land cover. Worldwide, land cover is changing fundamentally direct human use: agriculture and animal husbandry, forestry and management, and rapid construction in urban areas and development in rural areas also. There is also a random effect on soil and vegetation from other human activities, such as forests and lakes damaged by acid rain from burning fossil fuels and crops near cities affected by tropospheric ozone from vehicle exhaust.

Traditional methods of land use mapping are labor-intensive, time-consuming and made relatively rare. In a fast-growing environment, these maps became outdated and useless with the passage of time. In fact, Olorunfemi, (1983) stated that monitoring change and the analysis of the LULC with the time change is difficult and cumbersome with the conventional method of surveying. In recent years, with the advancement in the field of satellite remote sensing techniques, it has proven to be of great value for the preparation of accurate maps of LULC and monitor the changes frequently and regular intervals. This technique is also beneficial in the case of an inaccessible area, since in that areas perhaps it is the only techniques by which mapping can be done in a very efficient manner.

As remotely sensed images by various sensors provide a different type of images due to change in sensor characteristics, different azimuth angle, difference height, sun angle etc., so interpretation of satellite image and classification is not a simple task. Due to this problem, no single classification could be used with all types of images. In this regard, the most appreciable work was done by Anderson et al., (1976). Anderson proposed a general purpose classification scheme which is the most compatible with RS images, and this scheme is also referred to as the USGS classification scheme. After that other classification schemes are also developed which are basically modification on the Anderson scheme.

Shoshany et al., (1996) explored the upsides of remote sensing techniques methods in connection field surveys in providing a regional description of vegetation cover. The results of their research were used to produce four vegetation cover maps.

There are many studies which show the adverse effects of soil erosion on land use and land cover. Research of Bakker et al., (2008) reveals that erosion reduces productivity by an average of 4% for every 10 cm of soil loss. Even higher productivity reduction is possible although it depends on the distinct contract between topsoil and subsoil properties as texture, fertility and other characteristics of the soil.

Another problem is counter when soil erosion interacts with the slope of the land surface. The slope of the land surface can be seen as the driving force of soil erosion, but also as a direct driver of changes in land use, because slope, which is steep in nature, are more challenging to cultivate. The depth of the soil can, to some extent, be regarded as the result of erosion. Soil erosion can affect failure in other ways also: it affects the depth of the soil as well as affect the failure due to loss of nutrients and water holding capacity in the soil.

In connection with the development of the land, the land covers are subjected to change. The soil of many river watersheds is transformed to impermeable soil surfaces, which result in lower soil infiltration rates and therefore increase the rate of runoff. Due to this heavy runoff leads to lots of water makes its way to the sea during the rainy season.

In the past, several studies was done on hydrological simulation models which were applied to estimate the impact of land cover changes on water balance at the catchment scale (e.g. Bultot et al., 1990; Lorup et al., 1998; Lukey et al., 2000; Wegehenkel, 2002; Ott and Uhlenbrook, 2006). Hence studies related to this LULC within watershed plays a crucial role in watershed development and management.

Bosch and Hewlett, (1982); Hornbeck et al., (1993); also stated that change is LULC can significantly affect the water balance within the watershed.

In the literature, there are many studies, (Hibbert 1967, Bosch and Hewlett 1982, and Zhang et al., 2009) which point out that deforestation causes an increment in the mean annual discharge, have concentrated on the impacts of forest management on water yield and, therefore, have specific characteristics in common.

One crucial aspect for watershed management is the management of drainage network and for that one should know the drainage pattern and their properties. A useful way to understand conceptualization and competing demands on water resources is to consider the rain is falling within the watershed, as converted into two major components- Blue Water and Green Water. Falkenmark, (1997) used this type of nomenclature and made famous. According to Falkenmark 'Blue water' is the water that runs out of the watershed in the end and usually affected by a physical process like runoff, through flow and stream flow. 'Green Water' is the water that is lost from the watershed through various natural phenomena such as evaporation from water bodies and transpiration by vegetation. If the land use changes, then the ratio of blue to green water may change also.

2.5 Review on Soil Erosion Models

Soil erosion is a significant problem since watershed comprises so many streams and lack of management and conservation practices. Tonnes of soil are lost from the fields every year. This not only reduces crop production, but the soil also acts as a pollutant to rivers, lakes, and other water systems.

Yang et al., (2003) stated that soil erosion is a serious problem and is caused due to the intensification of agriculture, deforestation, land degradation, and global climate change.

Work of Bleecker et al., (1995); Savibi et al., (1995); Yamamoto et al., (2001) suggested that to assess soil-loss risk, first, potential soil loss must be simulated by a soil-loss simulation model in the GIS environment. Modeling can provide a quantitative and reliable approach to estimate soil erosion under a wide range of field conditions. In literature, the available model can be classified into two types:

1) Physically-based models and

2) Empirical models.

Here physically based models are projected to denote the essential mechanisms controlling erosion procedure by solving the corresponding equations. These models are quite good at assessing the soil erosion in spatial and temporal mode. Some of these models include ANSWERS (Beasley et al., 1980), WEPP (Nearing et al., 1989), KINEROS (Woolhiser et al., 1990) and EUROSEM (Morgan et al., 1998).

Application of empirically based models is limited due to the lack of input data set required for model simulation. Conventional empirical models are Universal Soil Loss Equation (USLE) (Meyer, 1984; Wischmeier and Smith, 1965), Modified Universal Soil Loss Equation (MUSLE) (Williams and Berndt, 1977), or the Revised Universal Soil Loss

Equation (RUSLE) (Renard et al., 1991).These models are commonly used for the assessment of erosion and sediment yield from watershed areas (Ferro and Minacapilli, 1995; Kothyari and Jain, 1997). To compute soil erosion based on USLE methodology, some examples of watershed models are Erosion Productivity Impact Calculator (EPIC) (Williams, 1990) and Agricultural Non-Point Source Pollution Model (AGNPS) (Young, 1987).

Although USLE/RUSLE doesn't depict the actual situation of soil erosion process, as they are based on the some computed coefficients which are based on field observations, it has been frequently used by the researchers all over the world due to its simplicity (Kothyari and Jain, 2002; Jain et al., 2005; Bartsch et al., 2002).

Work of Wischmeier and Smith, (1978) has proved that the USLE model provides a reasonable estimation of soil erosion at the plot scale. In the case of the watershed, part of eroded soil is deposited within watershed before it reaches the watershed outlet.

To overcome the effect of spatial variation of various parameters such as Land use, slope characteristics, soil variability and topography of the area, Geographical Information System (GIS) techniques are practical and well suited. For this, different models (both empirical and process-based) have been developed to find out the soil erosion and soil loss data, as it becomes a severe issue to the environmental consideration (Rewerts and Engel, 1991; Srinivasan and Engel, 1994; Marshringni and Cruise, 1997).

Jain et al., (2002) estimated the soil loss from a Himalayan watershed using RS and ancillary data in GIS environment using two different models (the Morgan model and Universal Soil Loss Equation (USLE) model). Further, he compared the results of both models. On comparing, results revealed that soil erosion estimated by Morgan model was within limits while the soil erosion found out by USLE gave a higher rate.

Fistikoglu and Harmancioglu, (2002) worked on the integration of the USLE model in GIS environment in the identification of rainfall-based erosion and the transport of non-point source pollution loads to the Gediz River, Turkey.

Babu et al., (1978) prepared iso-erodent maps, based on annual mean and seasonal mean erosion index values. From this map, the Universal Loss Equation's rainfall erosivity index could be directly derived for places in India.

Nema et al., (1978) worked out some of the fundamental parameters of the USLE, viz. rainfall erosivity factor (R), soil erodibility factor (K), slope length factor (L), slope steepness factor (S), crop management factor (C) and conservation practices factor (P) and this work was done on small runoff plots of 1.86 m width and 22 m length, at the Soil Conservation Research Demonstration and Training Centre (ICAR), Vasad.

Singh et al., (1992) prepared an iso-erodent map of the soil erosion for the whole country for land use planning for India. In generating the map, soil loss for different places was found out using the USLE model.

Gupta and Chaudhary (2008) measured soil loss on four runoff plots using the USLE model and then compared the results with the observed soil loss from the plots. Results revealed that predicted soil loss was slightly higher than the observed soil loss value.

SheikhÂ et al., (2011) made use of satellite imagery and GIS in calculating the soil loss for a Himalayan watershed, using the USLE model. He found that erosion was the highest in the case of cultivable land and lowest in the case of forest (dense as well as sparse), plantation and horticulture.

2.6 Review on Watershed Prioritization

To prepare sustainable development and management plan for conserving the natural resources, i.e., soil and water in the watershed, it is quite important to understand the basic characteristics of the watershed like current erosion status, drainage pattern and their characteristics, available natural resources and groundwater potential of the watershed. This watershed development and management planning are beneficial if divide watershed into small sub-watershed or say micro-watershed. Watershed can be delineated from the depression less Digital Elevation Model (DEM) providing an outlet point. By this extracted stream pattern match with the digitized stream pattern of the topographical map and thus visualizes the accuracy of the work. For generating micro-watersheds using raster DEM provides other outlet points and the specific threshold value.

Study of Martz & Garbrecht, (1992) said that Digital Elevation Model (DEM) could be made appropriate for watershed delineation at the small scale (sub-watershed level), by using the fill depression removal technique. The result of Freeman, (1991) shows that automated watershed delineation algorithm creates a layer of the flow path, which provide effective and useful results in the areas, where convergent flow occurs, along with well-defined valleys. Almost similar results presented by Moore, 2000. He stated that the D8 method likely to produce the flow in parallel lines along the main direction of the stream. For making small sized watersheds Liang & Mackay, (2000) proposed a methodology, which stated that sub-watersheds of appropriate sizes could be delineate using flow direction and flow accumulation raster map .Similarly, for preparing slope map and contour map in raster and vector form DEM can also be used.

So for locating suitable sites for land surface and water conservations structures in the watershed at a small level (Micro-watersheds), Geoinformatics techniques are handy, and it helps in formulating the different criteria standards (Ravindran et al., 1992). The same conclusion can be drawn from the work of Durbude and Venkatesh, (2004) a combination of Remote Sensing and GIS techniques has been proven a powerful tool for identifying the suitable sites for conservation structures at the micro-watershed level.

2.7 Review of Sediment Yield and Hydrological Modeling

During the past few years, some hydrological models such as AGNPS, MIKE SHE, and SWAT have been developed and are used to simulate hydrological processes (Young et al., 1987, Tripathi et al., 2003, Arnold et al., 2012). For example measurement and modeling of soil erosion and sediment yields in a vast cultivated land of south Brazil was done using Water and Tillage Erosion Model (WATEM) and Sediment Delivery Model (SEDEM) (Didone et al., 2017). WEPP cannot perform better than MUSLE for soil loss estimation; Yesuf et al., 2015 used three methods USLE-M, RUSLE-2, and WEPP for erosion management . In Chinese Loss Plateau soil erosion estimation was done using three methods Si Model, WEPP, MMF and then the results were compared (Li et al., 2017). WEPP is the model which can be successfully used for both runoff and sediment estimation using GIS and remote sensing techniques (Pandey et al., 2004). Unit Sediment Graph is the better process than Modified USLE and WEPP when Climate change factor is considered (ChandraShekar et al., 2015). Prediction of soil erosion is more straightforward using WEPP along with GIS techniques (Mahmoodabadi & Cerdà, 2013).

Among these models, the physically based circulated display SWAT is entrenched for dissecting the effects of land management practices on water, silt, and complex watersheds. SWAT is a very widely used model for sediment yield modeling (Jeong et al., 2013). SWAT is used for watershed management to enhance water quality requirements

(Mittelstet et al., 2016). Sediment yield estimation can be more easily done when SWAT is integrated with GIS using Arc SWAT (Kinnel 2016) studying all these models; it was concluded that SWAT is the most appropriate model to be used in the present study area for modeling. As the SWAT is the time persistent model and it can simulate surface discharge, soil erosion, and dreg collection and also the nutrient content of the soil (Fukunaga et al., 2015). SWAT and sediment filtration models help in control sedimentation during small storms. SWAT has been effectively utilized by specialists around the globe for appropriate hydrological modeling and management of water assets in watersheds with the different atmosphere and territory attributes.

The SWAT model is a physically based continuous model developed by the USDA Agricultural Research Service (ARS) (Arnold & Allen, 1996). The model is applied to hydrological modeling, runoff and soil loss prediction, water resource management, water quality modeling, land-use change affect assessment, and climate change impact assessment. Prabhanjan et al., (2014) prepared a watershed-based model using Soil & Water Assessment Tool (SWAT) integrated with geospatial techniques like Remote Sensing & GIS for modeling runoff and sediment yield for Khadakohol & Harsul watersheds in Maharashtra, India. The SWAT model was calibrated for the monsoon months of a year and validated for other years. Regionalization of constraints was attempted & its applicability was evaluated in an ungauged content.

Kumar et al., (2015) attempted to classify critical watersheds disposed to soil erosion by using a hydrological model in data scarce Damodar river catchment, located in the Jharkhand state of India. The results helped, to find methods for controlling water and soil losses, which can recover reservoir life and storage for its use in flood control purposes, irrigation and hydropower production. Such an approach is particularly required in emerging countries like India for better employment of limited resources or where data is not available in ample amount.

Karcher et al., (2013) proposed a modified form of Soil & Water Assessment Tool for identification of areas where a substantial improvement in downstream water quality would be seen by instigating principal management practices. The results suggested that a crop-rotation specific method can be used to deliver surplus information for spatially resolved decision making concerning nutrient loading and downstream nutrient concentrations.

Gayley, (2012) made an attempt to enumerate potential reserves by using the Arc-Map-based SWAT software to model hydrologic resources, in the San Miguel Creek watershed, Texas. The outcomes were applied to regionally same agricultural land in the Edwards Aquifer Groundwater Conservation District & Texas State Regional Water Planning Area L (RWPA-L). The upfront methodology can be used to predict water severity and prospective water savings in barred river basins; across borders; or in other regions where cultivated channel flooding is still dominant, where water inadequacy may be a concern.

Qui et al., (2013) applied the Soil & Water Assessment Tool (SWAT) to simulate water quality effects of land-use and management practices in the Neshanic River watershed. The demonstrating results affirmed that both Total Suspended Solids and Total Phosphorus were water-quality worries under the ebb and flow land use and the executive's conditions in the watershed.

Sardar et al., (2014) used the Soil & Water Assessment Tool (SWAT) to model the hydrology and to categorize acute erosion-prone regions of the Barakar Basin. This effort was supportive of choosing and implementing appropriate soil management methods to moderate soil erosion. Daily meteorological data and monthly discharge, sediment yield and reservoir inflow data of five years were utilized. It was seen that the SWAT model was a valuable tool to choose a management strategy for reducing reservoir sedimentation rate.

Dile et al., (2016) developed an open source user interface for the Soil & Water Assessment Tool (SWAT) model. The interface performed parallel functions to Arc SWAT, but with additional enhanced features such as unifying small sub-basins and static and dynamic conception of outputs. The interface was verified through a case study in the Gumera watershed in the Lake Tana basin of Ethiopia, where it displayed a positive performance. QSAWT proved to be a beneficial tool for the SWAT scientific community, with enhanced convenience and functionality related to other alternatives for generating SWAT models.

Cho et al., (2016) attempted to compile observations from diverse locations in the USA and Korea for a periodic inconsistency with respect to temperature levels. Fecal coliforms are indicators of pathogens. These were reasonably higher in summer and lowered during the winter season. The Soil & Water Assessment Tool (SWAT) was used to enhance prediction accuracy by evolving a different bacteria subroutine for SWAT. Outcomes showed that temperature was the first controlling factor for bacteria growth, demonstrating seasonal variability. The reformed SWAT model well captured the temporal variation of bacteria concentration, the assessment of fecal coliforms concentrations. The bacterial module presented could provide an upgraded bacterial algorithm for other hydrologic models such as HSPF and APEX, and can be useful to other watersheds.

Pisinaras et al., (2010) applied the Soil & Water Assessment Tool (SWAT) 2005 integrating it with a GIS interface to Kosynthos River watershed situated in Northeastern Greece. It was exhibited that the SWAT model if accurately validated, can be utilized efficiently in testing management situations in the watershed. The model solicitation, supported by Geoinformatics technology, was found to be a significant and consistent tool for water assessment, specifically under the water management strategies.

Kannan et al., (2007) evaluated the performance of the SWAT-2000 model using streamflow at the network of the catchment (Bedfordshire, UK). Hydrological modeling along with the accurate simulation of the courses driving the water stability was essential for envisaging pollutant transportation. Adequate model performance was attained in final model runs, with reasonable runoff segregating into the overland flow, tile drainage, and base current.

Vigiak et al., (2015) evaluated and reformed the Soil & Water Assessment Tool (SWAT) hillslope sediment yield model for applications in large basins; and to provide a robust sediment calibration method for large regions. A case study was done on the Upper Danube Basin. The Modified Universal Soil Loss Equation (MUSLE) was modified to ascertain appropriate algorithms for estimating hillslope parameters.

Mittelstet et al., (2016) showed how a watershed model could offer perilous information for watershed-based strategies to give numeric water quality standards by using the Soil & Water Assessment Tool (SWAT) model. The watercourse and basin numeric water-quality standards of the Illinois River (IRW) & Eucha-Spavinaw watersheds (ESW) were determined by estimating P-loads. Runoff and P calibration & validation methods were performed. The model was used to categorize an arrangement of prospective management practices in Oklahoma to encounter the water-quality standard in the Illinois River, Barren Fork Creek, and Flint Creek.

Vilaysane et al., (2015) attempted to model the hydrological stream course with the use of the Soil & Water Assessment Tool (SWAT) model in the Xedone River basin, in the Southern part of Laos. The model was calibrated and validated by using the SUFI-2 technique for inquiry of the climate and land-use change influences, sediment and water quality examination. This can be helpful in flood disaster threat management and dam construction.

Psomas et al., (2016) implemented catchment modeling in the Ali Efenti catchment of the upper Pinios River basin in Greece with the help of the Soil & Water Assessment Tool (SWAT) and the Water Evaluation & Planning System (WEAP). Both calibration and validation were performed. Both models follow two different methodologies.

Asres et al., (2010) applied the Soil & Water Assessment Tool (SWAT) model for estimation of sediment yield and runoff in the Gumara watershed, located in the Ethiopian islands. Based on the simulation results, the model proved to be useful in reducing sediment generation from two critical micro watersheds by calculating the potential of vegetation filter strips. Significant improvements in water quality could also be achieved with the help of this study.

Ghoraba et al., (2015) attempted to model the hydrology of Simly Dam watershed situated in Saon River basin at the north-east of Islamabad, the National Capital of Pakistan. The simulation was performed successfully, and monthly volume inflow to the dam was estimated. It was concluded that the SWAT, if correctly calibrated, can be applied in the provision of water management strategies of semi-arid zones.

Yesuf et al., (2015) proposed the application of the Soil & Water Assessment Tool (SWAT) model for the classification of soil erosion methods, estimation of sediment depositions into lakes, observation and assessment of various management set-ups in the Ethiopian highlands. Sequential Uncertainty Fitting-2 (SUFI-2), a SWAT-CUP2012 sub-module computer program, was applied to modify the performance of SWAT with the help of monthly observed sediment yield data at a location in Maybar watershed, Ethiopia. Calibration & validation were performed.

Fukunaga et al., (2015) showed that the Soil & Water Assessment Tool (SWAT) model performed efficiently in replicating continuous daily streamflow of the upper Itapemirim River Basin, located in Brazil. Calibration and validation were carried out. After the calibration stage, it was seen that the SWAT model delivered better outcomes for minimum and average courses than peak currents. Hence, SWAT proved to be a helpful tool for simulation of streamflow of tropical basins under rare data condition, especially metrological data.

Tuo et al., (2016) investigated the impact of four different precipitation inputs on stream flow predicted with the help of the Soil & Water Assessment Tool (SWAT) hydrological model in three catchments of Alpine, which are the availability of data is limited. Analysis of the model performances (comparison of simulated and observed stream flow data at the catchment outlet), rainfall features, prediction uncertainty, the potential relationship among the components and parameter uncertainty was carried out. The elevation band methods were applied to consider the orographic effects on precipitation in mountainous areas.

2.8 Review on Impact of Soil Erosion on Climate Change and Environment

Soil erosion has many impacts environment and climate change, reducing the fertility of the soil, it is also responsible for emitting greenhouse gases due to mineralization and the microbial reaction of soil organic compound during the erosion process. The detailed study of the soil impact on the environment is critical as it will help us know the problem of soil erosion. Many researchers have worked on analyzing the effects of soil loss on soil properties (Tuo et al., 2018) and fertility (Novara et al., 2018). Gu et al., (2018) assist the impact of water erosion on the productivity of the black soil in a North Eastern China region.

According to Lal (2005 & 2019), soil erosion is a four-step process that is detachment, splash, redistribution, and deposition. In the first three steps the soil organic carbon which was encapsulated in aggregated soil is now exposed to microbial process due to soil particles breakdown. And hence the decomposition occurs; this process leads to the emission of carbon dioxide under aerobic environment, methane under anaerobic environment and Nitrogen dioxide in both the situations. These gases are the greenhouse gases which are the primary cause of global warming and hence soil is the source of GHGs and directly responsible for climate change.

Abdalla et al., (2018) quantified the impact of grassland degradation on carbon dioxide emission in South Africa. He measured the amount of carbon dioxide emitted from the regions where the degradation was 0% , then where there was little degradation, then the moderately degraded area, and the highly degraded area with brass cover less than 5% grass cover. He concluded that there is a direct connection between land degradation and climate change due to the emission of carbon dioxide during erosion.

Similarly, many researchers have assessed and analyzed the emission of Carbon dioxide, Nitrogen dioxide, and Methane during soil erosion and discussed in their study whether soil degradation is a source or not of greenhouse gases.(Chaplot et al., 2012, Chappell et al., 2014, Dou et al., 2016, Gao et al., 2018, Huang et al., 2017)

Gaiser et al., (2008) worked on possible measures to reduce the emission of Carbon dioxide during erosion. He used environmental policy integrated climate model with an information system to analyze the carbon dioxide mitigation potential in the state of Germany.

Mchunu and Chaplot, (2012) studied the degraded rangeland of South Africa and analyzed the impact of soil erosion on carbon dioxide emission to the atmosphere. They concluded that the Grass Land Degradation, contrasted with a benchmark with hundred percent of the soil surface covered by grass, expanded mass soil erosion by 92% and soil organic carbon erosion by 21.3%, in this manner affirming past investigations on the effect of soil surface inclusion by vegetation on soil erosion.

Wei et al., (2016) concluded in his study that the breakdown and scattering of soil totals by disintegration expanded the carbon dioxide discharge rate from course size aggregate portions at the depositional slope position. The overall result is the net increase in carbon dioxide loss to the atmosphere at the eroded slope position as compared to the depositional slope position.