International Journal of Scientific Research in Civil Engineering
© 2020 IJSRCE | Volume 4 | Issue 2 | ISSN : 2456-6667

GIS - Based Surface Water Irrigation Potential Assessment of Muga Watershed, Abbay Basin, Ethiopia

Natnael Yasab Assefa

Master of Science in Hydraulic Engineering, Debre Markos University Institute of Technology, Debre Marqos, Ethiopia

ABSTRACT

Although Muga watershed has a large potential to develop surface irrigation, only 0.3% of the 73815.37 hectares (ha) potentially available has been developed. To examine the underlying causes of this lack of irrigation development, this study evaluates the suitability of surface water irrigation for the Muga watershed, Abbay Basin, Ethiopia. Surface water availability and land potentially suitable for irrigation development were considered. Surface water potential for ungauged each sub-watershed was simulated by using SWAT model, the performance of SWAT model was checked by SWAT-CUP model. Land suitable for surface irrigation was determined with a GIS-based multi-criteria evaluation, which considers the interaction of various factors such as climate, distance from water supply (sources), soil type, land cover, slope. The surface irrigation suitability analysis of these factors indicates that 70.64 % of soil and 66.63 % slopes in the study area are suitable for surface irrigation system. In terms of land cover/use evaluation, 72.43% of land cover/use is suitable for surface irrigation and 200m Euclidian distance was considered. The result of weighted overlay analysis indicates that, 8.408 % Muga watershed is suitable for surface irrigation. To grow on these identified irrigable areas, five crops such as maize, lentils ,tomato ,potato and cabbage were selected and their irrigation demand calculated by using CROPWAT model. The maximum crop water requirement for selected crop is 3.95m3/s with the coverage areas 2172.2295ha. The amount of flow in Muga river in the same crop period is 12.417 m3/s. Total surface irrigation potential of the study area was obtained as 6206.37 ha. The result indicated that Stream flows are much larger than their command area monthly irrigation demand. This implies that surface irrigation potential of these rivers limited by the land area to be irrigated along them. The irrigation potential of this study area can be increased by using sprinkler and drip irrigation methods.

Keyword : GIS, Crops water requirement, Muga watershed, SWAT model, CROPWAT mode

I. INTRODUCTION

Ethiopian highlands are comprised of land resources, which are potentially suitable for irrigation. Irrigation would provide farmers with sustained livelihoods and improve their general well-being (Hussain and Hanjra,2004, Belay and Bewket, 2013). However, the country's irrigable land has been underutilized, and only 6% of the potential area has been developed for irrigation (Awulachew,et al.,2005). Consequently, the agricultural economy of the country is largely based on rainfed cultivation, It is estimated that more than 94% of the food supply in the country comes from low productivity rain fed smallholder agriculture and hence rainfall is the single most important determinant of food supply and the country's economy (Bantero,2006).

Water has been recognized as the most important factor for the transformation of low productive rainfed agriculture into most effective and efficient irrigated agriculture (FAO,1994). It is obvious that the utilization of water resources in irrigated agriculture provides supplementary and full season irrigation to overcome the effects of rainfall variability and unreliability. Ultimately, increasing agricultural production using irrigation is one of the main drivers to end poverty caused by insufficient output from these rainfed systems. Therefore, the study investigates the causes of the underutilization of the land resources for irrigation.

According to the Ministry of Water, Irrigation & Electricity of Ethiopia, irrigation command areas can be classified into three groups (Awulachew, et al., 2005). The first group is small-scale irrigation areas of less than 200 ha, medium-scale between 200 and 3000 ha and large-scale above 3000 ha. Consequently, quantified both the potential land areas suitable for small, medium and large-scale surface irrigation; in addition, the available surface water potential for surface irrigation was identified by analyzing historical river flow data and simulated flow by using SWAT model for ungauged sub watershed in the study area. This investigation focused on the Muga watershed situated in the East choke Mountain's watershed, Upper Blue Nile Basin, Ethiopia.

1.1) Statement of Problems

Agricultures, being a key element of the national economy are challenged by variety of problems in development planning. Among these the major one are climate change, topographic constraints, population pressure, ecological degradation and low level of technological development (FAO7, 2001). One of the mitigation to reduce the challenge related to agriculture development is introduction of irrigation technology and appropriate extension services.

Surface water irrigation is a very important issue in the world considering their responses to environmental and socio-economic developments, especially for agriculture leading economy countries like Ethiopia, it is a scientific challenge to harvest surface water and their effects on irrigation mechanism(FAO7, 2001). Irrigation is responsible for only about 6% of the $70 * 10^6$ ha in Ethiopia (FAO,2007).The major problem associated with the rainfall-dependent agriculture in Ethiopia is the high degree of rainfall variability and unreliability.

Although the availability of Perennial River likes Muga in the Muga Watershed, exploitation of its water resources for irrigated agriculture has remained low in the region. The irrigation practice (coverage) is only around 0.3% of the total area of Muga Watershed. The efforts to establish small, medium and large-scale irrigation schemes in the watershed are constrained by a number of uncertainties. Firstly, stream flows from some of the tributaries of Muga River are not known. Secondly, potential irrigable areas in the watershed have not been identified and matched with the water requirements of some crops commonly grown in the watersheds.

1.2) Objectives

1.2.1) General Objective

The main objective of this study is to assess the surface water irrigation potential, from the available water resources and crop water requirements of the Muga Watersheds.

1.2.2) Specific Objectives

Some of the specific objectives of the study are:

a) To identify suitable land for surface irrigation in the study area
b) To investigate surface irrigation sustainability for the region
c) To simulate the Contribution of each Sub Basins to the stream flow
d) To estimate crop water requirements for selected crops in delineated suitable area

II. METHODS AND MATERIAL

2.1) Description of Study Area

The Muga watershed is located in the East Choke Mountains watersheds, Upper Blue Nile Basin, near Debre markos town in East Gojjam Zone, Amhara Regional state, Ethiopia. Geographically, it lies between10 ^{0}18’ N and 10 ^{0}39’ N latitude and 37 ^{0}44’E and 37 ^{0}53’E. The watershed has an area of 73,815.25ha. In terms of administrative boundaries, it covers the three Woredas of East Gojjam zone (Dibay Tilatgin, Enemay and Dejen). This study was conducted in the Muga Watershed.

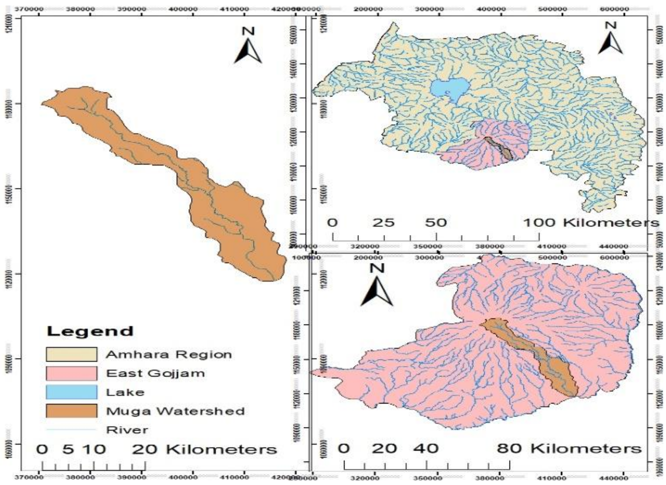


Figure 2.1: Map of the study area

The agriculture production system in the study area is a subsistence type of crop production system. A major type of crops grown in the area includes: barely, wheat, maize, Teff, sorghum, and small extent oil crops. In this watershed, some farmers also practice traditional irrigation development activities from Perennial River and springs. Moreover, recently Kulkual-Arajo (is installed to irrigate 163ha, but irrigated only 52 ha) and Wodeb-eyesus (is installed to irrigate 270ha, but it irrigate only 110ha), generally, small and medium scale irrigation development project with a command area of 433ha is under operation in the watershed (but only 162 ha are irrigated).

2.2) Input Data

2.2.1) Climate

Precipitation, temperature, wind speed, and relative humidity were collected from the Ethiopian Metrological Agency (EMA). Daily long-term rainfall was available from 1992 to 2017 for four stations (Fig.2.2). For calculating evaporation and solar radiation with the Penman–Monteith equation(Monteith, 1965) the daily measurements of temperature, humidity, wind speed and sunshine hours were collected from the synoptic stations at Debre markos (table. 2.1).The Meteorological data is needed to simulate the hydrological conditions and determined crop water requirement of the study area.

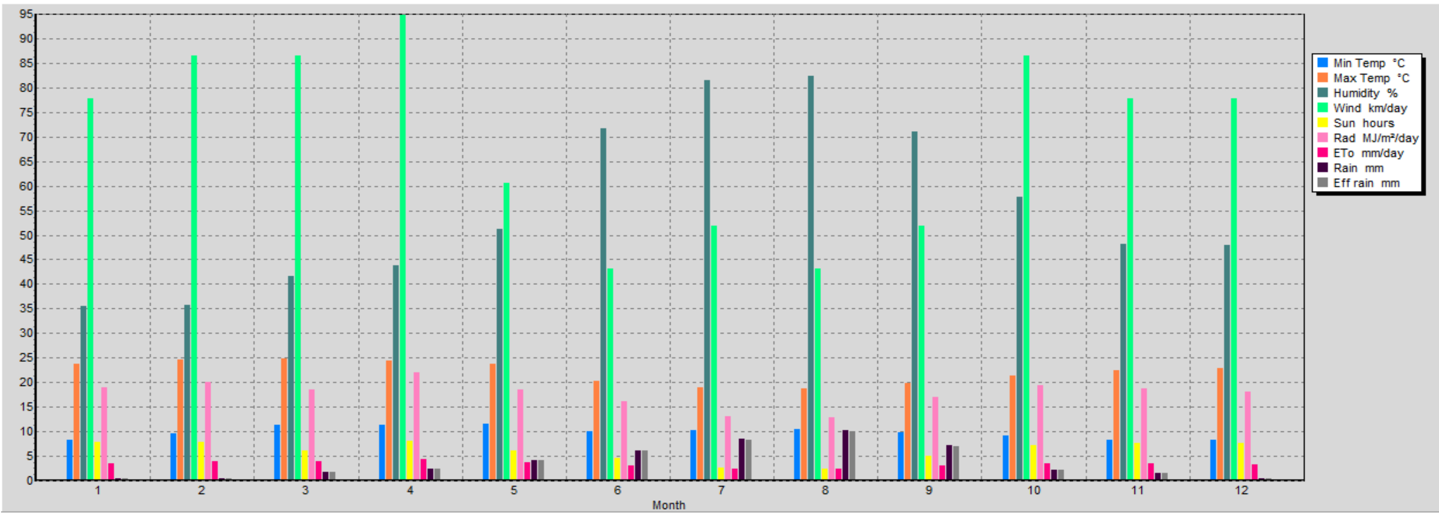


Figure 2.2: Mean monthly weather data distribution of synoptic station

Table 2.1: Names, locations and variables of the given Meteorological station

No	Station Name	Latitude (deg)	Longitude (deg)	Rain Fall	Max Temp	Min Tem	Relative Humidity	Wind speed	Sunshine Hours
1	Debre markos	37.45	10.2	√	√	√	√	√	√
2	Dejen	38.8	10.1	√	√	√			
3	Motta	38.8	11.5	√	√	√			
4	Bichena	37.01	10.1	√	√	√			

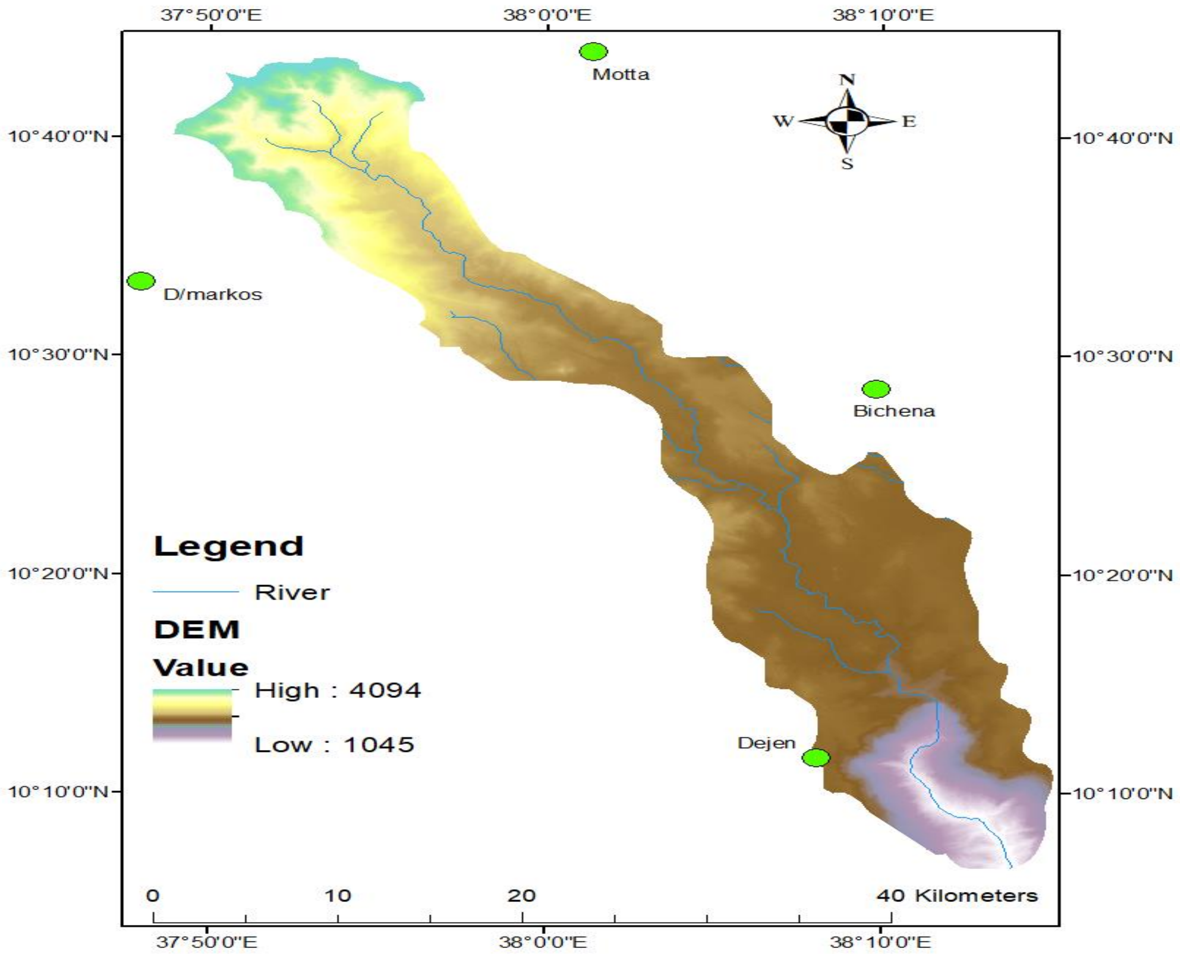


Figure 2.3: Location of meteorological stations in and around the watershed.

2.2.2. Land features

According to FAO classification, eight major soil groups were identified in the watershed of Muga (Figure 2.4) and (table 2.2). Soil is a key factor in determining the suitability of an area for agriculture in general and irrigation in particular.

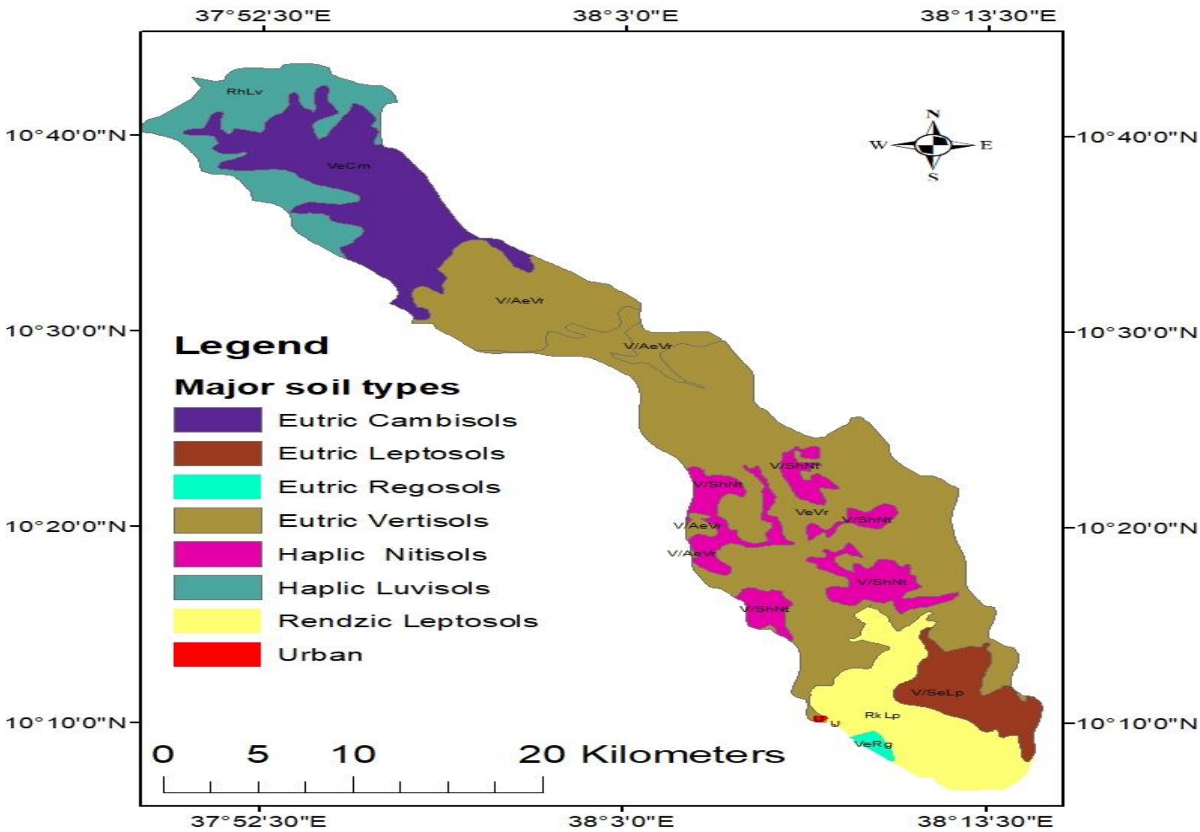


Figure 2.4: Map of the soil types of Muga watershed

Table 2.2: Soil types of Muga watershed and areal coverage

Soil Type	SWAT code	Area	
		Ha	%
Eutric Cambisols	Ap19-2b-3654	3923.28	5.47
Eutric Leptosols	Be21-1-2a-3350	35601.75	49.64
Eutric Regosols	Qc17-1a-172	11137.41	15.53
Eutric Vertisols	Nd39-3bc-807	228.87	0.32
Haplic Nitisols	Bf13-2-3b-4476	8342.28	11.63
Haplic Luvisols	Ao82-2-3b-3653	178.92	0.25
Rendzic Leptosols	Ag14-2ab-6338	7018.02	9.78
Urban	Ck1-3b-3914	5295.15	7.38

Land use/land cover data is one of the highly influencing the hydrological properties of the watersheds. It is one of the main input data of the SWAT model to describe the Hydrological Response Units (HRUs) of the watersheds and also used for identified suitable land for irrigation. The LU / LC map indicated that the study area was dominated by agricultural land covering (Fig. 2.5) and (table 2.3).

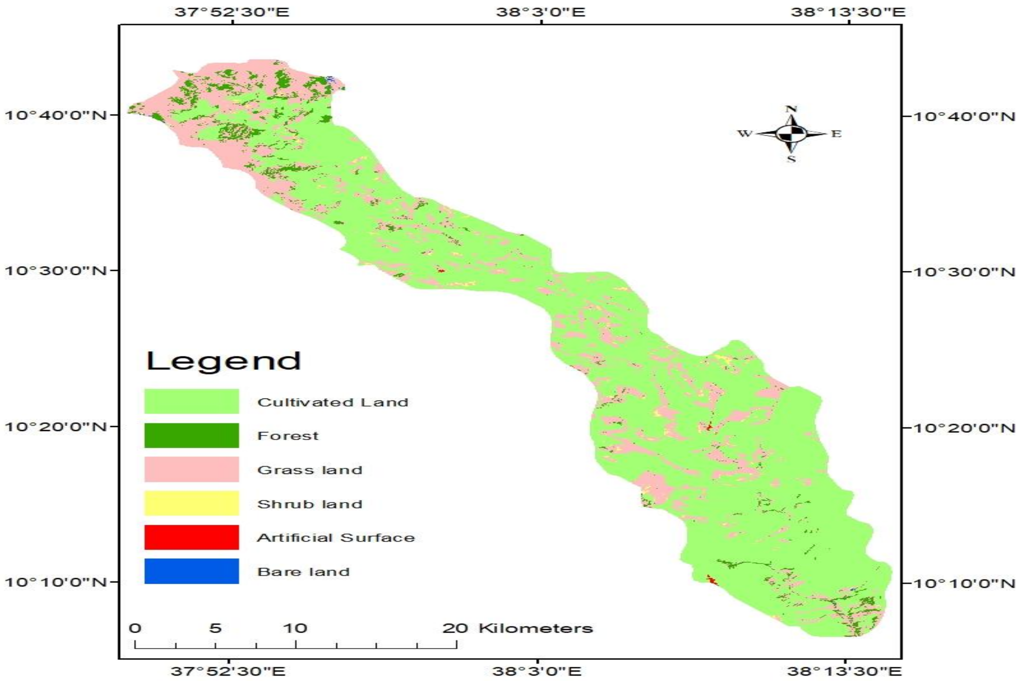


Figure 2.5: Land cover/use map of the study area

Table 2.3: Area coverage of land cover/use classes of the study

Land use / Land cover	SWAT code	Area in (ha)	Percentage (%)
Cultivated land	AGRR	53470.5	72.43
Forest	FRST	2720.07	3.68
Grass land	RNGE	16973.17	23
Shrub land	RNGB	570.87	0.77
Artificial Surfaces	POPL	47.55	0.06
Bare land	PAST	41.21	0.055
Total		73,815.25	100

The digital elevation model (DEM) is one of the essential inputs required by SWAT to delineate the watershed to a number of sub-watersheds. This data are required to calculate the flow accumulation, stream networks, slope, stream length, and width of the channel within the watershed. The slope is important to choice of types of irrigation. To identify irrigable land close to the water supply (rivers), a straight-line (Euclidean) distance from watershed outlet was calculated using DEM.

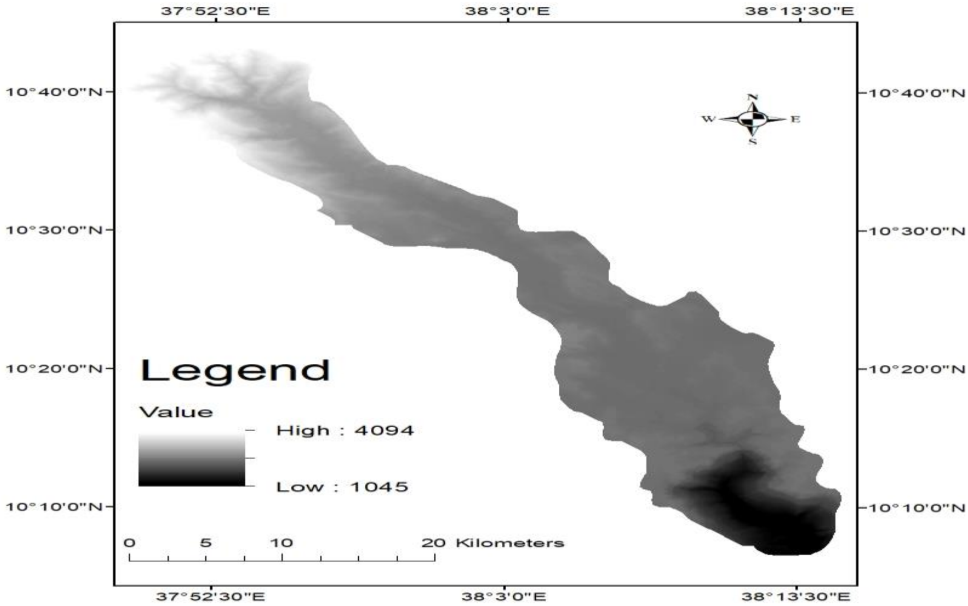


Figure 2.6: Digital Elevation Model of Muga watershed

1) **Hydrological Data: The stream flow data of Muga River in Muga Watersheds was needed for the calibration and validation of the SWAT model. Water availability is important to make sure that there is no lack of irrigation water.**

Table 2.4 summary of monthly average flow (m^3/sec) of Muga River from the year 1993-2014

	Summary of average monthly hydrological data (m3/sec)											
Station Name	Muga	Nr@	Dejen	Abbay	Basin	drainage	Area	2800	Sq.KM.	Stn.No.	112017	
Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
flow (m^3/s)	0.605	2.624	0.678	1.534	2.577	5.077	35.451	63.950	29.433	24.062	1.864	0.909
Average annual flow of in Muga river = 14 m^3/sec ,as volume =441,504,000m^3												

2.3 Methodology

2.3.1) Multi Criteria Evaluation (MCE)

2.3.1.1) Determination of surface water availability, crop water requirement and land suitability analysis for surface irrigation

Weighted overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis. Geographic problems often require the analysis of many different factors using GIS. Weighted overlay only accepts integer raster's as input, such as a raster of land cover/use, soil types, slope, and Euclidean distance output to find suitable land for irrigation (Janssen and Rietveld, 1990). Determination of the availability of surface water for ungauged sub watershed in Muga watershed was done by SWAT. The amount of water required for surface irrigation for different crop in the given area is done by CROPWAT model.

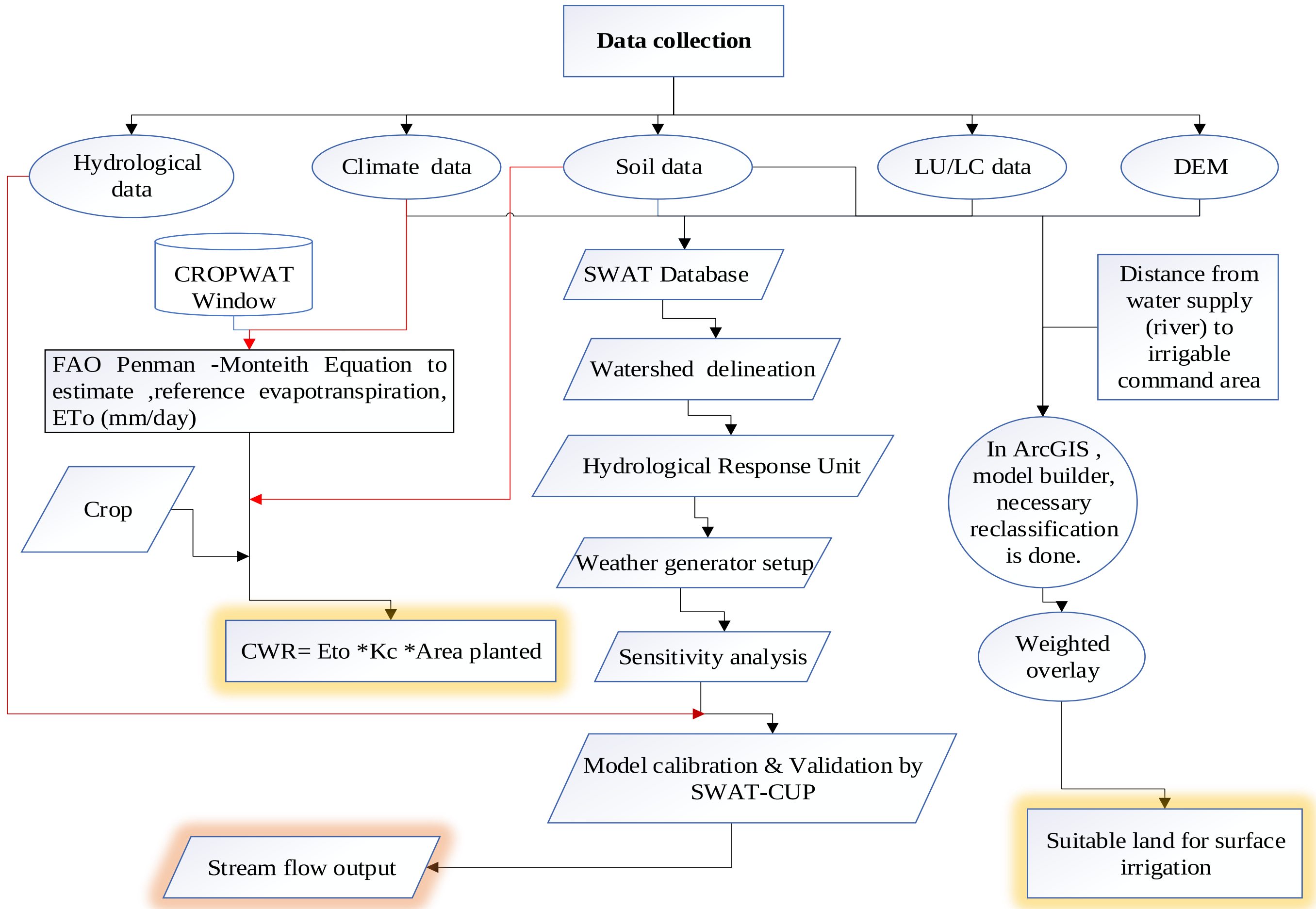


Figure 2.7: General workflow of data processing and analysis in Arc SWAT, CROPWAT model and surface irrigation suitability analysis model.

2.4) Identification of potential irrigable sites

The analysis results of surface irrigation suitability evaluation factors are presented in the following section.

2.4.1) Suitable slope

The slope gradient of the land has great influence on selection of the irrigation methods. According to FAO standard guidelines for the evaluation of slope gradient, slopes which are less than 2%, are very suitable for surface irrigation. But slopes, which are greater than 8%, are not generally recommended(FAO,1999).

Table 2.5: Slope suitability classification for surface irrigation

Legend	Slope (%)	Factor rating
1	0-2	S1
2	2-5	S2
3	5-5	S3
4	>8	N

Source: FAO (1996).

2.4.2) Soil suitability assessment

Chemical and physical properties of these soil groups were used for irrigation suitability analysis. The following soil suitability rating was used based on the FAO guidelines for land evaluation (FAO, 1976, FAO, 1979, FAO, 1990, FAO, 1991) and (FAO, 1997) .

Table 2.6: Soil suitability factor rating

Factors	Factor rating			
	S_1	S_2	S_3	N
Drainage class	Well	Imperfect	Poor	Very poor
Soil depth (cm	>100	80-100	50-80	<50
Soil texture	L-SiCL, C	SL	…	…
Salinity	<8 mmhos/cm	8-16 mmhos/cm		
Alkalinity	<15 ESP	15-30 ESP		

Source: FAO guideline for Soil evaluation, (1976, 1979 and 1991)

2.4.3) Land cover/use

Land cover/use of the study area is also the factor, which was used to evaluate the land suitability for irrigation.

2.4.4) Distance from water supply (source)

To identify irrigable land close to the water supply (rivers), straight-line (Euclidean) distance from watershed outlets was calculated using DEM of 20m* 20m cell size.

III. RESULTS AND DISCUSSION

3.1) Stream Flow Modeling

3.1.1) Sensitivity Analysis

Sensitivity analysis was performed on flow parameters of SWAT model on monthly time steps with observed data of the Muga River gauge station. For this analysis, 26 parameters were considered and only 10 parameters were identified to have significant influence in controlling the stream flow in the watershed. Table 3.1 presents parameters that resulting greater t- stat and lesser p- values for monthly stream flow.

Table 3.1: List of Parameters and their ranking with t-stat and p-values for monthly flow

Parameters		Lower and Upper Bound	t-stat	p-values	Rank
Name CN2	Description SCS runoff curve number (%)	-0.2 to 0.4	11.56	0	1
GW_DELAY	Ground water delay (days)	46.4 to 458.12	5.15	0	2
SOL_AWC	Soil available water capacity (water/mm soil)	-0.35 to 0.48	2.26	0.009	3
ESCO	Soil evaporation compensation factor	0.03 to 1.83	2.09	0.037	4
CH_K2	Effective hydraulic conductivity of the main Channel (mm/hr.)	-11.35 to 113.2	2.04	0.042	5
SOL_Z	Total soil depth (mm)	-0.2 to 0.2	1.97	0.049	6
CH_N2	Manning's roughness coefficient	-0.12 to 0.14	1.83	0.069	7
ALPHA_BF	Base flow alpha factor (days)	0.44 to 1.52	1.68	0.093	8
GWQMN	Threshold depth of water in the shallow aquifer required for return flow (mm)	0.08 to 2.56	1.63	0.103	9
SURLAG	Surface lag	0.04 to 1.06	1.59	0.111	10

The result of the sensitivity analysis indicated that these 10 flow parameters are sensitive to the SWAT model i.e the hydrological process of the study watershed mainly depends on the action of these parameters. Curve number (CN2), ground water delay (GW_DELAY), soil available water capacity (SOL_AWC), soil evapotranspiration factor (ESCO), and Effective hydraulic conductivity of the main channel (CH_K2) are identified to be highly sensitive parameters and retained rank 1 to 5, respectively. These parameters are related to ground water, runoff and soil process and thus influence the stream flow in the watershed. The result of the analysis was found that Curve number (CN2) is the most important factor influencing stream flow in the Muga watershed. The Curve number (CN2) is a direct index of surface runoff response to changes in stream flow. The Muga watershed is characterized with tertiary basalt and volcanic regional geology that have good potential for ground water recharge. The other most influencing stream flow parameter in this analysis is the ground water delay (GW_DELAY).

3.1.2) Calibration and Validation of Stream Flow Simulation

3.1.2.1) SWAT Model Performance Evaluation

There are various methods to evaluate the model performance during the calibration and validation periods. For this study, two methods may be use: coefficient of determination (R^2) and efficiency of Nash and Sutcliffe simulation (ENS).

The coefficient of determination (R^2) describes the proportion the variance in measured data by the model. It is the magnitude linear relationship between the observed and the simulated values. R^2 ranges from 0 (which indicates the model is poor) to 1 (which indicates the model is good), with higher values indicating less error variance, and typical values greater than 0.6 are considered acceptable (Santhi et al., 2001).

The value of ENS ranges from negative infinity to 1 (best) i.e, $(-\infty, 1]$. ENS value < 0 indicates the mean observed value is better predictor than the simulated value, which indicates unacceptable performance. While ENS values greater than 0.5, the simulated value is better predictor than mean measured value and generally viewed as acceptable performance (Santhi et al., 2001).

In this research the model was run for period of 17 years from 1993 to 2010. However, as the first three years was considered for model warm up period, calibration was performed for 14 years from 1996 to 2010. The calibration result for monthly flow is shown in the figure 3.1.

The model validation was also performed for 6 years from 2011 to 2017 without further adjustment of the calibrated parameters. The validation result for monthly flow is shown in the figure 3.2.

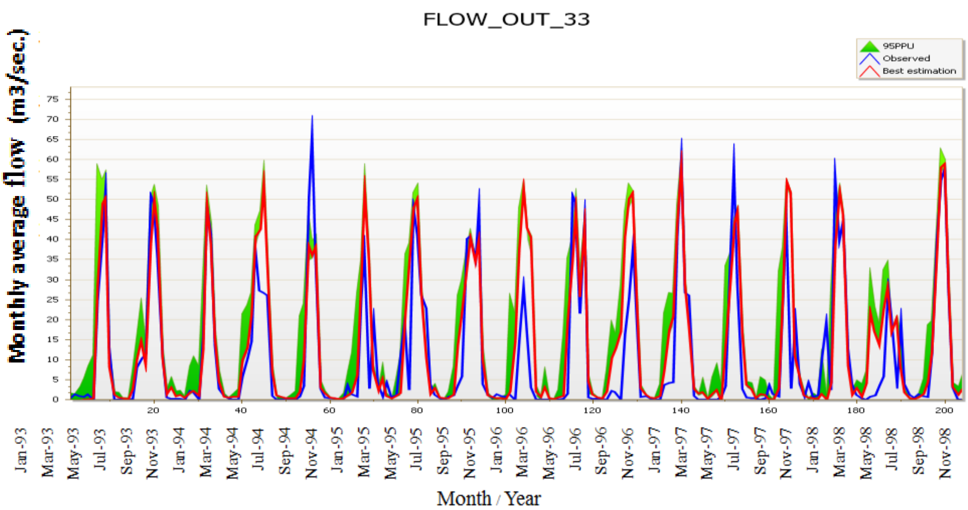


Figure: 3.1: The result of calibration for average monthly stream flows.

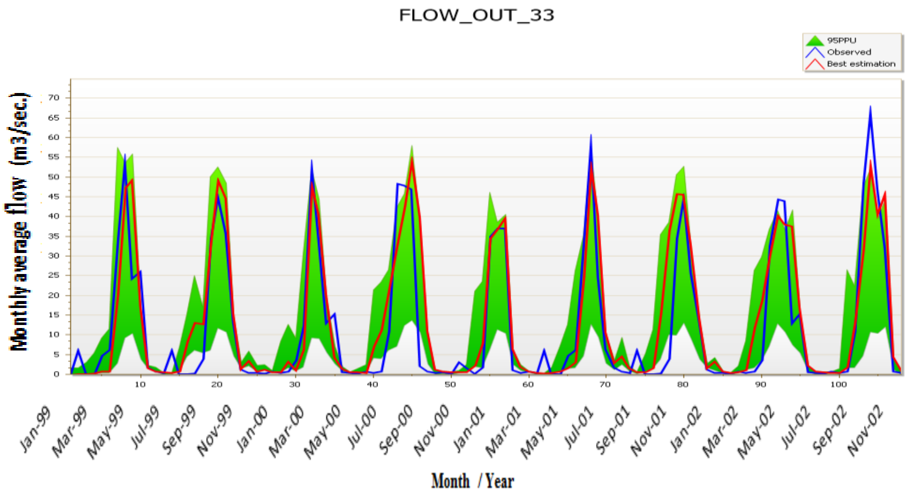


Figure 3.2: The result of Validation for average monthly stream flows.

The measured and simulated average monthly flow for Muga River was obtained, during the calibration period; they were 12.52 and 14.22 m³/s, respectively. The measured and simulated average monthly flow for the validation period was 12.69 and 14.49m³/s, respectively. These indicate that there is a reasonable agreement between the measured and the simulated values in both calibration and validation periods (Table 3.3).

Table 3.3: Comparison of Measured and simulated monthly flow for calibration and validation simulations

Period	Average monthly flow (m³/s)		ENS	R^2
	Measured	Simulated		
Calibration (1996-2010) Period	12.52	14.22	0.73	0.75
Validation (2011 - 2017) Period	12.69	14.39	0.83	0.85

As shown in the Table 3.3, the model performance values for calibration and validation of the flow simulations are adequately satisfactory. This indicates that the physically processes involved in the generation of stream flows in the watershed were adequately captured by the model. Hence, the model simulations can be used for various water resource management and development aspects.

3.1.3) Surface Irrigation Suitability Analysis

The analysis results of surface irrigation suitability evaluation factors are presented as the following sections

3.1.3.1) Suitable slope

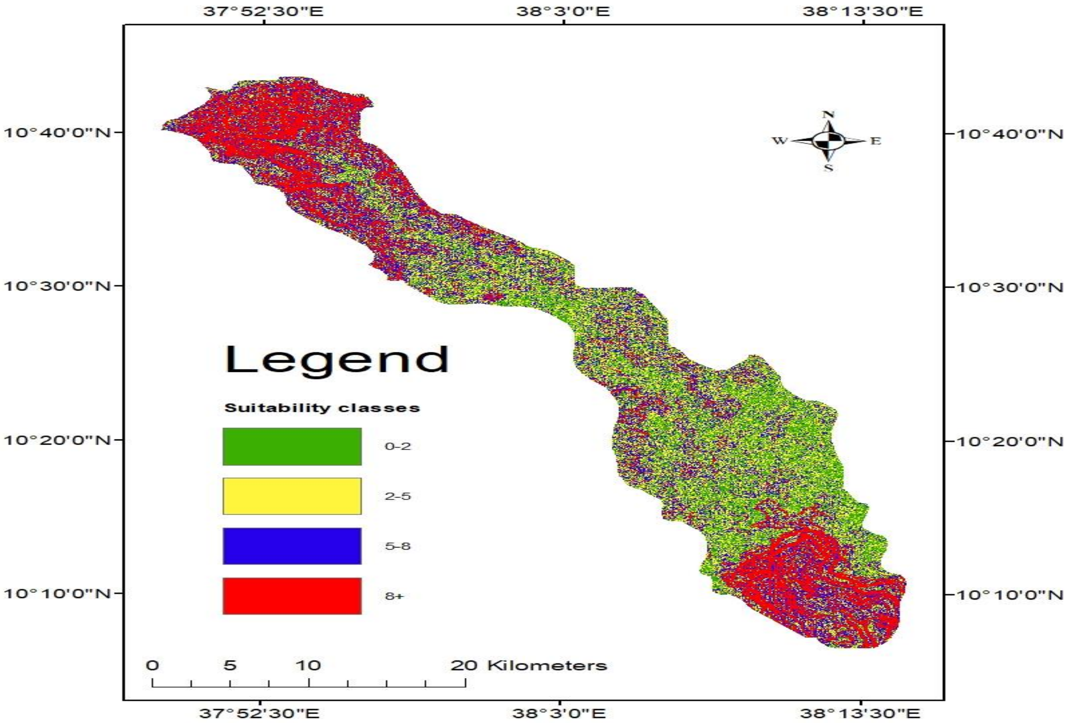


Figure 3.3: Slope suitability map of the study area for surface irrigation

Slope has been considered as one of the evaluation parameters in irrigation suitability analysis. Based on the four slope classes (S1, S2, S3 and N), the suitability of the study area for the development of surface irrigation system is shown in Figure 3.3 and the area coverage of the suitability classes are presented in Table 3.4.

Table 3.4: Slope suitability range of the study area for surface irrigation

Slope range (%)	Area coverage (ha)	% of total Area	Suitability Classes
0-2	3820.68	5.18	S1
2-5	11169.28	13.13	S2
5-8	35669.55	47.32	S_3
8+, (More than 8)	23155.74	33.37	N
Total	73,815.25	100	

The results in the table, (3. 4) revealed that 66.63% of the total area of the Watershed (covering an area of 50,659.51 ha) is in the range of suitable for surface irrigation system with respect to slope whereas the remaining 33.37% of the area (covering an area of 23,155.74 ha) is not suitable.

3.1.3.2) Soil suitability

Soil provides the room for water to be used by plants through the roots presents in the same medium as habitat for soil organisms. For his watershed seven main soil types are found which include, Eutric Cambisols, Eutric Leptosols, Eutric Regosols, Haplic Nitisols, Haplic Luvisols, and Rendzic Leptosols.

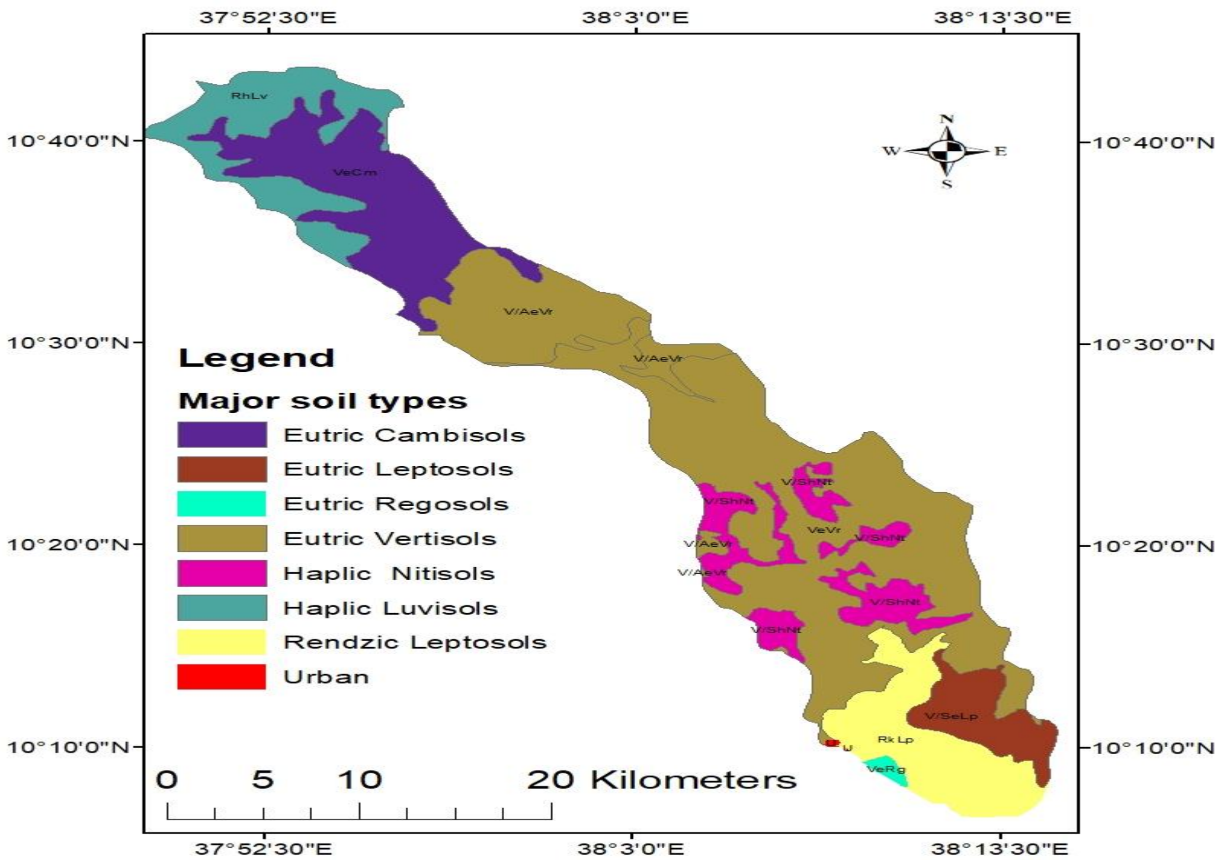


Figure 3.4: study area soil classification

Results of this analysis indicate that the study area can be generally classified into three irrigation suitability classes based on soil suitability as a factor: S1 (highly suitable), S2 (moderately suitable) and N (not suitable). Haplic Nitisols, covering an area of 8342.2800ha which accounts 11.63% of the total area, was classified as highly suitable (S1) for surface irrigation. In general, about 70.64% of the land in the study area (50662.44 ha) can be categorized as moderately suitable (S_2 class) for surface irrigation. These soils are classified as S_2 because of the presence of the factors limiting the land for the specified use (FAO, 1979). However, S_2 can be transferred to S_1 using the most appropriate irrigation methods such as sprinkler and drip irrigation on these soils.

Table, 3.5: Soil suitability classification result for surface irrigation

Soil type	Soil map unit	texture	Depth (cm)	Drainage	Salinity	Alkalinity	Irrigation	Area	
					(ds/m)	(ESP)	Suitability	Ha	%
Eutric Cambisols	VeCm	sandy loam	130	W	0.1	4.87	S_2	3923.28	5.47
Eutric Leptosols	v/SeLp	Clay loam	10	I			N	228.87	0.32
Eutric Regosols	VeRg	Sandy loam	130	I	0.1	4.93	S_2	11137.41	15.53
Eutric	v/AeVr	Sandy	200	W	0.1	0.7	S_2	35601.7	49.64

Soil type	Soil map unit	texture	Depth (cm)	Drainage	Salinity	Alkalinity	Irrigation	Area	
					(ds/m)	(ESP)	Suitability	Ha	%
Vertisols		loam						5	
Haplic Nitisols	v/ShNt	Clay	200	W	0	0.43	S_1	8342.28	11.63
Haplic Luvisols	RhLv	Clay	150	W	0	0.39	$S1^*$	178.92	0.25
Rendzic Leptosols	RkLp	Clay loam	37	W			N	7018.02	9.78
Urban	U						N	5295.15	7.38

S1= highly suitable, S2 = moderately suitable, N= Not suitable, W= Well, I = Imperfect

3.1.3.3) Land suitability

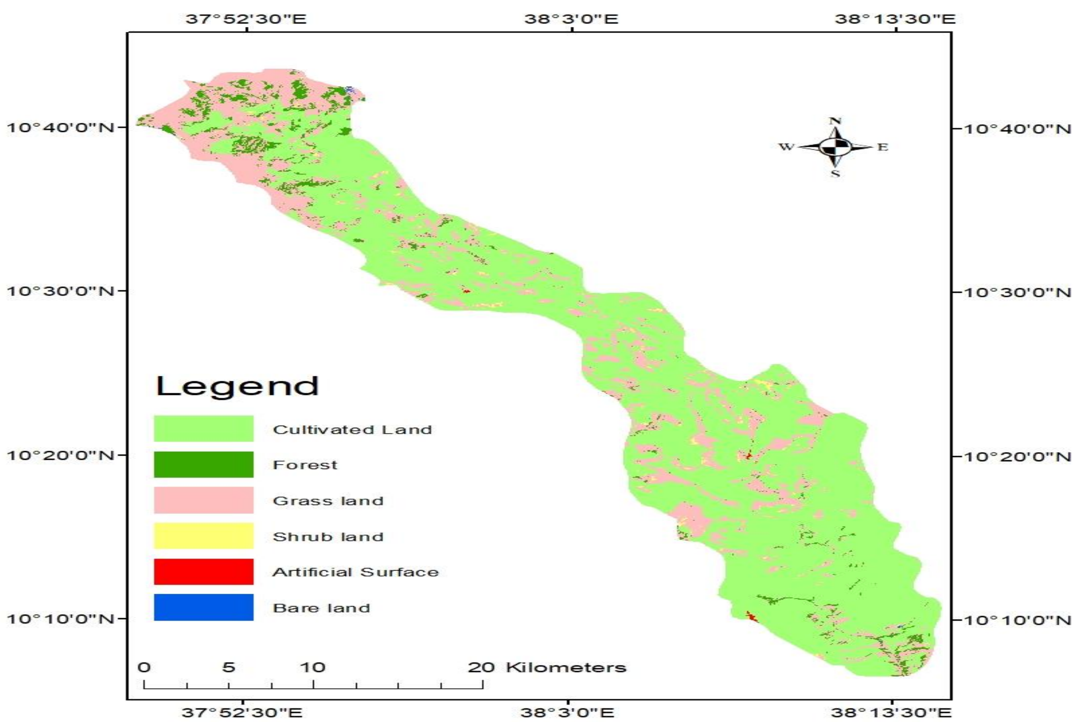


Figure 3.5: Land cover/use map of the study area

Table 3.6: Area coverage of land cover/use classes of the study area

Land use / Land cover	Area in (ha)	Percentage (%)
Cultivated land	53470.5	72.43
Forest	2720.07	3.68
Grass land	16973.17	23
Shrub land	570.87	0.77
Artificial Surfaces	47.55	0.06
Bare land	41.21	0.055

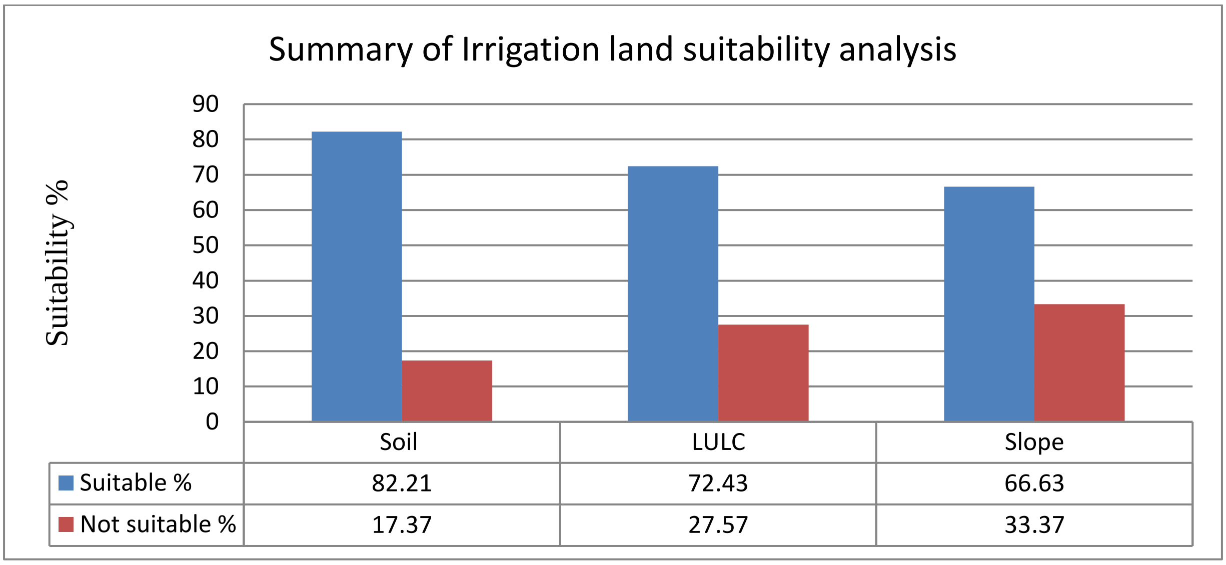


Figure 3.6: land feature analysis for surface irrigation

3.2) Identified Suitable Land for surface Irrigation

Potential irrigable land was obtained by creating irrigation suitability model analysis which involved weighting of values of all data sets such as soil, slope, land cover and distance from the water supply as shown in figure 3.7. The main and tributary rivers are referring to the main and sub-watersheds obtained by watershed delineation .Attempts were made to identify potential reservoir or diversion sites above the identified irrigable areas since the suitability was assessed for surface irrigation methods. Table 3.8, presents the identified irrigable land areas in hectares along rivers in Muga watershed.

Table 3.7: Weighted overlay influenced factor

No	Input data (Raster type)	% influenced factor (weighting)
1	slope	35
2	Euclidean distance from watershed outlets	15
3	soil	25
4	Land use	25

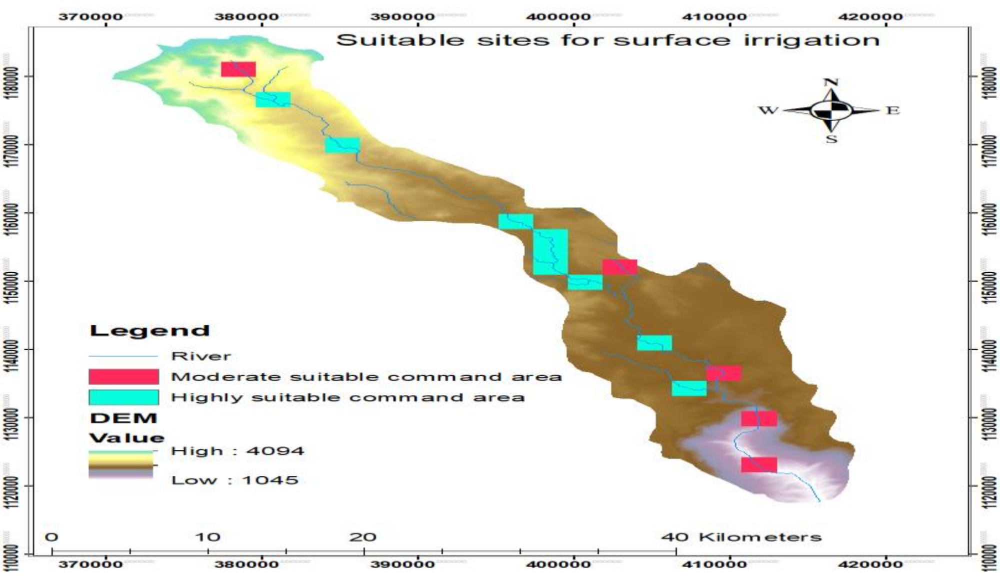


Figure 3.7 Suitable sites for surface irrigation development

Table 3.8: Suitable land for surface irrigation in the study area

No	Suitability	River	Command area in hectares
1	Moderate suitable command area	Muga	1699.53
2	Highly suitable command area	Muga	4506.906
Total			6206.37

3.3) Contribution of Sub Basins to the stream flow

3.3.1) Watershed Delineation

The Muga watershed was delineated in to 33 sub watersheds having an estimated total area of 73,815.25 ha (Figure 3.8).

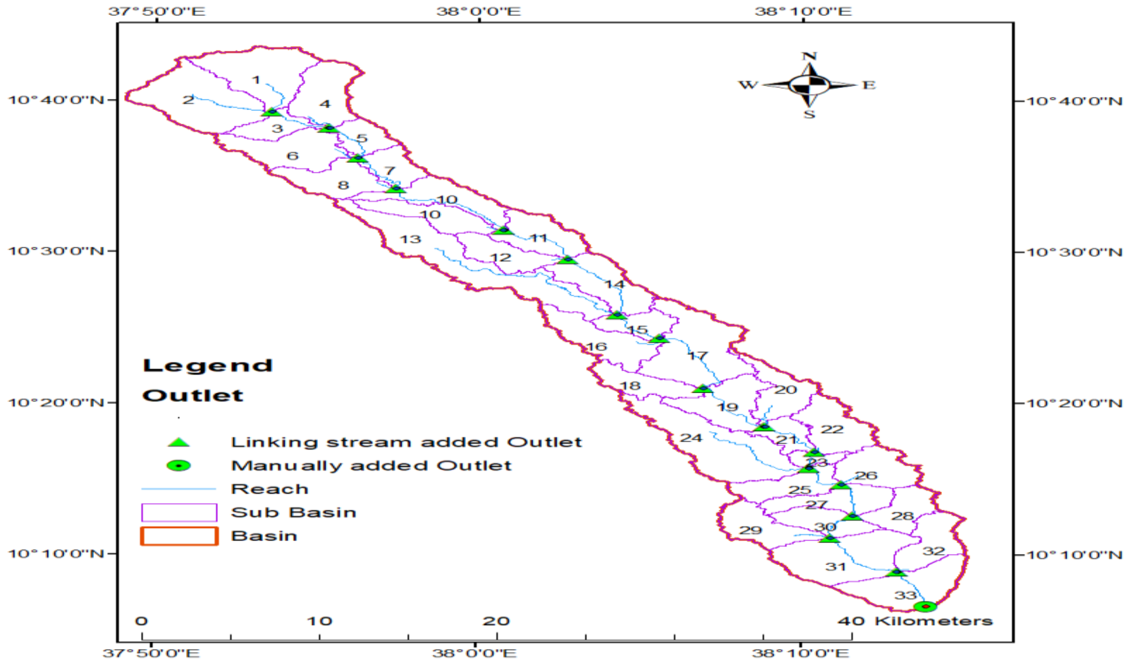


Figure 3.8: Sub watersheds map of the Muga watershed

Table 3.9: Average Annual surface runoff, Groundwater (Shal Aq), sediment load contributed by each sub basin

No. sub basin	Area (ha)	Surface runoff, mm	Groundwater(Shallow Aquifer), mm	Flow(m^3/sec)
1	3163	**209.62**(Min)	161.41	0.37
2	3930	316.62	147.3	0.58
3	1037	512.73	63.16	0.19
4	2264	534.22	43.91	0.42
5	1091	**711.93 (Max)**	**16.62 (Min)**	0.25
6	2410	356.01	180.31	0.41
7	1225	698.72	16.68	0.28
8	1854	616.69	46.29	0.39
9	2034	518.59	178.3	0.45
10	1589	331.53	338.51	0.34

No. sub basin	Area (ha)	Surface runoff, mm	Groundwater(Shallow Aquifer), mm	Flow(m^3/sec)
11	1929	345.01	355.56	0.43
12	1501	347.64	**357.05 (Max)**	0.34
13	5186	332.98	353.7	1.13
14	2352	303.96	266.45	0.43
15	1110	293.03	260.95	0.19
16	2265	289	262.02	0.4
17	4094	304.07	264.47	0.74
18	1457	278.88	249.07	0.24
19	2204	291.17	264.95	0.39
20	1760	284.48	270.28	0.31
21	959	259.41	264.16	0.16
22	2085	313.38	279.5	0.39
23	463	297.95	264.59	0.08
24	4556	290.41	266.34	0.8
25	1609	319.36	265.7	0.3
26	1835	333.52	272.63	0.35
27	1714	348.63	182.08	0.29
28	1435	334.37	260.13	0.27
29	1828	369.37	212.41	0.34
30	1393	393.18	182.11	0.25
31	3655	390.37	182.03	0.66
32	1742	336.5	257.48	0.33
33	2674	368.97	192.53	0.48
Annual average		355.89	293.71	0.41
Annual Average Stream flow from each sub-basin			355.89 + 293.71 = 649.6 mm = 0.41 m^3/sec	
Annual Average Stream flow @the outlet of watershed			649.6 mm *33 = 21436.8mm = 13.53 m^3 /sec	

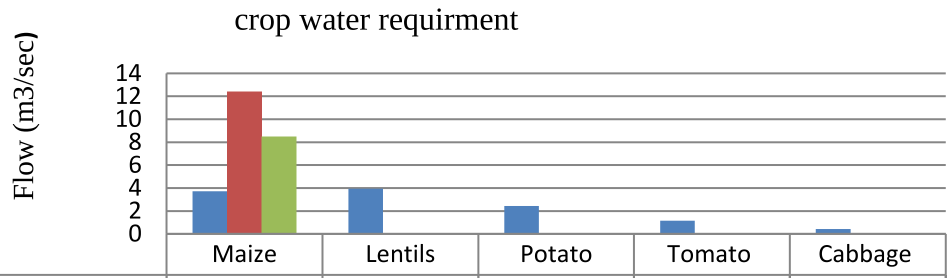
The highest annual surface runoff was attributed by sub basin, 5 and the minimum from sub basin 1. The contribution of ground water flow is maximum for sub basin 12 and minimum from sub basin, 5.

3.4) Determination of Crop Water Requirements of the Identified Command Areas by using CROPWAT model

Table 3.10: The summary of Crop water requirement and current flow through the river

Types of vegetable crops	Month s	Command areas (ha)	Crop water requirement for actual areas (l/s/ha)	Monthly average flow (m^3/s) in the river
	Jan		0.1	0.605
	Feb.		0.26	2.624
	Mar		0.49	0.678

Types of vegetable crops	Month s	Command areas (ha)	Crop water requirement for actual areas (l/s/ha)	Monthly average flow (m^3/s) in the river
Maize	Apr	1861.911	0.57	1.534
	May		0.45	2.577
	Jun		0.13	5.077
Total			2 l/s/ha =3.72 m^3 /sec	12.417 m^3/sec
	Jan		0.1	0.605
	Feb.		0.33	2.624
Lentils	Mar		0.52	0.678
	Apr	2172.2295	0.57	1.534
	May		0.31	2.577
Total			1.82 l/sec/har =3.95m^3/sec.	7.34 m^3/sec
	Jan		0.16	0.605
Potato	Feb.		0.35	2.624
	Mar	1241.274	0.59	0.678
	Apr		0.55	1.534
	May		0.31	2.577
Total			1.86 l/sec/har = 2.43 m^3/sec	7.34 m^3/sec.
Tomato	Jan		0.19	0.605
	Feb.		0.35	2.624
	Mar	620.637	0.49	0.678
	Apr		0.55	1.534
	May		0.26	2.577
Total			1.84l/sec/ha = 1.142 m^3/sec.	7.34 m^3/sec
Cabbage	Jan		0.23	0.605
	Feb.	310.3185	0.38	2.624
	Mar		0.46	0.678
	Apr		0.26	2.534
Total			1.33 /sec/har = 0.413 m^3/sec.	5.763m^3/sec.



	Maize	Lentils	Potato	Tomato	Cabbage
Water requirement for d/t crops (m3/sec)	3.72	3.95	2.43	1.142	0.413
Current flow in the river (m3/sec)	12.417				
Surplus flow (m3/sec)	8.467				

Figure 3.9: The relationship between crop water requirement and current flow

IV.CONCLUSION AND RECOMMENDATION

4.1) Conclusion

Surface irrigation land suitability analysis result indicates that 8.408% (6206.37ha) of the study area is suitable for surface irrigation; currently in the study area 162ha areas are irrigated by different crops, 6044.37 ha areas suitable lands for surface irrigation are remain unused.

The water resources assessment is done by SWAT mode, and also the performance of on the study area is checked by using SWAT-CUP model, in this study area the annual average stream flow at the outlet of the watershed simulated by SWAT model is 13.53m^3/s. The maximum annual stream flow was attributed by sub basin 5, the minimum flow from sub basin 1, in terms of ground water maximum yield from sub basin 12 and minimum from sub basin 5.

The maximum crop water requirement is 3.95m^3/s, the total monthly average flow in the same period of crop water determination (Jan to Jun) is 12.417m^3/s, 8.467m^3/s amount of water flow is remaining unused. The result indicated that Stream flows are much larger than their command area monthly irrigation demand. This implies that surface irrigation potential of these rivers limited by the land area to be irrigated along them.

4.2) Recommendation

In order to implement the funding of this study on the ground to give serves to the last customer, it needs the collaboration of all concerned stakeholders including you and me is very important and mandatory, because this finding should be develop into irrigation project to enhance the low rainfed smallholder agriculture to all season irrigation system to reduced poverty.

In this research surface irrigation potential analysis was carried out by considering only distance from water sources, soil, slope, and land cover/use factors. Future researcher may better to see the effects of other factors such as water quality, environmental, economic and social terms should be assessed to get sound and reliable result. The land suitability analysis result indicates that only 8.408% of the study area is suitable for surface irrigation, to increase suitability land for irrigation, land suitability analysis for sprinkler and drip irrigation irrigation method should be considered.

V. REFERENCES

[1]. Awulachew, S., et al. (, 2005). "ater Resources and Irrigation Development in Ethiopia. IWMI."

[2]. Bantero, B. (,2006). ""Across systems comparative assessment of Hare Community managed irrigation schemes performance. MSc thesis, Arba Minch University."."

[3]. Belay, M. and W. Bewket (, 2013). "raditional irrigation and water management practices in highland Ethiopia: case study in Dangila Woreda. Irrig. Drain. 62, 435–448."

[4]. FAO7 (, 2001). "Land evaluation towards a revised framework. Land and Water Discussion Paper 6 FAO, Rome.".

[5]. FAO (,1985). "Guidelines Land Evaluation for Irrigated Agriculture.FAO Soils Bull 55, Rome, 290 pp.".

[6]. FAO (,1994). " Sustainable Agriculture and Environmental Rehabilitation (Working Document), Tigray, Ethiopia.".

[7]. FAO (,1999). "The future of our land Facing the challenge. Guidelines for integrated planning for sustainable management of land resources. FAO, Rome. Land and Water Digital Media Series 8.".

[8]. FAO (,2007). "Land evaluation towards a revised framework. Land and Water Discussion Paper 6 FAO, Rome.".

[9]. FAO (, 1976). "A framework for land evaluation. FAO Soils Bulletin No. 32. FAO, Rome."

[10]. FAO (, 1979). "Land evaluation criteria for irrigation. Report of an Expert Consultation, 27 February-2 March, 1979. World Soil Resources Report No. 50. FAO Rome. 219 p."

[11]. Hussain, I. and M. A. Hanjra (,2004). " Irrigation and poverty alleviation: review of the empirical evidence. Irrig. Drain. 53, 1–15."

[12]. Janssen and P. Rietveld (, 1990). " Multi-criteria Analysis and GIS: An Application to Agriculture Land use in the Netherlands".

[13]. Monteith, J. (, 1965). "Evaporation and environment. Symp. Soc. Exp. Biol. 4."

[14]. Seleshi (,2001). " Investigation of Water Resources Aimed at Multi Objective Development With Respect to Limited Data Situations The Case of Abaya-Chamo Basin, Ethiopia. Ph.D Thesis Technische Universitat Dresden Institute Fur Wasserbaw und Technische Hydromechanik D-01062 Dresden."

Cite this article as :

Natnael Yasab Assefa , "GIS - Based Surface Water Irrigation Potential Assessment of Muga Watershed, Abbay Basin, Ethiopia", International Journal of Scientific Research in Civil Engineering (IJSRCE), ISSN : 2456-6667, Volume 4 Issue 2, pp. 49-68, March-April 2020.

URL : http://ijsrce.com/IJSRCE120426