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EFFECT OF SPATIAL RESOLUTION ON SOIL AND WATER ASSESSMENT TOOL SIMULATION A CASE STUDY OF OYUN RIVER, KWARA STATED

BY

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BEING IN RESEARCH WORK SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING, INSTITUTE OF TECHNOLOGY, KWARA STATE POLYTECHNIC, ILORIN

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CERTIFICATION

This is to certify that this research study was conducted by **ONI OLUBUNMI EMMANUEL (HND/23/CEC/FT/0256)** and had been read and approved as meeting the requirement for the award of Higher National Diploma (HND) in Civil Engineering of the Department Civil Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin.

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DEDICATION

This project is dedicated solemnly to ALMIGHTY GOD, who is the sole inspiration of all things, without whom there would not be, and neither would this project.

Appreciation goes to my loving parents for their support in the fulfillment of my Higher National Diploma (HND) both orally and financially. May God allow them to eat the fruit of their labor (Amen)

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First and foremost, I thank God for His guidance, wisdom and strength although the period of this project.

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ABSTRACT

This study investigates the impact of spatial resolution on hydrological modeling using the Soil and Water Assessment Tool (SWAT) in the Oyun River Watershed, Kwara State, Nigeria. The research focuses on how variations in the resolution of input data particularly Digital Elevation Models (DEM), land use, and soil data affect the prediction of streamflow, sediment concentration, and sediment yield within the watershed. Three DEM resolutions (90 m, 250 m, and 1 km) were analyzed to evaluate their influence on watershed delineation and model accuracy. Using 19 years (2001–2019) of meteorological data, SWAT simulations were performed, and spatial variations in hydrological outputs were assessed across 55 sub-basins. The results revealed significant differences in predicted flow, sediment concentration, and sediment yield across varying resolutions. Sub-basin 51 recorded the highest streamflow (181.39 m^3/s), while sub-basin 23 had the lowest (4.10 m^3/s). Similarly, sediment concentration ranged from 5,652.11 mg/L in sub-basin 49 to 17,240 mg/L in sub-basin 11. Sediment yield varied between 9.28 tons/ha in sub-basin 46 and 50.65 tons/ha in sub-basin 50. The findings emphasize the critical role of spatial resolution in hydrological modeling, with coarser datasets potentially masking local variability and leading to inaccurate predictions. The study concludes that careful selection of spatial resolution is essential to balance model accuracy and computational efficiency. The outcomes provide valuable insights for watershed managers, modelers, and planners aiming to improve water resource management and land-use planning.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Hydrological models are essential tools for understanding and predicting water flow, sediment transport, and watershed dynamics. One widely used model is the **Soil and Water Assessment Tool (SWAT),** which integrates spatial data such as topography, land use, soil characteristics, and climate to simulate hydrological processes (Arnold et al., 1998). The accuracy of SWAT simulations depends significantly on the spatial resolution of input data, particularly the **Digital Elevation Model (DEM),** land use, and soil datasets.

Spatial resolution refers to the level of detail represented in a dataset, with higher resolution providing finer details and lower resolution simplifying spatial features. Several studies have examined how variations in spatial resolution influence hydrological modeling outcomes, with findings suggesting that **coarser resolutions may lead to inaccuracies in streamflow predictions, watershed delineation, and runoff estimations** (Wu et al., 2018). However, higher-resolution datasets require more computational power and storage, raising the need for an optimal balance between accuracy and efficiency.

One common challenge with DEMs is their spatial resolution, which refers to the size of each grid cell and, consequently, the level of detail they can capture. In many cases, DEMs are derived from remote sensing data sources, such as satellite imagery or airborne LiDAR (Light Detection and Ranging), and the chosen spatial resolution may not fully capture local topographic variations or fine-scale features.

To address this limitation, researchers often employ resampling techniques. Resampling involves altering the spatial resolution of a DEM by aggregating or disaggregating data points. By doing so, researchers can enhance the level of detail in specific regions or reduce computational demands for large-scale analyses.

The selection of an appropriate resampling technique is a critical decision in DEM processing, as it directly impacts the accuracy and reliability of subsequent analyses. Depending on the research objectives and the region of interest, researchers may choose to upscale or downscale DEM data.

In the context of hydrology and environmental studies, resampled DEMs can have a profound effect on the prediction and modeling of flow patterns, sediment transport, erosion, and other important processes. Therefore, investigating the impact of resampling techniques on these predictions is a valuable endeavor, as it can inform best practices for terrain analysis and modeling in various applications.

Digital Elevation Models (DEMs) are essential tools for studying land surface processes and modeling the flow of water and sediment in river catchments (Viglione et al., 2013). DEMs provide a digital representation of the elevation of the land surface, typically at a spatial resolution ranging from several meters to several kilometers (Tarboton et al., 2015). DEMs can be used for a wide range of applications, including terrain analysis, land use planning, environmental monitoring, and hydrological modeling (Su et al., 2017). The development of DEMs has revolutionized hydrological modeling by providing a detailed and accurate description of the topography of river catchments (Wu et al., 2013). The resolution of a Digital Elevation Model can have a significant effect on flow and sediment loading predictions upstream of a river catchment. When a DEM is resampled to a lower resolution, it loses some of the fine-scale details that may have been present in the original data. This loss of detail can result in a coarser representation of the terrain, which can affect the accuracy of the flow and sediment predictions. Resampling a DEM can also introduce errors in the calculation of slope and drainage area, which are important parameters in predicting flow and sediment loading.

The **Oyun River Watershed,** located in Kwara State, Nigeria, plays a crucial role in water supply, agriculture, and ecosystem sustainability. Understanding the impact of spatial resolution on SWAT simulation in this watershed will help improve water resource management, flood prediction, and land-use planning.

1.2 PROBLEM STATEMENT

Hydrological models like SWAT rely heavily on spatial data, but the choice of spatial resolution can significantly impact the accuracy of model outputs. Inconsistent streamflow predictions, watershed delineation errors, and runoff estimation discrepancies have been reported in previous studies when different resolutions of DEM, land use, and soil data are used (Chaubey et al., 2005). Despite the importance of spatial resolution, there is limited research on its specific impact on SWAT simulations for the Oyun River Watershed.

This lack of research creates a challenge in selecting appropriate datasets for hydrological modeling in the region, potentially affecting water resource management, erosion control, and flood risk assessment. Therefore, it is necessary to investigate how variations in spatial resolution influence SWAT simulations in order to determine the most suitable resolution for accurate hydrological predictions.

1.3 AIM AND OBJECTIVES

The aim is to investigate the effect of spatial resolution on SWAT simulation outcomes for the Oyun River Watershed.

The objectives are

i. To predict stream flow in the study area

ii. To predict the sediment concentration upstream of Oyun River using soil and water assessment tool.

iii. To predict the sediment yield of Oyun River using soil and water assessment tool.

1.4 SCOPE OF THE STUDY

The study focuses on the Oyun River Watershed in Kwara State, Nigeria. Spatial resolution effects will be analyzed using different DEM resolutions (e.g., 30m, 90m, and 250m), land use, and soil datasets. The SWAT model will be used to simulate streamflow, runoff, and watershed delineation. The research will use 19 years of metrological data for the prediction of flow and runoff.

1.5 JUSTIFICATION

Understanding the effect of spatial resolution on SWAT simulations is crucial for improving hydrological modeling accuracy. This study is important for the following reasons:

- Enhancing Model Accuracy – Investigating spatial resolution effects will help select the most appropriate input data for reliable streamflow and runoff simulations.
- Supporting Water Resource Management – Accurate hydrological predictions will aid policymakers and water managers in sustainable water allocation and flood control.

- Improving Computational Efficiency – By determining an optimal resolution, the study will balance model accuracy and computational efficiency, making hydrological modeling more practical.
- Contributing to Hydrological Research in Nigeria – There is limited research on how spatial resolution affects SWAT simulations in Nigerian watersheds. This study will fill that gap and provide insights for future hydrological assessments.

CHAPTER TWO

LITERATURE REVIEW

2.1. PREAMBLE

Watershed analysis is a technique used to manage, conserve, and plan the Earth's natural resources. Because watersheds are the units of study in hydrology, the DEM model is an important topic. It is a component of the watershed segmentation process, which involves splitting the watershed into discrete land and channel segments in order to examine watershed activity. A watershed is a section of land that serves as a catchment region for water. From the watershed, either the surface water then enters a common outlet in the form of a body of water, such as a lake, stream, or wetland; or it infiltrates into the groundwater. It is simply an area that drains surface water from a high elevation to a low elevation. The watershed is a hydrologic unit that is used to be modeled as it is considered fundamental to hydrologic design and it is used to aid in the study of the movement, distribution, and quality and quantity of water in an area. The cost of a hydrology and water quality modeling study is a small part of the overall management system, but the expense of implementing an inefficient system based on an incorrect simulation could be much higher. As a result, reliable model results are extremely important. Model uncertainty is made up of four parts: uncertainty in input parameters, observations, model structure, and initial values. Depending on its topography and stream distribution, a watershed can always be divided into multiple sub-basins. The degree of detail in stream distribution upstream prediction in a watershed would affect flow routing modeling accuracy and estimation of watershed responses.

The main objective of this literature review is therefore to examine various aspect of watershed resampled DEM predicting the water upstream and be acquainted with different terminologies as it relates to the study process. In addition, various methods by which watershed delineation can be estimated and existing work on hydrological processes around the world will be reviewed.

2.2. RESAMPLED DIGITAL ELEVATION MODEL

According to (Polidori & El, 2020), digital elevation model quality assessment methods, Digital elevation models (DEMs) are widely used in geoscience. The quality of a DEM is a primary requirement for many applications and is affected during the different processing steps, from the collection of elevations to the interpolation implemented for resampling, and it is locally influenced by the land cover and the terrain slope. The quality must meet the user's requirements, which only make sense if the nominal terrain and the relevant resolution have been explicitly specified. The aim of this article is to review the main quality assessment methods, which may be separated into two approaches, namely, with or without reference data, called external and internal quality assessment, respectively. The errors and artifacts are described. The methods to detect and quantify them are reviewed and discussed. Different product levels are considered, i.e., from point cloud to grid surface model and to derived topographic features, as well as the case of global DEMs. Finally, the issue of DEM quality is considered from the producer and user perspectives.

Fashae et al., (2018) examined the Digital Elevation Model for Geospatial Studies: A Case Study of Alawa Town, Niger State, Nigeria. Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER GDEM), Shuttle Radar Topography Mission (SRTM), and GTOPO30 are forms of open source DEMs that are freely available for nearly the entire globe (Fashae et al., 2018).

Barros et al., (2021) the study was developed in the Lajeado Ferreira creek catchment (1.23 km^2) in southern Brazil. Two interpolated 5-m resolution DEM maps obtained from: (i) remote sensing source Shuttle Radar Topography Mission (SRTM), and (ii) field topographic survey with Global Navigation Satellite System using Real Time Kinematic (GNSS/RTK); were used as input in the Limburg Soil Erosion Model (LISEM) to simulate runoff and sediment transport. Two other maps required for modelling were developed from each DEM source: the flow direction and drainage network map. Six monitored rainfall events were calibrated for the variables, timing of peak flow (Q_{time}), peak flow (Q_{peak}), surface runoff coefficient (C), total surface runoff volume (Q_{total}) and sediment yield (SY). Most variables calibrated were within the acceptable statistical ranges. The Q_{time} and Q_{peak} simulated for all events were close to the measured values with minor modification of the input parameters while using GNSS/RTK. However, even in maps with better accuracy of relief description (GNSS/RTK), the erosion parameters adjusted for calibration were not within an acceptable physical limit. For example, soil cohesion values had to be multiplied for at least eight times their original value. Hydrograph and sedimentgraph shapes calibration did not reach a satisfactory statistical level, even with the GNSS/RTK database and the incorporation of relevant features of the landscape based on local observation. Although GNSS/RTK database resulted in gains for some variables calibrated with the LISEM model, the advantages were not significant for the conditions of this study.

2.3. WATERSHED DELINEATION

Watershed delineation is the process of identifying the boundary of a watershed, also referred to as a catchment, drainage basin, or river basin. It is an important step in many areas of environmental science, engineering, and management, for example to study flooding, aquatic habitat, or water pollution. Watersheds are a fundamental geographic unit in hydrology, the science concerned with the movement, distribution, and management of water on Earth. Delineating watersheds may be considered an application of hydrography, the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes, and rivers. It is also related to geomorphometry, the quantitative science of analyzing land surfaces. There are several tools and techniques available to delineate watersheds. For example, the NHD Watershed Tool is an ArcView extension tool that allows users to delineate a watershed from any point on any

NHD reach in a fast, accurate, and reliable manner. Watershed boundaries can also be drawn on topographic maps using basic concepts such as water flows downhill and tops of hills and ridges are the boundaries between watersheds ("watershed delineation", 2023). In addition, ArcGIS Pro provides a Watershed tool that can be used to delineate watersheds from a DEM by computing the flow direction and using it in the tool. To determine the contributing area, a raster representing the direction of flow must first be created with the Flow Direction tool.

2.4. PREDICTION OF FLOW IN SWAT

The Soil and Water Assessment Tool (SWAT) is a hydrological model that can be used to predict streamflow in a watershed (Yuan & Forshay, 2021). There are several methods that can be used to enhance the accuracy of streamflow predictions with SWAT, including:

i. Support Vector Regression (SVR): This is a machine learning technique that can be used to calibrate SWAT for spatial calibration, which can improve the accuracy of streamflow predictions (Yuan & Forshay, 2021).

ii. Discrete Wavelet Transform (DWT): This is a mathematical technique that can be used to analyze and filter time-series data. Coupling DWT with SVR can further improve the accuracy of monthly flow prediction in SWAT (Yuan & Forshay, 2022).

iii. Artificial Neural Networks (ANN): Coupling SWAT with ANN models can enhance daily streamflow prediction (Senent-Aparico et al., 2019)

iv. Predicting discharge flow: SWAT can also be used to predict the discharge flow in small hydropower stations without hydrological data (Xie & Zhu, 2022).

Overall, there are several methods that can be used to enhance the accuracy of flow prediction with SWAT, including machine learning techniques, mathematical transformations, and coupling with other models.

CHAPTER THREE

METHODOLOGY

3.1 DESCRIPTION OF THE STUDY AREA

The study area is the Oyun River Basin, which has a terrain elevation of 259 meters above sea level and can be found between latitudes 9^0 5^01 and 8^0 24^1North and Longitudes 4^0 38^1 and 4^0 03^1 East. The river Oyun, which starts near Ila Oragun at an elevation of 465.003m above the sea level, flows for about 80 kilometres to the northeast and converges with the river Asa. The area of Oyun in Kwara State is located southeast of Ilorin and is known for its open and undulating terrain, rocky outcrops, and varying slopes in the northwestern portion. It is a region of Nigeria's grass plains that is mostly used for farming with only a small section of forest reserve.

The River Oyun is a major water source for Offa town and its neighboring areas, and it also supplies raw water for the University of Ilorin water supply scheme. Figure 1 shows a map of the Oyun River basin, which includes a network of rivers and catchment areas, with the catchment area of interest being enclosed within the thick black boundary line.

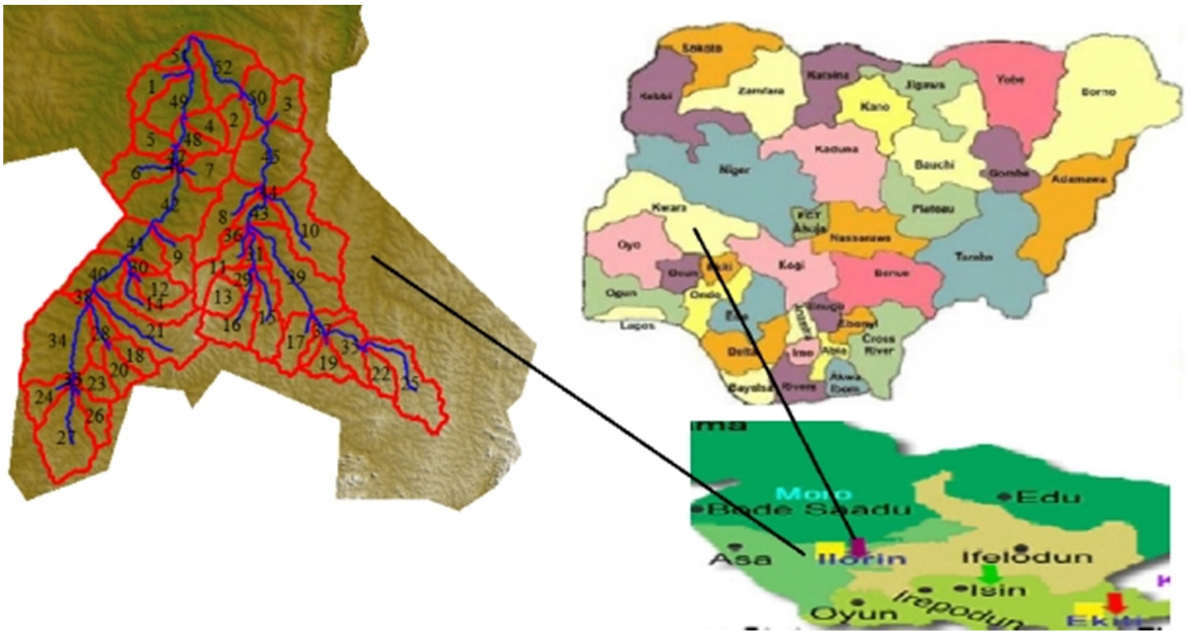

Figure 3.1: Location map of the study area.

3.2 MODEL SELECTION

The model used in this study is the soil and water Assessment Tool, SWAT (neitsch et al., 2005). The selection of SWAT for this study was based on many reasons which are listed as follows

i. SWAT is an existing software that is available for free on SWAT website.

ii. It also has several user groups e.g SWATworld, SWAT Africa and waterbase Goggle group which serves as plus to the acceptability of the tool among researchers.

iii. Its availability and efficacy in prediction of different hydrological processes has also been reported in many studies (Adeogun et al., 2015; Chen *et al.,* 2021) which make it attractive to engineers and other users.

3.2.1 INTRODUCTION TO SWAT MODEL DESCRIPTION

The description that follows describes the conceptual Soil and Water Assessment Tool (SWAT) model version 2009 and how the model was implemented and calibrated for selected priority watersheds: Bayou Bartholomew, Beaver Reservoir (Upper White River), Illinois River Drainage Area in Arkansas (IRDAA), and Lake Conway Point Remove.

3.2.2 THE CONCEPTUAL MODEL

The SWAT model originated from the collaborative efforts of the U.S. Department of Agriculture – Agriculture Research Service (USDA-ARS) and operates on a continuous time basis as a conceptual model. Its integral components encompass weather patterns, hydrological processes, erosion and sedimentation dynamics, plant growth mechanisms, nutrient and pesticide interactions, agricultural management practices, channel and reservoir routing, among others. Within the agricultural realm, it accounts for variables like fertilizers, crops, tillage methods, grazing, and even the incorporation of point source loads (Neitsch et al., 2009). Focusing on the influence of land management practices on constituent yields within a watershed, the SWAT model continues to build upon over three decades of development by USDA-ARS. Predecessors like the CREAMS, GLEAMS, and EPIC models (Knisel, 1980; Leonard et al., 1987; Williams et al., 1984) have contributed significantly to the evolution from smaller field-scale models to a comprehensive framework that encompasses extensive river basins. As a publicly available model, SWAT is actively maintained by USDA-ARS at the Grassland, Soil, and Water Research Laboratory in Temple, Texas. Its utility is underscored by a substantial body of literature, with over 700 peer-reviewed scientific journal publications documenting its development and diverse applications.

The development of the SWAT model is an ongoing progression, succeeding the "Simulator for Water Resources in Rural Basins" (SWRRB) model. The SWAT model is a sophisticated physically grounded framework designed to assess and predict water and sediment movement, as well as agricultural chemical interactions, within ungauged basins. It excels at conducting extended-term simulations. The model divides the entire catchment into sub-catchments, further segmented into hydrologic response units (HRUs) distinguished by land use, vegetation, and soil properties. Inputs for the model encompass daily rainfall data, maximum and minimum air temperatures, solar radiation, relative air humidity, and wind speed. This framework adeptly depicts the circulation of water and sediment, vegetation growth, and nutrient dynamics. Snowfall rates can be determined based on precipitation levels and mean daily air temperature. Evapotranspiration estimates rely on the Penman-

Monteith, Priestley-Taylor, and Hargreaves methods. For precise forecasting of water, nutrient, and sediment movements, the model prioritizes the simulation of the hydrologic cycle, which encompasses the overall water flow within the catchment. To achieve this, the model employs the subsequent water balance equation within the catchment area.

SWAT is a theoretical model that operates on a daily time step. In order to adequately simulate hydrologic processes, the watershed is divided into sub-watersheds through which streams are routed. The sub-units of the sub-watersheds are referred to as hydrologic response units (HRUs) which are the unique combination of soil, land use, and slope characteristics and are considered to be hydrologically homogeneous. Both sub-watersheds and HRUs are user defined, providing model users with some control over the resolution considered in the SWAT model (Neitsch et al, 2005). The model calculations are performed on a HRU basis and flow and water quality variables are routed from HRU to sub-watersheds and subsequently to the watershed outlet. The SWAT model simulates hydrology as a two-component system, composed of land hydrology and channel hydrology. The land portion of the hydrologic cycle is based on a water mass balance. Soil water balance is the primary considerations by the model in each HRU, which is represented as (Arnold et al, 1998)

In the watershed's hydrologic balance, each hydrologic response unit (HRU) encompasses four reservoirs: snow accumulation, the soil profile (0-2 meters), a shallow aquifer (2-20 meters), and adeep aquifer (>20 meters). The soil profile consists of multiple layers. Processes involving soil water entail infiltration, percolation, evaporation, plant uptake, and lateral flow. Surface runoff is estimated using either the SCS curve number method or the Green-Ampt infiltration equation. Percolation is simulated using a layered storage routing approach in conjunction with a crack flow model. The calculation of potential evaporation can be achieved through the Hargreaves, Priestly-Taylor, or Penman-Monteith methods (Arnold et al., 1998).

3.3. MODELING TOOL AND GIS INTERFACE

The selected modeling tool for this study is the Soil and Water Assessment Tool (SWAT). Developed by the United States Department of Agriculture (USDA), SWAT was designed to predict the impact of land management practices on water, sediment, and agricultural chemical yields within extensive basins where measurement data is lacking (Arnold et al., 1995). The establishment of sub-catchments and other spatial data manipulation was performed using MapWindow GIS. MapWindow GIS, devised by Leon (2011), serves as a compact resource for delineating watersheds based on Digital Elevation Models. It represents a window-oriented, open-source GIS client capable of visualizing, administering, editing, analyzing data, and composing printable maps. Its functionalities extend to robust analytical processes achieved through integration with GEOS and Geospatial Data Abstraction Library (GDAL).

3.3.1 DIGITAL ELEVATION MODEL (DEM)

This is a map of the elevation of the terrain in the basin being modeled. It is used to calculate the slope and aspect of the land, which are important factors in determine the movement of water through the basin. Digital elevation model used in this study is of resolution 90m x 90m and was obtained from online database developed by [CGIAR (2012) SRTM 90m Digital Elevation Data (2012) April, 2013]. The CGIAR-CSI GeoPortal is able to provide SRTM 90m Digital Elevation Data for major part of the entire world. The DEM provides the basis for watershed delineation into sub-basins. Also, topographic parameters such as terrain slope, channel slope and reach length are derived from the DEM.

3.3.2 LAND USE/COVER DATA

This is a map of the different types of land use and land cover in the basin, such as forests, croplands, and urban areas. It is used to determine the amount of water that is intercepted by vegetation, as well as the amount that infiltrates into the soil. The Land use map that is needed to run SWAT was extracted from the Global Land Cover Characterization (GLCC) database, and it is also used to estimate vegetation and other parameters representing the watershed area. The GLCC database was developed by United State Geological Survey and has a spatial resolution of 1Km and 24 classes of land use representation (GLCC (2012) Assessed on 8th May 2013).

3.3.3 DIGITIZED SOIL DATA

This is a digitize soil data of the different types of soil in the basin, including information on soil texture, depth, and water-holding capacity. It is used to determine how much water can be stored in the soil, as well as how quickly water can move through the soil. The digital soil data for the study was extracted from harmonized digital soil map of the world (Harmonized World Soil Database (HWSD)) produced by Food and Agriculture Organization of the United Nations, Rome (Nachtergaele et al., 2009). 16 soil samples were collected from two different layers (0 - 30 cm and 30 - 100 cm depth) and the samples were analyzed and used to update the model parameters.

3.3.4 WEATHER DATA

This includes information on precipitation, temperature, and other weather variables. It is used to drive the model and simulate the movement of water through the basin. Meteorological data necessary to run the SWAT model was obtained from Nigeria Meteorological Agency (NIMET) station based in Ilorin, Kwara State. The data collected includes daily precipitation, maximum and minimum temperature, solar radiation, relative humidity and wind speed, in order to perform the hydrological analysis. The collected weather variables for driving the hydrological balance within the watershed were for a period of 19 hydrological years i.e. (January 1, 2001 to December 31, 2019).

3.4 WATERSHED DELINEATION IN SWAT

Water delineation in swat involves using digital elevation model (DEMs) and other spatial data to identify the boundary of watershed. The process involves identifying the ridgelines that separate one watershed from another and then using algorithm to determine the flow direction of water within the watershed. This information is then used to model the hydrology of the watershed, including the amount and timing of water runoff, the amount of sediment and nutrient carried by the water, and the impact of land use and management practices on water quality and quantity. Swat is a powerful tool for watershed management and planning, and accurate watershed delineation is essential for ensuring the accuracy of its predictions. And also watershed delineation using DEM in a Geographical Information System (GIS) provides better analysis and visualization capabilities to understand the simulation of various parameters in the watershed.

3.5 MAP WINDOW GIS

A map window in GIS (Geographic information system) software refers to the area where map data is displayed. It is the main interface for viewing and interacting with spatial data layers which include vector data (points, lines, and polygon). The map window is typically the main area where you view and interact with spatial data. It is well you can see the different layers of data that makes up a map, such as land use. The map window allows you to zoom in and out on the map pan to different locations, and select and identify features on the map. You can also perform various spatial analyses in the map window, such as measuring distances and areas, creating buffers, and performing overlay operations. The map window is a critical component of GIS software, as it allows you to visualize and analyze spatial data in a way that is not possible with traditional 2D maps. Map Window GIS has been embraced by the United States Environmental Protection Agency as a platform for its BASINS watershed analysis system. Moreover, it experiences a monthly download rate exceeding 3000 instances by both end users in need of a free GIS data viewer and programmers seeking tools for applications, both commercial and non-commercial in nature.

3.6 WATERSHED DELINEATION INTO SUB-BASINS AND HYDROLOGIC RESPONSE UNITS (HRUS):

The Soil and Water Assessment Tool (SWAT) model is used to analyze and delineate the watershed into sub-basins and delineation of sub-basins into Hydrologic Response Units (HRUs). SWAT model is a watershed scale and continuous-time model scale capable of simulating long-time yields for determining the effects of land management practices (Arnold and Allen 1999). The delineation of the watershed was achieved using reprojected DEM of the study area. A threshold size of $20km^2$ was set and maintained all resolutions of the DEM for the GIS interface. A total of 55 sub-basins were created in the watershed and was subdivided into 59 hydrologic response unit (HRUs) for all the resampled DEM and the watershed was delineated automatically. The HRU is the smallest spatial unit needed for running the hydrological model.

3.7 SWAT SETUP AND RUN

SWAT was executed using the Soil Conservation Service (SCS) Runoff Curve Number method for estimating surface runoff from precipitation. The SCS curve number method is a rainfall-runoff model that was designed for computing excess rainfall (direct runoff). This method assumes an initial abstraction before ponding that is related to curve number. The daily weather (precipitation, wind, solar radiation, relative humidity and daily minimum and maximum temperature) data were prepared in the appropriate file format (as Microsoft excel file) required by the model and imported into the model. The resampled DEM of the study area were used in turn for the prediction of flow and the sediment loadings. The simulation period is from 01 January 2001 to Dec 31, 2019. All the necessary files needed to run SWAT were written and the appropriate selection of weather sources done before running the SWAT executables.

Therefore, the study seeks to find answers to the effects of resampled DEM on prediction of flow and also the sediment loadings. In this regard, the case study of oyun river catchment in kwara state during the period of 2001- 2019.

CHAPTER FOUR

RESULT AND DISCUSSION

4.0 RESULTS FOR PREDICTION OF FLOW AND SEDIMENT LOADINGS

4.1 PREDICTION OF STREAM FLOW

Figure 4.1 shows the spatial variation of flow map prediction of the study area. The results of the streamflow prediction analysis revealed significant variation in streamflow across the subbasins.

Two key findings are highlighted below:

1. Highest Streamflow (Subbasin 51): Subbasin 51 was identified as having the highest recorded streamflow value, with a peak flow of 181.39. This high streamflow value suggests that Subbasin 51 is a significant contributor to the overall flow in the watershed. The reasons for this high flow may include factors such as high precipitation, land use characteristics, soil properties, and the presence of significant tributaries.

2. Lowest Streamflow (Subbasin 23): In contrast, Subbasin 23 exhibited the lowest recorded streamflow value, with a minimum flow of 4.10. This subbasin likely experiences lower streamflow due to factors such as lower precipitation, different land use patterns, soil

properties that promote infiltration and groundwater recharge, and minimal contributions from smaller tributaries.

The observed variation in streamflow between Subbasin 51 and Subbasin 23 underscores the importance of local factors and watershed heterogeneity in determining streamflow patterns. It is important to note that streamflow is influenced by a complex interplay of meteorological, geological, and land use factors. Therefore, variations in streamflow values across subbasins are expected and provide valuable information for water resource management.

Understanding the spatial distribution of streamflow can aid in the identification of areas with potential water resource challenges, such as flood risk in high-flow subbasins or water scarcity issues in low-flow subbasins. Additionally, these findings can guide land use planning and conservation efforts to mitigate the impact of land use changes on streamflow.

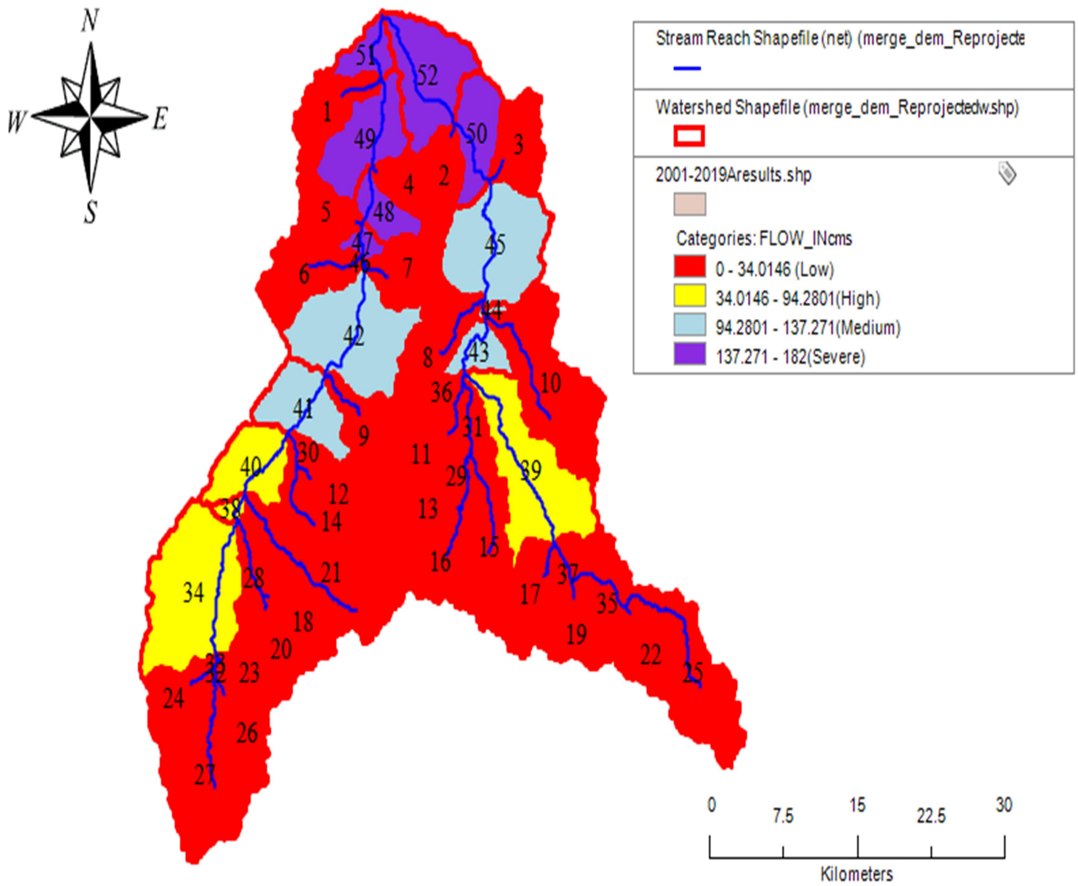

Figure 4.1: Spatial variation of predicted Flow of the study area

4.2 PREDICTION OF SEDIMENT CONCENTRATION

Figure 4.2 visualized the spatial variation of the sediment concentration prediction across the study area. The analysis of sediment concentration within the subbasins reveals noteworthy variations, with two subbasins, Subbasin 11 and Subbasin 49, displaying extreme values:

1. Subbasin 11: This subbasin recorded the highest sediment concentration among all subbasins, with a concentration value of 17,240. This indicates that Subbasin 11 is a significant contributor of 48 sediment to the watershed's streams. The high sediment concentration may be attributed to factors such as extensive agricultural activities, steep slopes, or soil erosion.

2. Subbasin 49: In contrast, Subbasin 49 exhibited the lowest sediment concentration, with a concentration value of 5,652.11. This suggests that Subbasin 49 has a relatively lower sediment contribution to the stream network. Factors such as land use practices, vegetation cover, and lower erosion rates may contribute to this lower sediment concentration. The observed variation in sediment concentration values across subbasins underscores the spatial heterogeneity of erosion and sediment transport processes within the watershed. Several factors can explain these differences:

i. Land Use: Subbasins dominated by agricultural or urban land uses are more likely to experience higher sediment concentrations due to increased runoff and soil disturbance.

ii. Topography: Steeper slopes in some subbasins can lead to higher erosion rates and subsequently, elevated sediment concentrations in the water.

iii. Soil Erosion: The type of soil and its susceptibility to erosion significantly affect sediment concentration. Subbasins with soils prone to erosion may exhibit higher sediment values.

iv. Vegetation Cover: Areas with extensive vegetation, such as forests, tend to have lower sediment concentrations, as vegetation acts as a natural buffer against erosion.

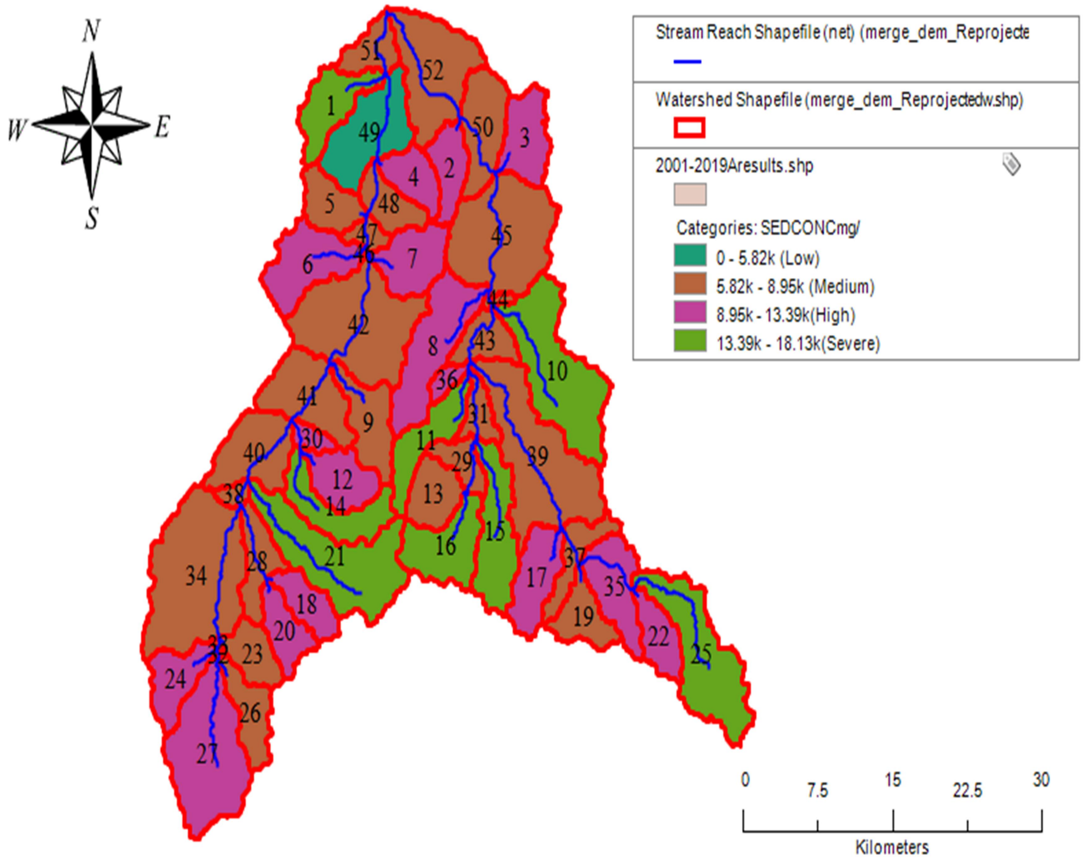

Figure 4.2: visualization of spatial variation sediment concentration prediction across the study area

4.3: PREDICTION OF SEDIMENT YIELD

Figure 4.6 shows the spatial variation for sediment yield prediction across the study area. The analysis of sediment yield within the subbasins reveals noteworthy variations, with two subbasins, Subbasin 50 and Subbasin 46, displaying extreme values:

1. Subbasin 50: This subbasin recorded the highest sediment yield among all subbasins, with a yield value of 50.65. This indicates that Subbasin 50 contributes a substantial amount of sediment to the watershed's streams. The high sediment yield may be attributed to factors such as intensive agricultural activities, steep slopes, or increased soil erosion.

2. Subbasin 46: In contrast, Subbasin 46 exhibited the lowest sediment yield, with a yield value of 9.28. This suggests that Subbasin 46 has relatively lower sediment contribution to the stream network. Factors such as land use practices, vegetation cover, and lower erosion rates may contribute to this lower sediment yield 49

The observed variation in sediment yield values across subbasins underscores the spatial heterogeneity of erosion and sediment transport processes within the watershed. Several factors can explain these differences:

i. Land Use: Subbasins dominated by agricultural or urban land uses are more likely to experience higher sediment yields due to increased runoff and soil disturbance.

ii. Topography: Steeper slopes in some subbasins can lead to higher erosion rates and, consequently, elevated sediment yields in the water.

iii. Soil Erosion: The type of soil and its susceptibility to erosion significantly affect sediment yield. Subbasins with soils prone to erosion may exhibit higher sediment yields.

v. Vegetation Cover: Areas with extensive vegetation, such as forests, tend to have lower sediment yields, as vegetation acts as a natural buffer against erosion.

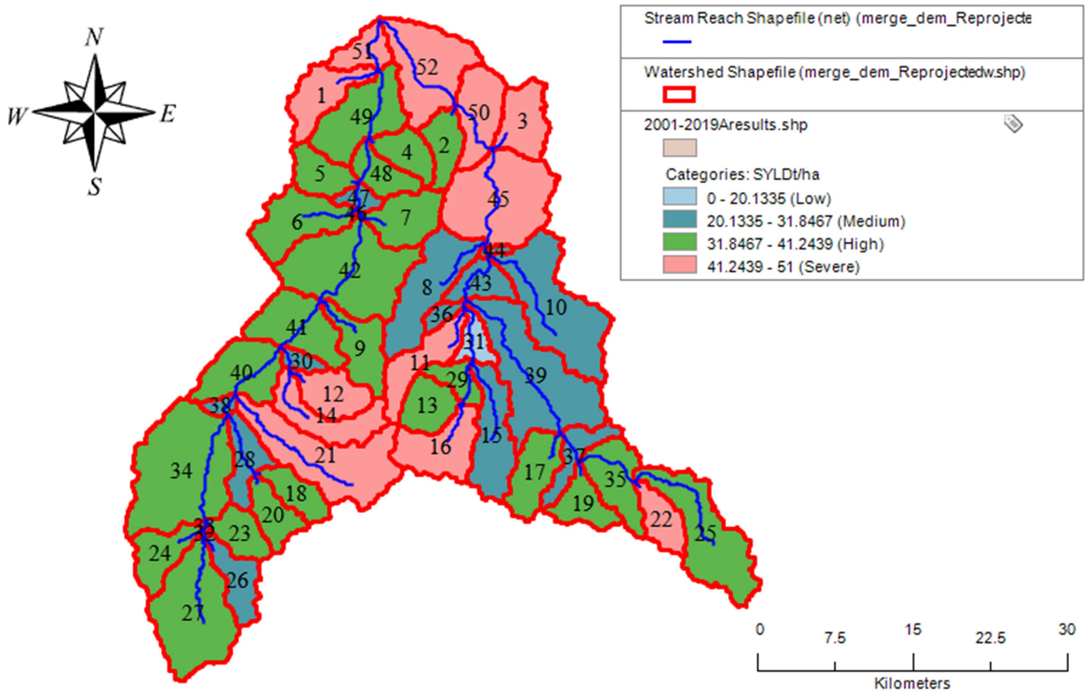

Figure 4.3: Spatial variation for sediment yield prediction of the study area

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

i. The SWAT model's streamflow prediction analysis has provided valuable insights into the variation of streamflow within the study area. Subbasin 51 exhibited the highest streamflow value, while Subbasin 23 had the lowest. These findings highlight the need for targeted management strategies that consider local factors and watershed characteristics to address water resource challenges effectively. Further research and data collection may be required to better understand the specific drivers of streamflow variations in these subbasins and their implications for watershed management.

ii. The analysis of sediment concentration within subbasins provides crucial insights into the sediment dynamics of the watershed. The significant variation observed between Subbasin 11 and Subbasin 49 highlights the need for localized erosion control and sediment management strategies. These findings have implications for water quality, aquatic habitat preservation, and overall watershed management.

iii. The analysis of sediment yield within subbasins provides crucial insights into the sediment dynamics of the watershed. The significant variation observed between

Subbasin 50 and Subbasin 46 highlights the need for localized erosion control and sediment management strategies. These findings have implications for water quality, aquatic habitat preservation, and overall watershed management.

5.2 RECOMMENDATION

i. Further investigation is required to determine the specific factors contributing to the extreme sediment concentration values observed in Subbasin 11 and Subbasin 49.

ii. Future research could explore the effects of DEM resolution on other watershed characteristics, such as soil erosion and sediment transport.

iii. When performing hydrological modeling, it is essential to carefully consider the appropriate resolution of DEMs. Finer resolutions provide more detailed data but may introduce computational overhead. Therefore, the selection of resolution should strike a balance between data precision and computational efficiency.

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