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Integrated Analysis of Land Use, Soil Saturation, and Runoff Generation in Hydrologically Sensitive Zones of an Choke Agricultural Watershed

Walelgn Dilnesa[1] Tesfaneh Getaw[1] Nebyu Kassahun[1]

[1]Markos University, hydraulic and water resources engineering Academic program, P.O. Box 269 Debre Markos, Ethiopia tsegayesusd@gmail.com

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Abstract

Evaluation of hydrologically sensitive areas was a big challenging issue, especially to identify and locate the particular areas. In the upper Blue Nile basin, hydrological sensitivity was a more and intensive phenomenon that leads to watershed alternativeltity with influencing the streamflow parameters. This watershed area leads to hydrologic sensitivity due to anthropogenic and natural factors, which particularly existed in river morphology. This study focuses on, the identifications of hydrologically sensitive areas in the Ziya (choke) watershed area, depend on the topographic, slope and hydraulic roughness parameters. For the analysis of the sensitive area, it was used the soil topographic index (STI), topographic witness index (TWI) and considered TOPOMODEL for surface runoff evaluation. An investigation made on selections of sensitive area and prone regions, high regions generate more amount of surface runoff accompanied by land use/cover change, variable surface area, climate change. In Lowest, parts of the watershed have low soil moisture contents in Belg seasons with a range of 25.53 NMC, 38.7 FC, and 27.24 PWP. The TWI values in this watershed range from -3 through 28.6 with the threshold of values identifying areas of significant wetness between 9 and 29.5. The TOPMODEL result shows that a large amount of surface runoff has occurred in the upper parts of a watershed with a range of 320 mm/ year. The lower reaches also suffered by high levels of sedimentation rate with a value of 3.873 t/ha. Generally, the watershed has suffered under hydrological sensitivity with a high level of severity. Therefore, the remedial measure should have been applied by an intervention of ecological and social welfare.

Keywords: TWI, Hydrological sensitivity, STI, VSA

1. Background

A Hydrologically Sensitive Area (HSA) is any area in a watershed that is prior to generating runoff and therefore has the potential to transport pollutants, nutrients, biodegradable chemicals, and soil saturations(Walter et al., 2000). These phenomena directly linked with Variable source area hydrology, which is a watershed runoff process whereby saturated areas are the primary sources of runoff; i.e. rain that falls on saturated areas becomes overland flow(Hewlett and Hibbert, 1967). Therefore, the propensity of an area to produce runoff is largely independent of rainfall intensity.

In places where VSA hydrology is a dominant process, there will be regions within a watershed that are more susceptible to producing runoff than others are(Huang et al., 2008). Therefore, there is an enhanced hydrologic sensitivity associated with these areas relative to non-runoff generating areas; runoff provides quick transport mechanism for potential pollutants between the landscape and surface water bodies. These areas are appropriately called hydrologically sensitive areas (HSA's). A quantifiable description of HSA's provides a basis or at least a starting-point for water quality risk assessment and developing water quality management practices for NPS pollution(Skaggs et al., 1994).

Realization of variable source area hydrology is bit valuable hydrological phenomena towards for the developments of water quality risk assessments. The irrefutable thing that water quality depends on the wide range of physical, chemical, biological, socio economic factors and hydrological process in general. Thought interacted study among variable source area hydrology, water quality and hydrologically sensitive areas are quite feasible in the sectors of integrated watershed management and propertied stakeholders for water resources experts (Reddy et al., 2018). Historically, water quality protection efforts have been (and continue to be) largely influenced by a dogma developed by the soil conservation infrastructure.

The aims of this research proposal to investigate associated effects of land use, water quality, soil saturation, and runoff generation in delineated areas of the choke mountainous watershed. It is well known that in the watershed area the effectiveness of the hydrological and ecological

as well as environmental conditions vulrunable in the last several years. However, it is hypotheses that the effectiveness of the existing practices significantly improved by incorporating additional criteria into their implementation strategy. That are well designed to better protections of hydrological sensitive areas from the urban development and it should be maintain healthy watershed for the nearest living society without scarifying the original purpose of the controls. In this study, we are doing on the agricultural watershed land scopes located in east

gojjam zone, where the variable source area was the main influencing components as we have studded by certain scholars(Shelemay, 1994). Risks of VSA storm runoff generation are closely correlated with soil moisture (or soil moisture deficit) (Buchanan et al., 2014). Therefore, we need to take care about the hydrologic sensitive areas for the better protections of our water resources potential and a remedial measure to alleviate wide problems associated with this.

1.1 Problem of the Statement

One of the focusing sector in the soil and water lab across the globe is quantifying the risk of soil saturation and mapping HSs in Watershed area. Protection of ecological integrity of watersheds would be relatively less expensive than restoration of ecological functions of impaired watersheds. Urban development imposes immediate threats to water resources because it increases impervious surfaces and diminishes groundwater recharge resulting in greater storm water runoff that carries more pollutants into waterways (Arnold and Gibbons 1996; Alberta et al. 2007; Schuler et al. 2009). Increases in urban land use accompanied by loss in agricultural lands, wetlands, and forestland greatly alter watershed hydrology and exacerbate the problem of nonpoint source pollution, which degrades stream integrity, including stream chemistry and biotic health (Gupta 1995; Goma et al. 2002; Kennan et al. 2008, 2010).

The higher volumes of runoff generated by HSAs implies that HSAs account for the bulk of pollutants transported to waterbodies and, hence, most of the water quality degradation in watersheds. Therefore, identifying HSAs is a crucial step in understanding the effect of land use change on water quality, stream integrity, distribution of denitrification rates in the landscape, estimation of soil water distribution, and placement of land use restrictions to protect sensitive areas of a landscape.

Improper protection of Hydrologic sensitive areas was a big issue in several parts of the worlds Moreover, a Cause of loss in human's being and materials. Frequents landslide, flooding, in several country's correlates directly and indirectly with the issues of lack of attention in sensitive areas. These issues were the common problems of Ethiopian highlands in lack of delineation and preservations, especially in guna watershed, simenn mountainous area and this was a case of eastern choke watershed area.

Due to the interventions of anthorophoneginc and natural factors, the study area suffers problems like, excessive overland flow, water quality problem, land use/cover change, and excessive soil saturation conditions. Indeed, the areas have unique physiographic characteristics of, namely valley and ridge, highlands, piedmonts physiographic region and the source of many rivers and springy, though the topographic features more excretes the problems. In the last several years, the study area was experienced more agricultural practices and less of rapid urbanization process. In the recent time period, rapid urbanization took place in the study area at the expense of agricultural lands, forest, and wetlands (Giri et al., 2017). New urban development consisted primarily of low-density residential housing and other infrastructure, such as parking lots, roads, and rights of way (Newman et al., 2016).

The study area is most intensely affected and inundated by the floods. As a 'result/ these conditions adversely affect them. Rivers discharging the flood water through their mouths. Very often, the floods are accompanied by the storm runoff surges during the pre-and post-summer seasons. Besides quick discharge of floodwater, storm surges cause water quality inundation in the lower portion of the watershed tract. Normally low floods are beneficial to crops and improve the fertility of the soil by the deposition of fine detrital matter. In the last summer season under in the study area, around 100 peoples suffered by landslides. Highland streams also face non-point source discharges from domestic activities, grazing fields and agricultural runoff (Alemneh et al., 2017). In addition, due to high degree of elevation of the watershed, the water sources are highly exposed to sedimentation because of ecological degradation of the surrounding watershed. Therefore, studying and identifying the hydrologically sensitive areas being the main concerns of the eastern choke watershed area.

1.2 Objective of the Study

The main objective of the study is to identify hydrologically sensitive areas in eastern choke mountainous watershed

1.2.1 Specific Objective

i. To mapping runoff generations contributing area
ii. To evaluate threshold soil topographic indices (STIs)
iii. To identify critical management zones under the interstation between hydrological sensitive area and pollutant loading regions

2. Methodology

2.1 Study Area

Choke Mountains are a large block of highland founds in south of Lake Tana in the center of Gojjam. The eastern choke also one parts of choke watershed that located in the side of Debre Markos town for east gojjam zone. The central area is located at 10042' N and 370 50' E. The highest peak rises to 4100 m.a.s.l. From this mountainous watershed, it originates 59 rivers and 273 springs and it is named as a water tower of the upper Blue Nile Basin. The watershed area composed of plants and animals diversity and lives in under the forms of endemism. In addition, the area is the wettest place around in east gojjam zone and whole in gojjam. Due to these, the soil saturation is high and the water tables rise up in the tip parts of the mountains and the ability to contribute overland flow with the reasons of high slope variation. There are eight types of soil groups and they could be a source of inspiration and adventure destinations for the people if they properly conserved the flora, faun in general.

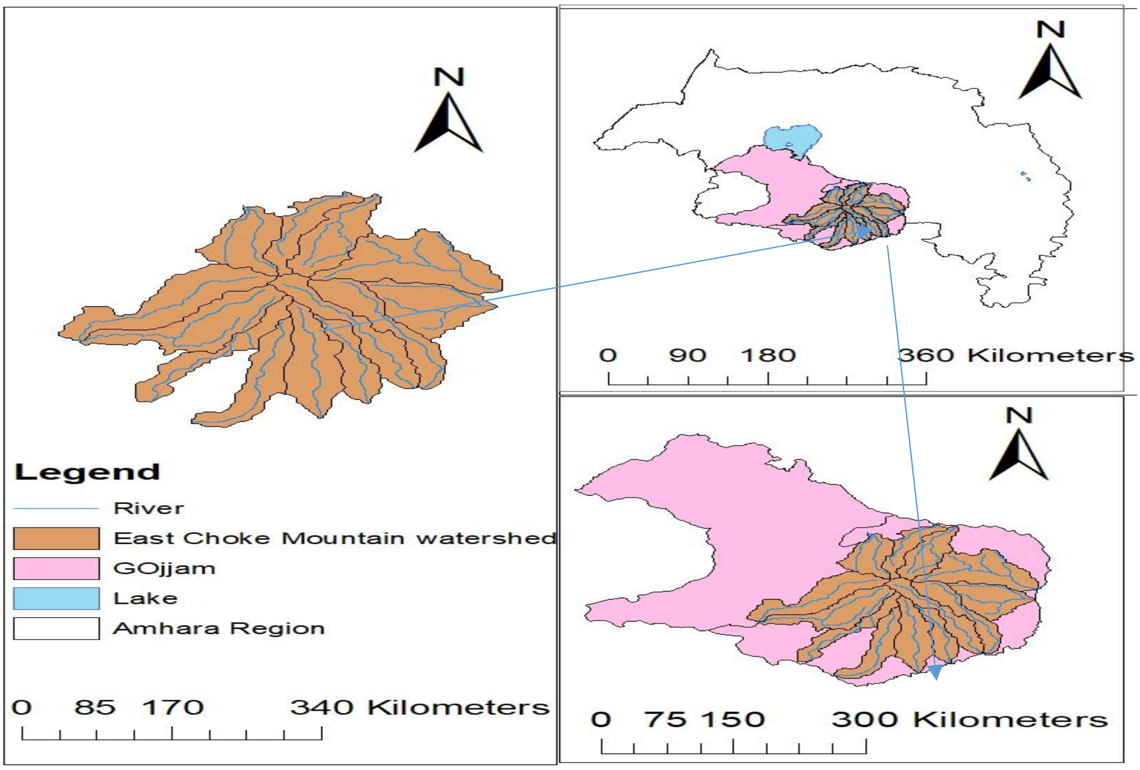


Figure 2.1 relative location of the study area

The eastern choke watershed area has face a land degradation problem, which was early studied by(Adane et al., 2015) due to the reasons of overgrazing deforestation, and unsuitable land use/cover practices. This intensive land use/cover change practices increase soil erosions, this intimates the sedimentation probability of the nearest constructed hydraulic structures such as weir, dam and barrage. Most of the biological diversities, ecosystems, & functions in Choke Mountains are heavily threatened therefore the eastern choke mountainous watershed becoming hydrologically sensitive area.

2.2 Materials

The research input data will be obtained from different institutions, governmental organizations, and online access such as earth explorer. This study will be performing the examination of hydrological sensitivity in the eastern choke mountainous watershed for the last 32 years i.e. (1987-2019 GC).

Table 2.1 data collection from different sources

No	Data type	Source	Description
1	DEM	Usgs.gov.survey	For topographic index extraction and visualization
2	Land use	Minister of irrigation, water resources and electricity of Ethiopia	For water quality and land use interaction examination
3	Precipitation and temperature	NMSA	Surface runoff generation analysis
4	Soil moisture data	From satellite (ALASKA facility)	Soil saturation and topographic index analysis
5	ground truth soil moisture data	Filed soil moisture data collection	Soil saturation and topographic index analysis

2.3 Methods

I use Arc GIS environment and TOPMODEL combindly to estimate runoff risk as well as the fraction of runoff generating areas and its corresponding frequency. Considering the geography of the eastern choke mountainous watershed, we treat the production of runoff as a bivariate process, which involves the interaction between temperature, precipitation, water quality and precedent soil moisture conditions.

Based on the predicted spatial extent of saturated areas, runoff-generating areas will be mapping in a Geographic Information System (GIS) using a Soil Topographic Index (Walter et al. 2002.

Field soil moisture data will be collect under in the study area in respective of three For the soil topographic indices analysis we have been assess on the relationship between the observed soil moisture and the calculated soil topographic index (STI). In sites using a modelled approach, and validate the identified threshold STIs in delineating HSAs in several watersheds in eastern choke mountainous watershed based on a linear mixed modeling of the relationship between land use, soil moisture and surface runoff generation, flood and water

Quality at the watershed and HSA scales (Giri et al., 2017). Months i.e. January, February, and March. The linear mixed models assess the relationship between land use variations in terms of percentages of land uses and three water quality indicators including total suspended solids, total nitrogen, and total phosphorus in streams at all watershed and HSA scales. The detail working methodology and conceptual framework for identifying hydrologically sensitive areas are shown in the figure below.

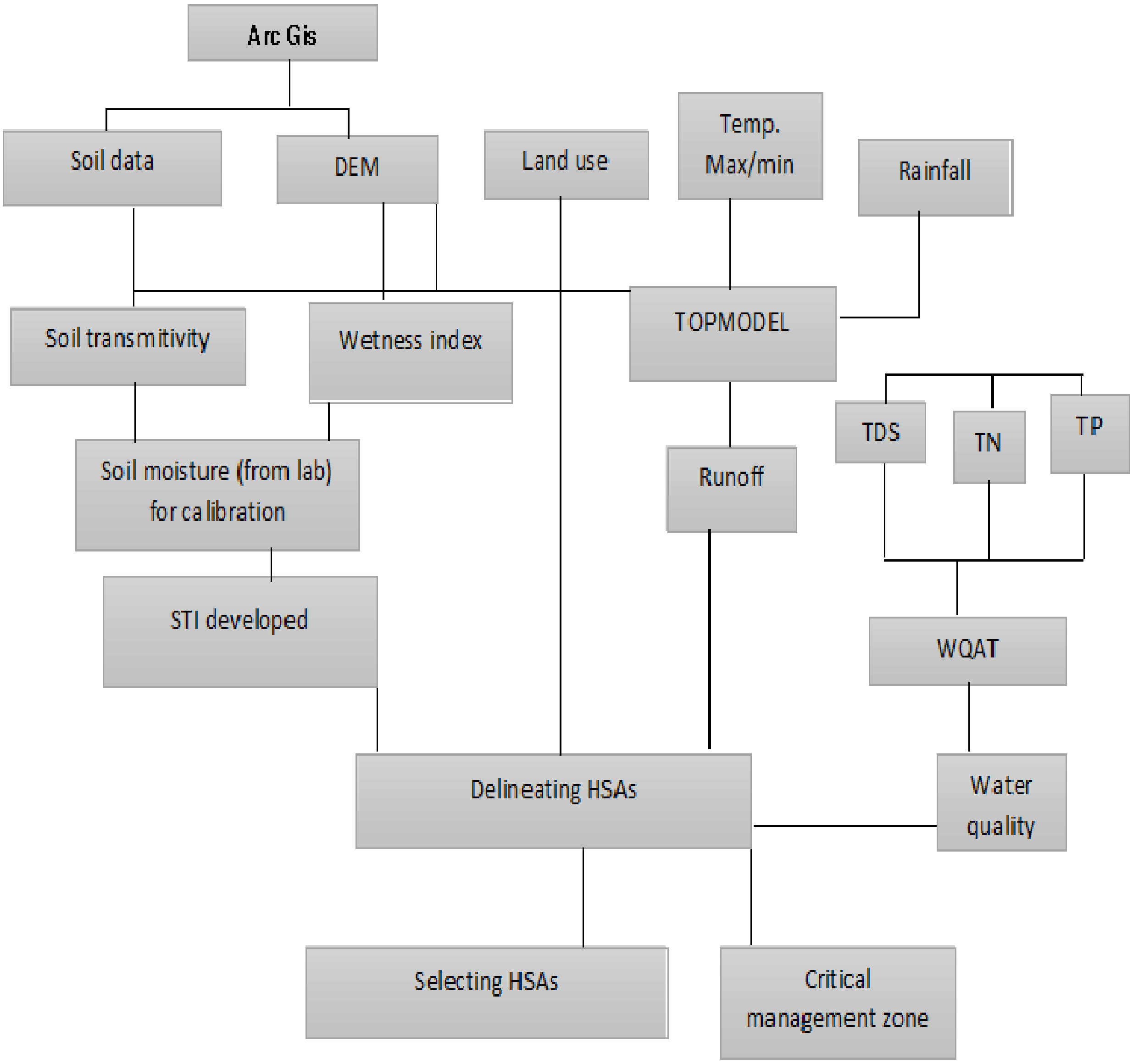


Fig. 2.2: the conceptual framework for identifying hydrologically sensitive areas

2.4 Soil Moisture Data Collection

Soil moisture filed measurement is a key step for this research study, in order to evaluate the impacts of soil moisture saturation on runoff generation. In some regions of the study area, the soil property is shallow, Due to low permeability of the shallow restrictive layer; soil moisture in the upper soil layer is a key variable influencing runoff generation, which is primarily a saturation–excess process in the Study region (Walter et al., 2003; Easton et al., 2008). All field sites will chose based on their proximity to the research facility, land use characteristics, similar mid slope positions, sites access, and minimal influence from subsurface drainage. Specific sampling points within each site were chosen to cover the full range of TWI-values while allowing for reasonable sampling time. Volumetric soil moisture readings in the upper 12 cm will be collected with time domain reflectometry (TDR) probes across a gradient of TWI values at each site. A minimum of three TDR readings were recorded at each sampling point and used to calculate the average point VWC for each date.

All sampling points were located with GPS units (horizontal accuracy 3 m). For storms greater than 6 mm, a minimum of 24 h elapsed before collecting TDR measurements in order to allow for gravity-driven redistribution of soil moisture. All VWC measurements normalized by the average field soil moisture for each sampling date. Consequently, all soil moisture values represent a relative measure of wetness. Gravimetric soil moisture measurements, made on soil cores taken from each site will be use to calibrate the TDR probe. The soil cores are collect across a range of wetness conditions.

2.5 Model Calibration and Validation

A calibration curve, which related to TDR period and gravimetric measurements, will be then construct to correct VWC readings derived from the TDR probe. To validate the optimal models identified via the AIC analysis, we calculated rs and R2 values, which were averaged across field sites and sampling dates as a means for controlling for the lack of independence among soil moisture measurements (albeit more crudely than the mixed effects models). The average rs and R^2 values not only help to evaluate the accuracy of the optimal TWIs but also facilitate inter study comparisons as most previous research assessed the strength of correlation between soil moisture patterns (either observed or model generated) and various TWI formulations via these two methods.

2.6 Data Collection Protocols

1. In order to avoid a direct impacts of precipitation on soil moisture data collection scheduled such as there will not be precipitation for 24 hr before data collection
2. At each monitoring location soil, moisture measurement will be take different point one meter apart from each other around the study area.
3. The soil moisture prone will be insert vertically in to the ground at each point avoid any measurement errors
4. Global positioning system units will be used for to identify those measurement locations

2.7 Model Description

2.7.1 Soil Topography Wetness Index

Two different approaching methods used for calculating the TWI were compared the original topographic index (TI) which was early developed by (Beven, 1997), and the soil–topographic wetness index (STI), which extends the purely topography-based TWI by accounting for spatial variation in hydrologically corresponding relevant soil properties. For this study, we will have selected to use soil topographic wetness index, because it is more appropriate for representing the watershed area, rather than other methodologies. Particularly this method accounting the soil transmissivity furtherly elaborating by the product of the average saturated hydraulic conductivity (m day^{-1}) and the depth to restrictive layer (m).

2.8 Top Model

It is well-known that, The TOPMODEL was considered as a semi-distributed model, as it uses distributed topographic information to determine the topographic index and to distribute saturation deficits throughout the basin, as well. It's good and manageable software that will evaluate the rainfall and runoff relationship as well as the concentrated load of pollutants that apply on the out let level in course of river. Its main parameter is the topographic index derived from a digital elevation model, and it will make a relationship among other geospatial parameters. This index represents the propensity of a cell or region to become saturated

3. Results and Discussion

Adaptation to climate change in tropical highland regions is complicated, because elevation contrasts and dissected topography produce diverse climatic conditions that are often accompanied by significant ecological and agricultural diversity within a relatively small region. Such is the case for the Choke mountain watersheds, in the Blue Nile highlands of Ethiopia. The physical diversity of the area and the accompanying socio-economic contrasts demand diverse strategies for enhanced climate resilience and adaptation to climate change. To support these goals, this study presents an the identification of sensitive area, that significantly produce high amount of surface runoff and pollutant loading capacity at the lower reach of abay river basin. Understanding the topographic condition of the watershed area, and make analysis considering the terrignvalue to identify hydrologic sensitives groups. Analysis of Choke Mountain, under the premise that the agroecosystem (the intersection of climatic and physiographic conditions with agricultural practices) is the most appropriate unit for defining adaptation strategies in these primarily subsistence agriculture communities.

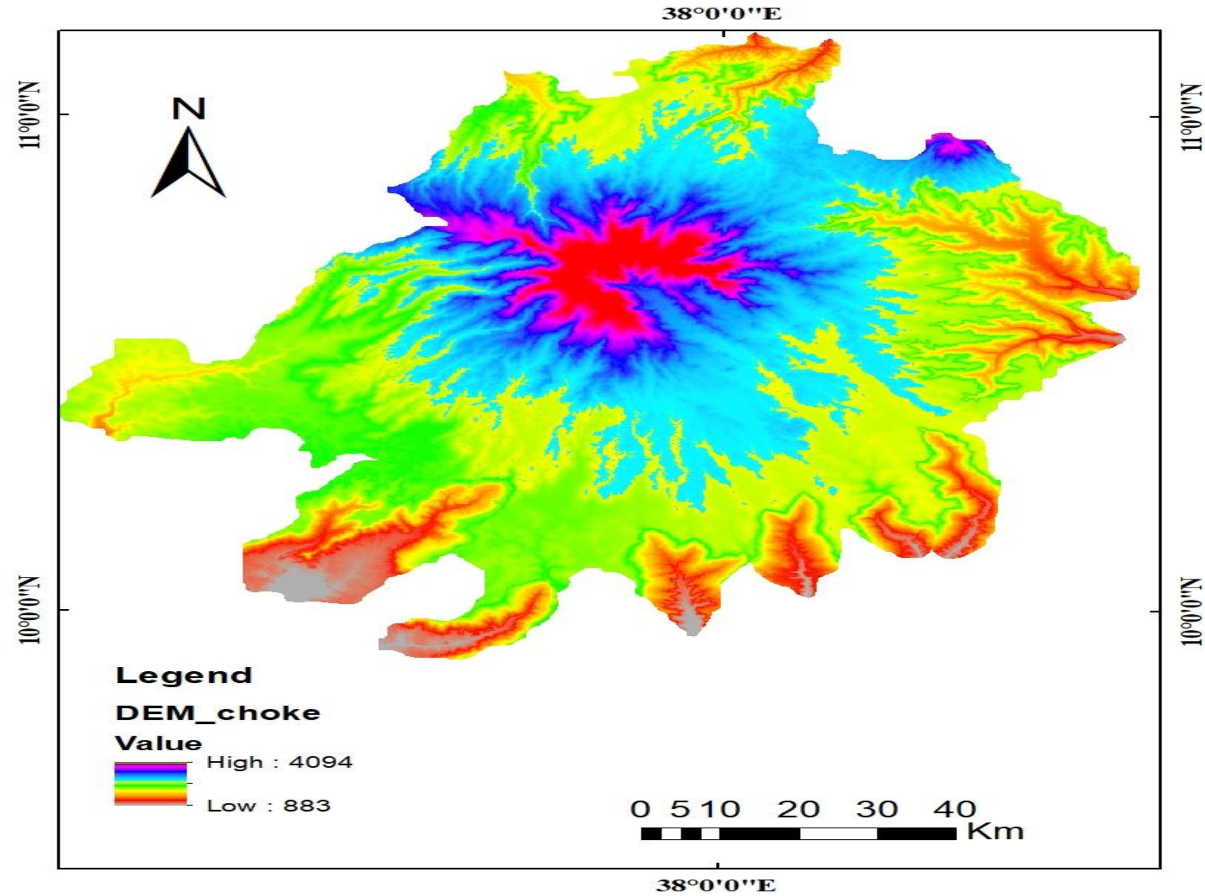
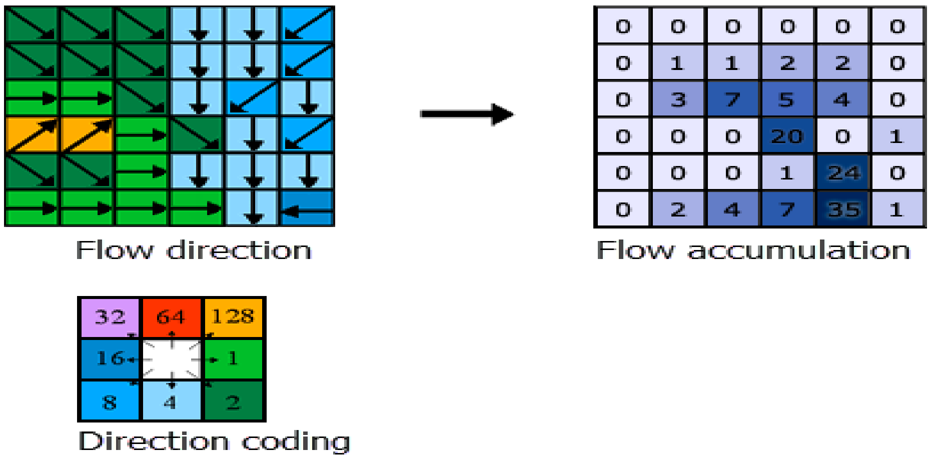


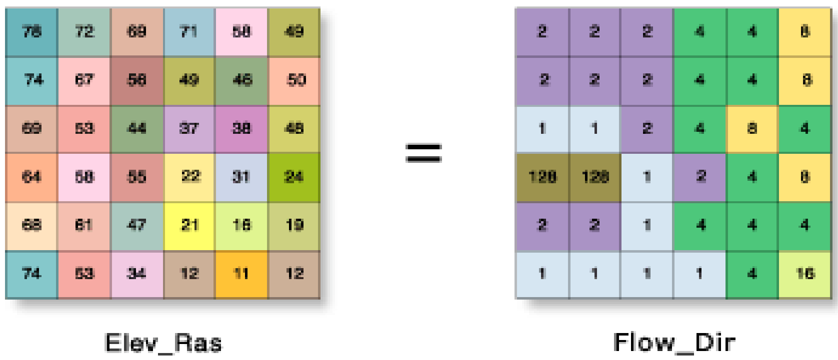
Fig. 3.1 topographic conditions of the watershed area

3.1 Flow Accumulation

The Flow Accumulation tool calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster. If no weight raster is provided, a weight of 1 is applied to each cell, and the value of cells in the output raster is the number of cells that flow into each cell. In the graphic below, the top left image shows the direction of travel from each cell and the top right the number of cells that flow into each cell.



Cells with a high flow accumulation are areas of concentrated flow and may be used to identify stream channels. This is discussed in Identifying stream networks. Cells with a flow accumulation of 0 are local topographic highs and may be used to identify ridges. The output of the Flow Direction tool run with the D8 flow direction type is an integer raster whose values range from 1 to 255. The values for each direction from the center are the following.



32	64	128
16		1
8	4	2

3.2 Flow Direction

The MFD flow direction output when added to a map only displays the D8 flow directions. As MFD flow directions have potentially multiple values tied to each cell (each value corresponds to proportion of flow to each downslope neighbor), it is not easily visualized. However, an MFD flow direction output raster is an input recognized by the Flow Accumulation tool that would utilize the MFD flow directions to proportion and accumulate flow from each cell to all downslope neighbors. The D-Infinity (DINF) flow method, described by Tarboton (1997), determines flow direction as the steepest downward slope on eight triangular facets formed in a 3x3 cell window centered on the cell of interest. Flow direction output is a floating point raster represented as a single angle in degrees going counter-clockwise from 0 (due east) to 360 (again due east).

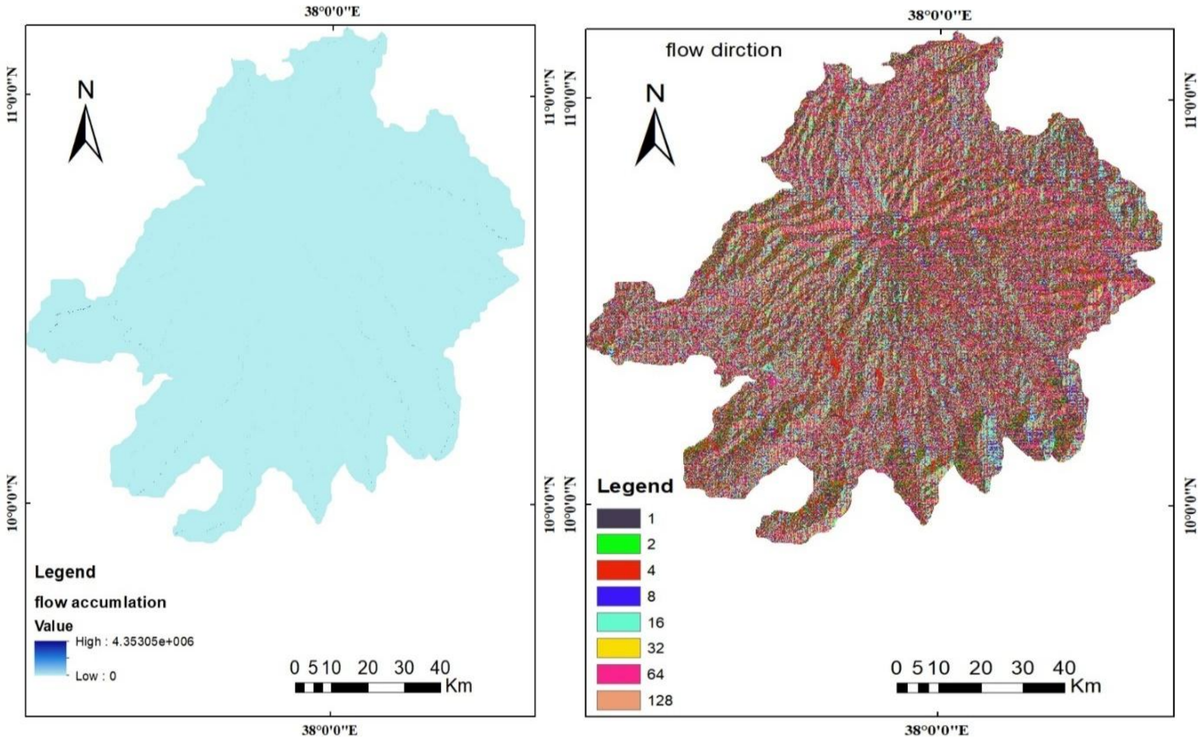


Fig. 3.2 flow direction and accumulations of watershed area

Table 3.1 model results of hydrological sensitivity of the watershed area

Month	Rainfall	SURQmm	Sediment yield	QW_Qmm	\SWmm
1995	131.6	0.02	0.034	80.4	159.8
1996	137.1	0.004	0.086	74.6	158.3
1997	166.2	0	0.122	84.7	144.8
1998	138.3	0.556	0.129	93.5	158.9
1999	137.6	0.518	0.075	85.9	159.1
2000	130.4	0.824	0.114	94.2	165.9
2001	110.4	0.639	0.032	39.0	152.6
2002	106.9	0.636	0.057	96.7	154.6
2003	106.2	0.497	0.04	98.7	153.1
2004	116.3	1.167	0.022	84.3	149.01
2005	109.2	0.62	0.006	92.6	153.2
2006	121.4	0.838	0.012	97.2	147.3
2007	131.8	0	0.594	89.1	146.4
2008	123.2	1.205	0.926	41.2	139.0
2009	134.1	2.215	0.663	124.3	145.2
2010	136.3	0.722	2.522	89.6	131.0
2011	138.2	1.553	1.142	117.3	153.2
2012	137.6	0.919	1.624	76.8	147.3
2013	126.8	1.277	1.768	74.01	151.8
2014	172.3	0.725	1.581	73.7	131.2
2015	161.5	0	3.337	81.9	140.8
2016	51.9	0.028	3.873	76.112	142.7
2017	49.7	0.961	2.643	86.11	116.98
2018	51.9	0	2.172	94.47	130.62
2019	65.3	37.921	0.849	87.46	119.3
2020	4.66	38.174	0.936	95.8	120.5

The maximum surface runoff potential has been recorded in 2020 with an average annual 38.174 mm. It indicates variable source area, hydrology merely contribute maximum rate of overland flow in the upper nexus of watershed area. In the upper reach of the watershed, maximum altitude has been indicated as a result high source runoff being contributed. Due to adverse in hydrologic condition in the recent century, the hydrological process in the catchment area also altered. The sediment yield, the ground water potential, soil water content and soil water holding capacity mainly varied in year to year. Hydrological system additionally caused by anthropogenic factors, like land use land cover change, deforestation, land degradation, forest fire, and over grazing. The overall runoff potential in the catchment area anlysised and evaluated through Arc GIS Environment with an average maximum values of 8.701e +007 and

With minimum values of under 20 has been fall in the lower course of the basin. *The* upslope contributing area was calculated within Arc GIS utilizing the flow accumulation tool. The flow accumulation tool uses the flow direction raster to calculate the accumulated weight of all the cells contributing to each downslope cell. The output raster cells with low flow accumulation values tend to be areas with a high local slope, whereas areas with high flow accumulation values are areas with low slope and increased susceptibility to flow accumulation and concentration. The flow accumulation tool is commonly used in the identification of flow routes. The flow accumulation values are the area a used in the TWI formula.

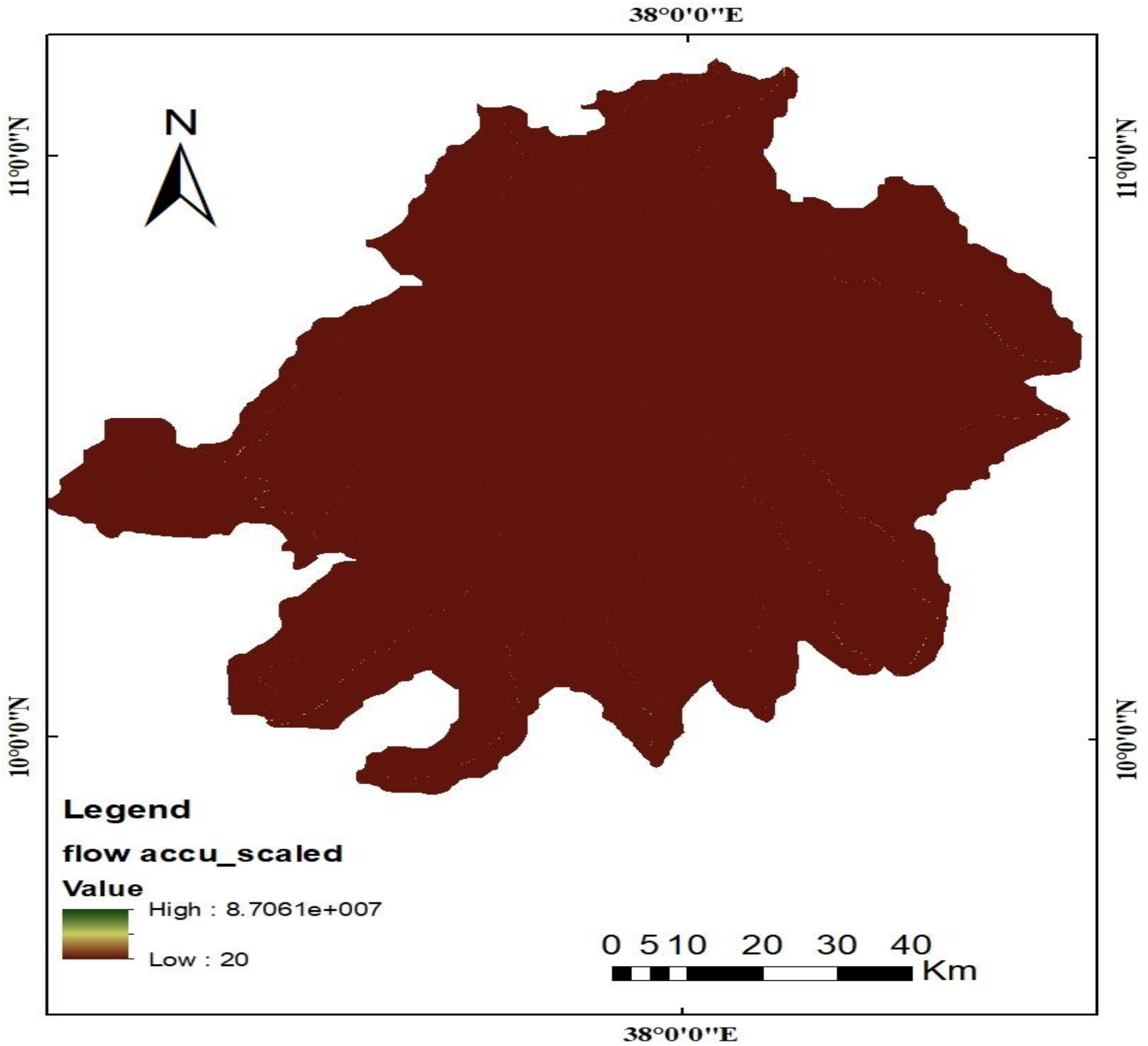


Fig. 3.3 flow accumulated scaled of the watershed area

3.3 Slope

Slope plays an important role in hydrologic processes determining the movement of water on the Earth's surface. For example, flow across areas with a high degree of slope (steeper terrain) tends to concentrate water flow, forming channels moving through the landscape, whereas in areas with low slope (flatter terrain) there is a substantial decrease in the movement of water and an increase in the likelihood of ponding. Slope (tanβ) in the TWI formula is calculated by performing analyses on a DEM to determine the local slope for each cell. As the analysis created in Arc Gis, software Figure 3.4 displays an example of local slope created in the development of a TWI. Local slope is calculated for each cell within the DEM by determining the maximum downslope gradient between each cell and its eight neighboring cells. Within this figure, the areas shaded in red color indicate areas with steeper slopes with the green cells showing flatter areas.

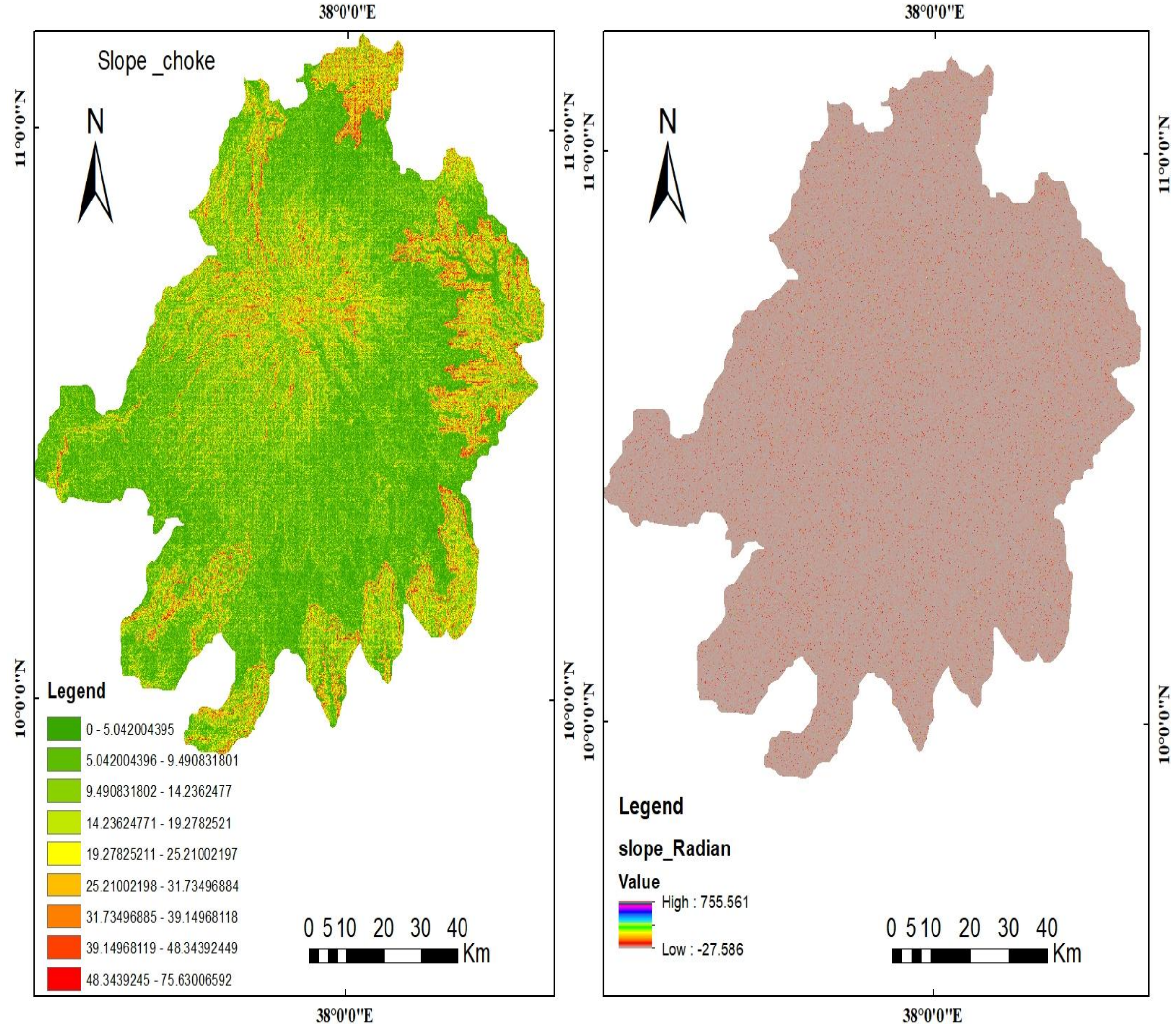


Fig. 3.4 slope and slope radians of the watershed area

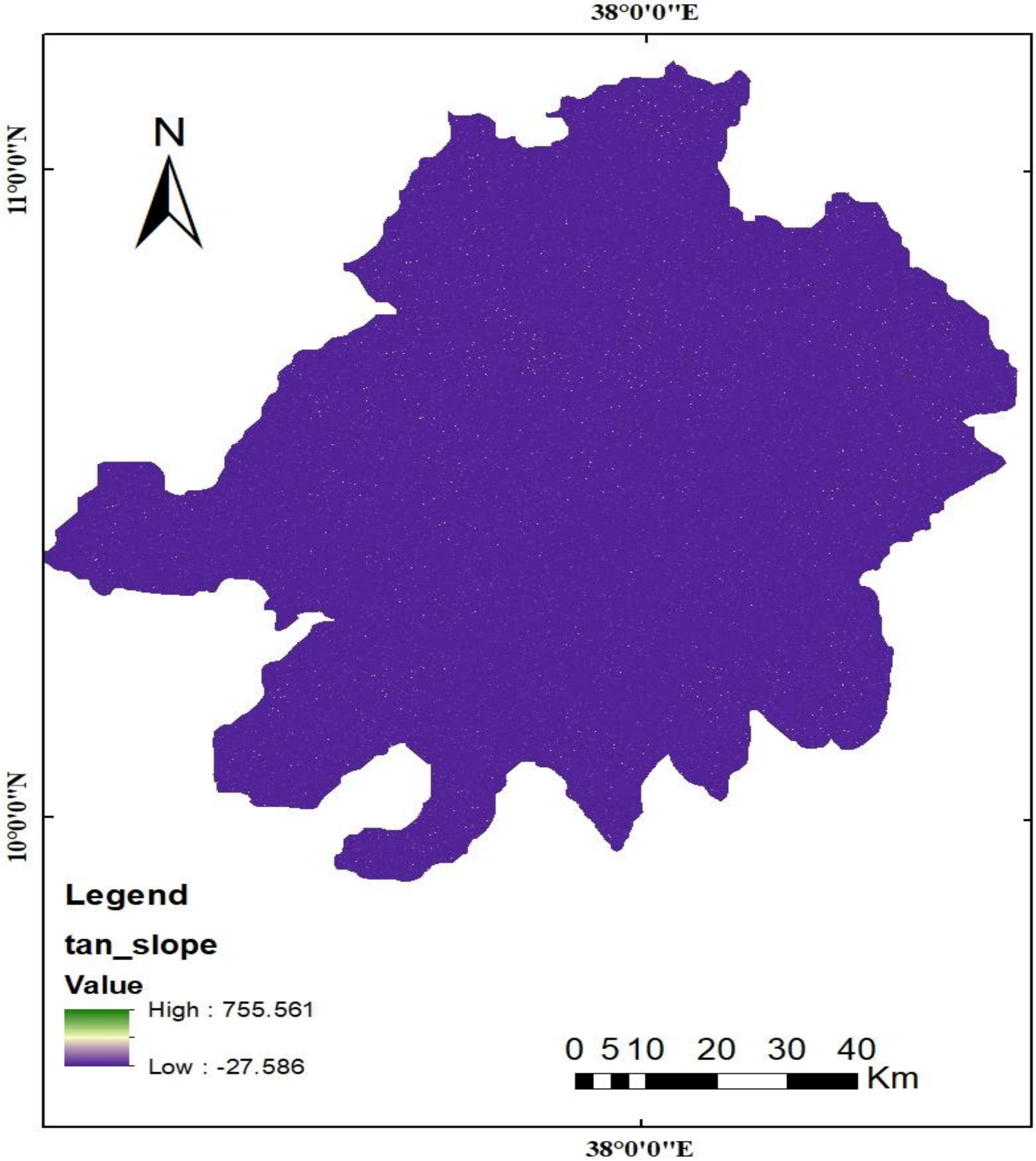


Fig. 3.5: tan_slope of the area

3.4 Topographic Wetness Index

The TWI formula used in this study is I=ln (a/tanβ), where a is the upslope contributing area and β is the topographic gradient, and is calculated utilizing a DEM of the study areas. (Wolock, 1995) was developed into a python algorithm, used for the computation of the TWI utilized for the current study area. The result is a TWI raster in which each cell is assigned a wetness indicator value [I=ln (a/tanβ)]. These indicator values are non-dimensional and vary based on the topographic profile of the region and the resolution of the DEM. Typically the raw TWI indicators range from -3 to 30. The value gets in our watershed was -3 up to 28.6 under the lower ranges of the threshold values. Higher cell values represent areas with increased accumulated runoff potential. A low slope and large upslope contributing areas identify these areas.

The probability of saturation shows monthly and annual averages estimated over the selected areas of Dejen with values of 36.88 % to debre work 1 with a soil moisture content of 25.53 %. The months June–September are on average the wettest months of the year where more than 50% of the rainfall and relative humidity events cause the entire watershed to saturate. During June, July, and August

25percentage of the rainfall events, causes the entire watershed area to contribute runoff. Only during the drier summer months (October–May) does the saturation probability decreases below 25%, with May being the driest month and July being the wettest summer month on average (refer table 3.2) The annual probability of saturation statistic indicates that the wettest 10% of the watershed saturates and generates runoff for more than 50% of the rainfall events. The remaining areas of the watershed have the potential to transport nutrients and pollutants to streams, on average, in over 25% of the rainfall events.

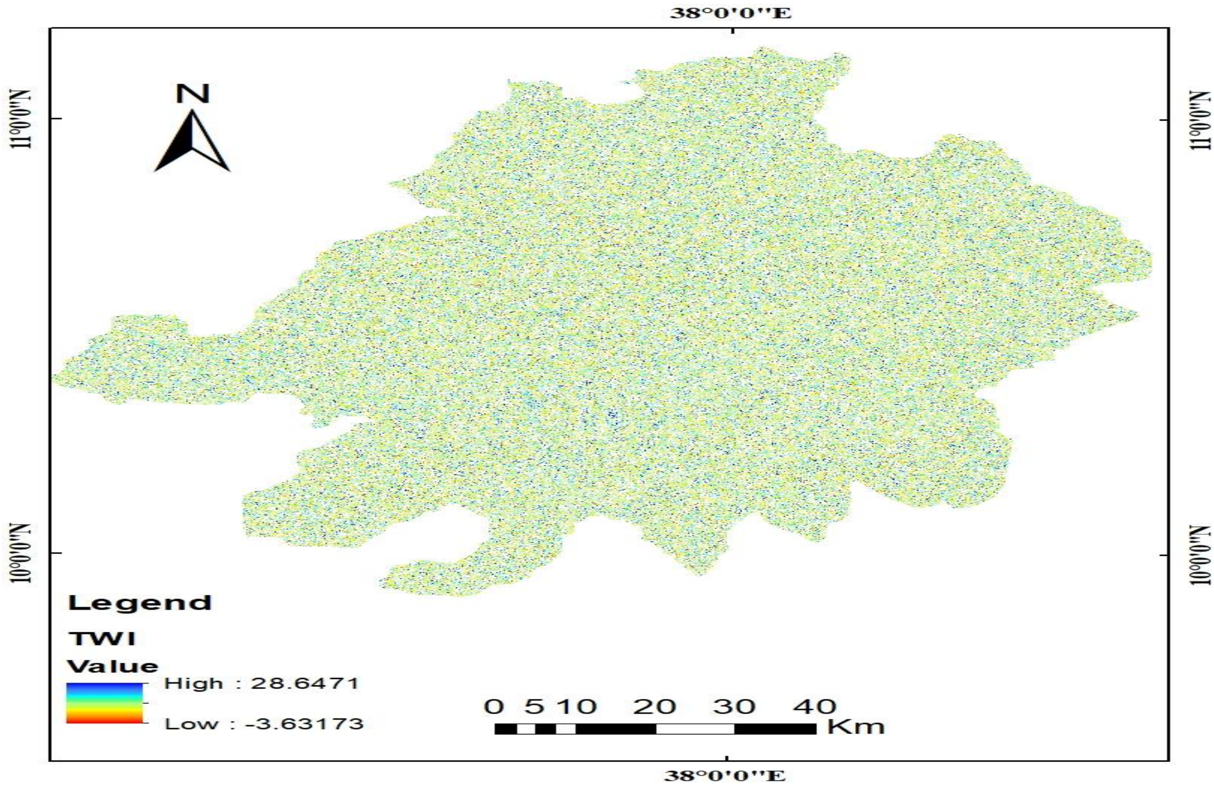


Fig. 3.6 calculated values of TWI in the watershed area

Table 3.2 Soil moisture evaluation of the watershed area

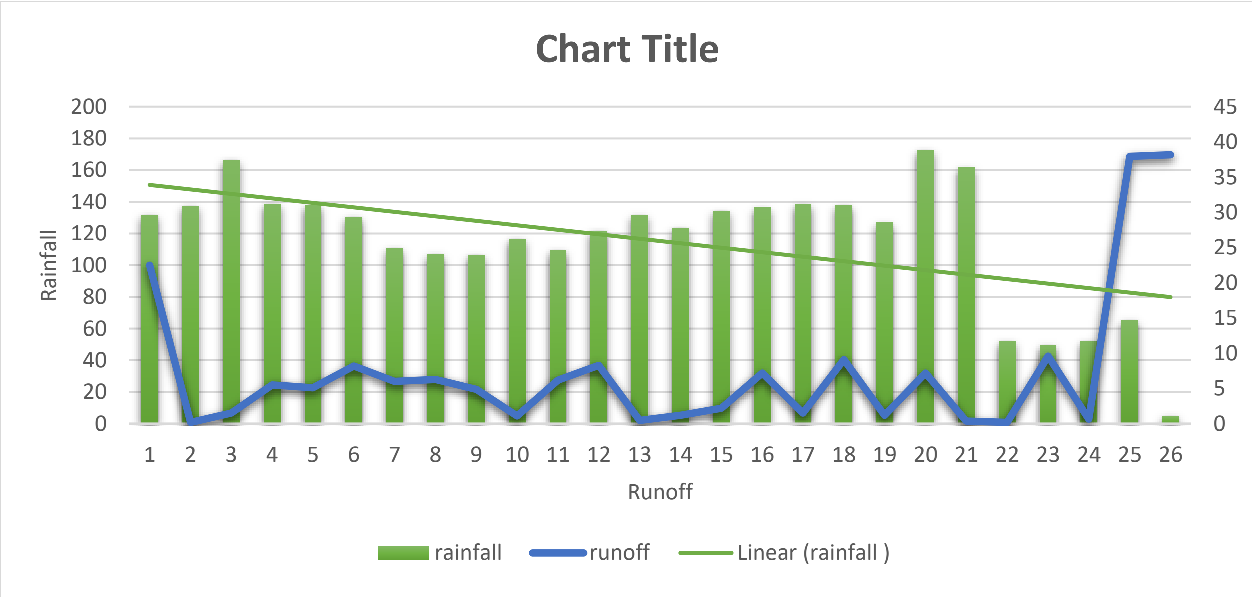
No	Area	SM %	FC %	PWP %
1		36.88	37.22	26.74
2	Bichena	23.79	26.13	15.29
3	m/lemariyam1 1	18.66	26.24	16.83
4	m/lemariyam1 2	15.41	26.8	17.33
5	Amber	15.29	37.38	24.68
6	Awobel 1	9.15	36.7	24.59
7	Awobel 2	12.43	35.6	24.81
8	Yeduha	12.22	37.6	25.35
9	Yeduha 2	9.31	39.5	26.4
10	Yeduha 3	12.58	40.1	28.4
11	Debrework 1	25.53	38.7	27.24
12	Debrework 2	23.29	36.04	24.52
13	Gendewoyn 1	14.59	27.9	14.8
14	Gendewoyn 2	21.31	26.04	16.5

This study suggests the increase in runoff return for each unit increase in land area designated HSA will progressively diminish when trying to account for more than 20% of the runoff with HSA's. The first 20% of the runoff required only 10% of the land to be designated as HSA. Now, designating another 10% of the land as HSA (20% total) results in only 15% more of the runoff being generated from HSA's (35% total). The return rate continues to diminish and the next 10% of land designated HSA (30% total) returns only about 13% additional runoff (48% total).

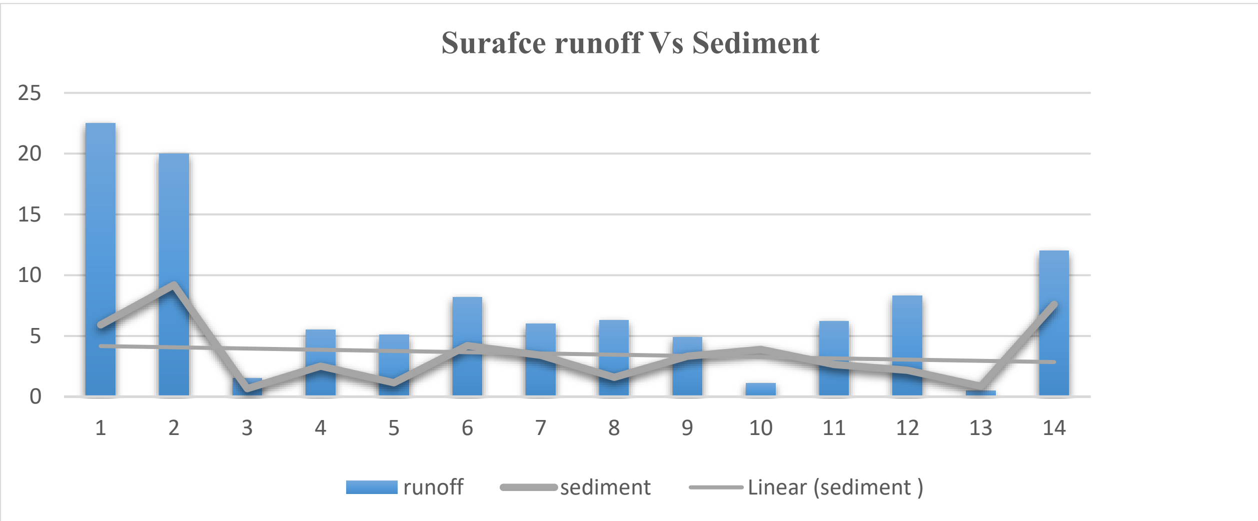
As a final comment, improved understanding of the details of VSA hydrology may provide insights for modifications to the approach described here. For example, though the physical reasonableness is uncertain, slightly different results can be obtained by relaxing the constraints on A(P) and R(P) which force the functions through 100% at P=0%; e.g. it is plausible that all the runoff (100%) is coming from HSA's at some small P greater than 0%. Both hyperbolic and simple exponential functions were found to fit this relaxed description well and, following the procedure outlined in the methods discussed earlier, L_{HSA} were determined as high as 15%. . This cut-off protects approximately 50% of the runoff but restricts run off spreading on about 30% of the land area. Work continues to determine the best approach for determining $L_{HSA.}$

Evaluation of hydrological parameters to sensitivity

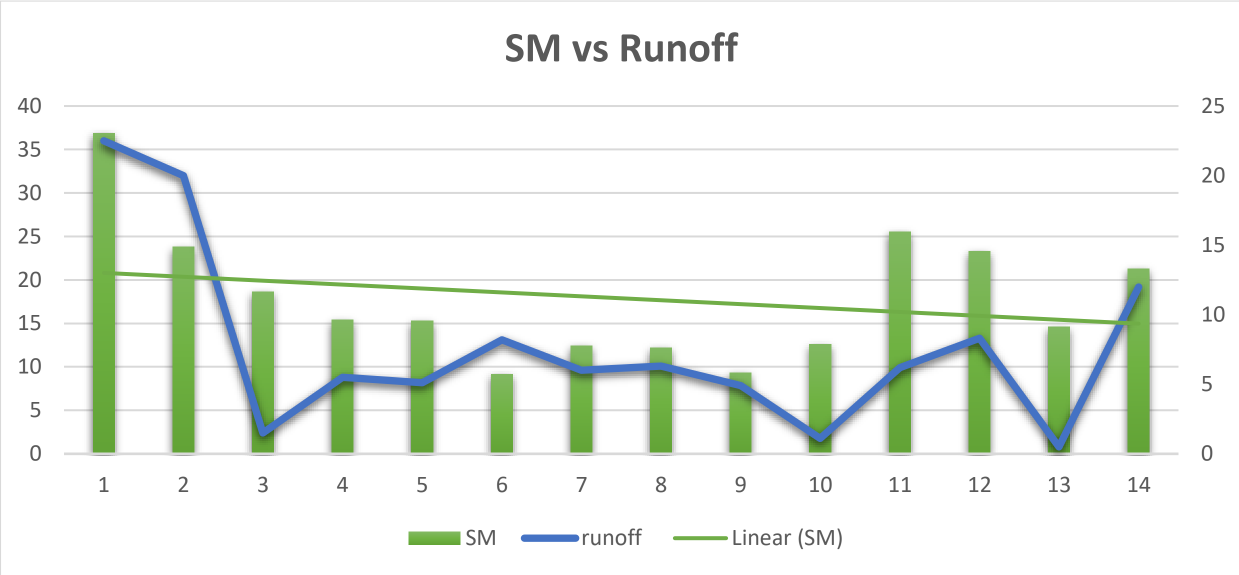
Rainfall runoff



Sediment yield and surface runoff



Soil moisture and surface runoff



3 Conclusion and Recommendation

The TWI provides important information at very low cost compared to detailed hydrologic and hydraulic studies and is an excellent planning tool. The TWI is a unique tool, which allows the user to identify areas that could be adversely affected by ponding and flooding caused by rainfall events. The TWI added to the compliment of data and GIS tools can provide planners a visual mechanism for site selection of green infrastructure projects, the identification of areas with an increased susceptibility to ponding due to sewer overflow or basement back

ups, and in the planning of new residential and urban areas.The watershed area being reserved from land use/cover, deforestation and other anthropogenic activities to increase the hydrologic condition of the area. Artificial recharge and rapid infiltration mechanisms being carried out to increase the surface runoff potential of the area. Generally natural conservation practice strongly manipulated to protect the overall mal functions of activities in the watershed area.

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