JOURNAL OF INDIGENOUS KNOWLEDGE AND DEVELOPMENT STUDIES
JIKDS 03(02)2021
ISSN (online) 2708-2830 ISSN (print) 2707 – 7640
www.bhu.edu.et/jikds

Irrigation Potential Assessment for Effective Agricultural Production in West Guji Zone, Ethiopia.

Mr. Kasim Safaye Koma [1*], Mr. Duba chana[1]

[1]Department of hydraulic and water resources engineering, College of Engineering and Technology, Bule Hora University, Ethiopia. Email: [*]Kasimsafaye1@gmail.com

ABSTRACT

Irrigation is one method of increasing agricultural output in response to rising food demand. Increasing agricultural yield, arable land area, and cropping intensity are three ways to meet rising demand (number of crops per year). The purpose of this research is to determine the irrigation potential of the West Guji zone. A comprehensive study on irrigation potential, land suitability, water resources, and crop selection must be conducted to achieve this goal. The land's suitability for irrigation was determined using a combination of the Geographical Information System (GIS) and the Analytical Hierarchy Process (AHP). Water availability was determined by using streamflow discharge for gauged watersheds and the runoff coefficient method for un-gauged sites, and the results are presented every month. To calculate the crop water requirement of the dominant crop in the study area, the crop wat-8 Model was used. According to the results of the irrigation suitability model's weighted overlay analysis, 3.1 percent of the total area is covered by a highly suitable class(s_1), 57.2 percent by a moderately suitable class(s_2), 39.6 percent by a marginally suitable class(s_3) and the remaining 0.1 percent by an unsuitable class(N). The result of streamflow analysis in both gauged and ungauged watersheds was estimated as 232.25 m^3/s. In most river catchments, the gross irrigation water requirements exceed the available water. As a result, the effective irrigable area must be calculated using the minimum effective flow.

Keywords: Analytic Hierarchy Process; Dominant Crop; Agricultural Productivity; Land Suitably;

INTRODUCTION

Irrigation potential studies are critical in eradicating poverty in any country. Ethiopia's economy is predominately based on agriculture(Mayol, 2015). Agriculture employs roughly 85 percent of the workforce. Irrigation development in Ethiopia is in its infancy, and it is not making a significant contribution to the agricultural sector's growth (Assefa *et al.*, 2018). The country has development potential in terms of both vast tracts of suitable land and the availability of freshwater resources suitable for irrigation. However, due to the limited amount of study conducted on land available for irrigated agriculture at the moment, crop production is primarily based on rainfed agriculture(Belete *et al*, 2011). Irrigation development could boost agricultural productivity as well as the socio-economic development of the community (Ashine, 2019).

The main challenges in Ethiopia's irrigation potential, particularly in West Guji, are insufficient studies on the utilization of water resources and a lack of awareness of irrigation water management techniques such as irrigation scheduling techniques, water-saving irrigation technologies, and water assessment methods(Awulachew, 2015).

As a result, this research focuses on the assessment of land resources, water resources, and farming systems in southern Ethiopia, as well as the major crops grown, crops commonly used by farmers, and other crop yield factors. The West Guji zone has an abundance of fertile land and water resources, including perennial rivers like the Kojowa, Gelana, Gololcha Lakkole, Badhu, and Afelata. Despite such perennial rivers, agricultural use of their water resources has remained low in the zone across all weredas. As a result, the primary goal of this research is to assess, the land suitability, river water resources, and crop water requirements of selected crops in the West Guji zone using a combination of AHP, GIS, and CROP WAT8.0.

MATERIALS AND METHOD

Description of Study Area

West Guji zone is located in Oromia Regional State, Ethiopia, in the southern part of the country (Fig.1). Geographically, it is located between the latitudes of 5° 10 N and 6° 40 N and the longitudes of 37° 50 E and 38° 50 E.

There are two distinct rainy seasons in the precipitation pattern. The West Guji zone receives a lot of rain between March and May, as well as a lot of rain between September and November. The dry season runs from December to February, with some overlap between June and July. In the study area, the highest mean annual average rainfall recorded was 983.2 mm, while the lowest mean average was 40.8 mm. The lowest mean average temperature recorded was 21 degrees Celsius, while the highest was 27.4 degrees Celsius.

Crop production in the West Guji zone is bimodal, with two growing seasons per year that rely on rainfall. Arfasa (spring) and ganna (summer) are the two major rainy seasons. Arfasa is the most important crop season, especially for field crop cultivation. The second rainy season begins on March 15 and lasts until May 15. Ganna is a region that grows only a few cereal crops, and it runs from September 15 to November 15. The West Guji zone area's topography is dominated by the alluvial plain. The topography of the study area is generally flat to rolling, with some flat land vulnerable to flooding as the river overtops its bank. The elevation of the watershed ranges from

887 meters above sea level at the mouth of the river to 2735 meters above sea level in the upper reaches. The soils are dominated by clay loam content, with some medium-textured soils and gravel.

Data Source for Study

Based on the study's objective, the necessary data sets were gathered from various sources. The study's primary objectives were to assess land suitability, assess water resources, and identify dominant crops grown in the area to quantify their water demand and supply. Physical soil properties, land use land cover, and slope data from Oromia water work design supervision and enterprise (OWWDSE) were used to assess land suitability, which was based on the FAO land evaluation framework. By analyzing historical river flow data from the major rivers, the available surface water potential for irrigation was quantified. Ethiopia's ministry of water, electricity, and energy provided long-term streamflow records (1989-2016) from five stations in and around the catchment. The agricultural office of the West Guji zone was then contacted to obtain the dominant crop commonly grown in the area, as well as their calendars. The climate data has been collected from the national metrology agency of Ethiopia.

Land Suitability Assessment

The development of an irrigation suitability model analysis, which included weighing the values of all data sets in the land characteristics dataset, was used to identify potentially irrigable land. To develop land suitability, the selection of suitability factors is the first step. The choice was influenced by the availability of data on the irrigation environment's requirements(Journal *et al.*, 2014). The following evaluation criteria are used to determine whether the land in the study area is suitable for identifying irrigation potentials (Mandal *et a*l., 2018). They are as follows:

A) Soil physical properties

B) Topographic factor (slope)

C) Land cover /use

A) Soil physical properties (depth, texture, and drainage)

The most important factor in determining land suitability for surface irrigation development is the soil (FAO, 2007). To assess soil suitability for irrigation, the Oromia water work design supervision and enterprise provided a soil shapefile and report (OWWDSE). According to FAO and(OWWDSE (Table 1) guidelines, the basic physical parameters used in the suitability analysis are texture, depth, and drainage classes(Leenaars *et al,* 2014),(Bousquet *et al.*, 1995).

B) Topographic factor (slope)

The land slope is the most important topographical factor influencing land suitability for irrigation (FAO, 2007). To create slope suitability maps for the study area, a 20-meter-resolution digital elevation model of the area was clipped from SRTM using the study area's masking layer. Based on the classification system of the DEM, the slope was classified using the "Reclassification" tool, which is an attribute generalization technique in ArcGIS(FAO, 2007). (Table 2.)

C) Land cover /use

A 1:250,000 scale land-use/land-cover map was used to create a land-use and land-cover map of the study area in 2017 by Oromia waterwork design supervision and enterprise OWWDSE. The watershed's LULC map was created and used in the evaluation process to identify potentially suitable irrigation sites.

2.3.2 Analytical Hierarchy process (AHP)

The AHP is a mathematical method for solving extremely complex decision-making problems with multiple scenarios, criteria, and factors (Saaty, 2006). AHP has been proposed as a decision analysis technique for one or more decision-makers to evaluate complex multi-attribute alternatives. It is thought to be superior to other methods of decision-making because it allows for the consideration of subjective factors (Saaty, 2001).

To express individual preferences or judgments, the AHP employs a basic 9-point scale measurement (Saaty, 2001), resulting in a matrix of pairwise comparisons (Table 3). These pairwise comparisons enable independent evaluations of each factor's contribution, which simplifies decision-making (Rezaei-Moghaddam K, 2008).

The matrix format in pairwise comparisons is described as $A = \lfloor a_{ij} \rfloor n * n$

$$A = \begin{bmatrix} a_{11} a_{12} \ldots\ldots\ldots\ldots a_{1n} \\ a_{21} a_{22} \ldots\ldots\ldots\ldots a_{2n} \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ . \\ . \\ a_{n1} a_{n2} \ldots\ldots\ldots\ldots a_{nn} \end{bmatrix} \text{-----------------------Eq.1}$$

Where for all i and j, it is necessary that $a_{ii} = 1$ and $a_{ij} = 1/ a_{ji}$. After all pairwise comparison matrices are formed, the vector of weights, $w = [w_1, w_2, w_3, \ w_n]$ is calculated based on saaty 's eigenvector method. Then, this eigenvector is normalized by eq.2 and then the weights are computed by eq. 3. The elements of the normalized eigenvector are weighted for the criteria or sub-criteria and rated to the alternatives(Yavuz, 2016).

$$a_{ij} = \frac{a_{ij}}{\sum_{j}^{n} = 1 a_{ij}} \quad \text{.. Eq.2}$$

$$w_{ij} = \frac{\sum_{j}^{n} = 1 a_{ij}}{n} \quad \text{..Eq.3}$$

where i , j = 1, 2, 3 …. n

The AHP also includes mathematical measures that can be used to determine the consistency of the judgment matrix. A consistency ratio (CR) can be calculated using the matrix's properties. The largest eigenvalue (kmax) in a matrix is always greater than or equal to the number of rows or columns (n). A consistency index (CI) that measures the consistency of pairwise comparisons is denoted by (Saaty, 2001):

$$Consistencyindex(C.I) = \lambda_{\max} - n \big/ n-1 \quad \text{-------------------- Eq.4}$$

Where: n is the number of compared elements /factors n=4. In this case, λ_{max} is the average sum value of criterion weight, then the consistency ratio (CR) can be calculated as

$$CR = C..I \big/ R.I \quad \text{...................... Eq.5}$$

Where: CR: consistency ratio, C.I: Consistency index, R.I: random index, R.I can be read from the random index. (Table 4). After the pair-wise comparison matrices were filled, the weight module was used to identify the consistency ratio and develop the best-fit weights(Vaidya, 2019). The consistency ratio should be less than 0.1 (<0.1)(Herzberg *et al.*, 2019).

Overall Suitable Sites for Irrigation

The irrigation suitability factors were fed using the pair-wise comparison matrix (Table 6). Because the five factors are listed in columns and rows, the importance of the row factors to irrigation was compared to the importance of the column factors, and then the Saaty scoring was used(Saaty, 2006). The consistency ratio (CR) is 0.090, indicating that the comparisons of land characteristics were consistent and that the relative weights were appropriately chosen (Table 8).

Surface Water Availability Assessment

The catchment's available surface water can be assessed using gauged streamflow from all perennial rivers(Nasir GT*, 2019). Flow data were used to assess the irrigation water resource potential of gauged and ungauged sites (Tesfaye, 2014). The average annual monthly streamflow, as well as the maximum and minimum flow, were all calculated. However, an effective irrigable area will be calculated using the minimum streamflow (Assefa et al., 2018). The results of the rainfall data analysis that, has been collected from the national metrological agency of Ethiopia, combined with discharges from gauged sites that were collected from the ministry of water electricity and irrigation of Ethiopia, were used to estimate streamflow at un-gauged sites in the study area (Oudin et al., 2018). Because only the irrigation potential of perennial rivers was considered in this study, the discharges at un-gauged sites were estimated using a long-term average of streamflow at gauged sites and mean monthly areal rainfall at the sites. This was accomplished by applying the gauged sites' runoff coefficients to ungauged sites (Kim *et al.,* 2016). As a result, the streamflow and rainfall data were combined to assess the water resource potential of the gauged and ungauged sites for irrigation purposes. The runoff volume per month at the un-gauged site was then estimated using the formula below(Ganole, 2010).

$$Q_{ungauged} = \left(\frac{A_{Ungauged}}{A_{Gauged}}\right) * Q_{Gauged} * \left(\frac{P_{Ungauged}}{P_{gauged}}\right) \text{---------------------Eq.6}$$

Where: $Q_{ungauged}$ discharge at the un-gauged site ($m^{3/s}$), $A_{ungauged}$ is drainage area of the un-gauged site (km^2), $P_{un\text{-}gauged}$ is a real rainfall at the un-gauged site (mm), Q_{gauge} discharge at the gauged site ($m^{3/s}$), A_{gauged} the drainage area at the gauged site (km^2) and P_{gauged} is a real rainfall at the gauged site (mm).

Crop Water Requirement

The amount of water required by a crop or diverse patterns of crops in a given period for normal growth under field conditions at a location, regardless of its source, is referred to as water requirement(OIAD, 2018). Reference crop evapotranspiration (ETO) expresses the evaporating power of the atmosphere at a specific location and time of year without taking crop characteristics or soil factors into account (Allen, 2006). The FAO Penman-Monteith method is recommended (eq.7), as the sole method to determine ETO while all climate data are available(Nasir GT*, 2019). The method is considered to offer the best results with the minimum possible error with a living grass reference (Adamu, 2017).

$$ET_o = \frac{0.408\Delta(R_n - G) + \frac{900\gamma}{T+27.3} * U_2(e_s - e_a)}{\Lambda + \gamma(1 + 0.34U_2)}$$ ---------------------------------Eq.7

Where: ETO: reference evapotranspiration [mm/day]

Rn: net radiation at the crop surface [MJ/day m2]

G: soil heat flux density [MJ/day m2]

T: Mean daily air temperature at 2m height [O C]

U2: wind speed at 2m height [m/s] es saturation vapor pressure [k Pa]

Ea.: actual vapor pressure [k Pa], es –ea.: saturation vapor pressure deficit [k Pa]

Δ: Slope vapor pressure curve [k Pa/ O C] γ: Psychrometric constant [k Pa/ O C]

The sum individual

Net irrigation water requirement (NIWR): crop water requirements (CWR) calculated for each irrigated crop(Nasir GT*, 2019).

$$NIWR = \frac{\sum_{i=1}^{n} IWR_i * A_i}{A}$$ **--------------------------**Eq.8

Where: NIWR=Net irrigation water requirement (mm), A_i=the area cultivated with the crop i (ha), A=the area of the scheme (ha).

Gross irrigation water demand (GIWD): The gross irrigation requirement is the total amount of water required to bring the crop root zone to field capacity, including the water needed to offset application losses (OIAD, 2018).

$$GIWR = \frac{NIWR}{E} * A(ha)$$ -------------------------------Eq.9

Where:

NIWR-: net irrigation water requirement (l/s/ha)

GIWR: gross irrigation water requirement (m^3/s)

A: area covered by crop (ha)

E: overall irrigation efficiencies

The irrigation efficiency is computed by the following formula(FAO, 2013).

$$E = \frac{E_{c*} E_a}{100}$$ ---------------**Eq.10**

Where; E - Irrigation efficiency (%) Ec - Conveyance efficiency (%)

Ea - Field application efficiency (%).

Irrigation Water Demand For Selected Crops

Crops were chosen based on local cropping patterns, farmer practices, and preferences, crop value to ensure food security in the area, and economic value to improve farmers' livelihood and income (OIAD, 2018). The five crops to be evaluated for irrigated agricultural development in the watershed are maize, barley, wheat, Teff, and grain.

The gross irrigation water requirement of each of the selected crops was calculated using the net irrigation water requirement from the CROPWAT.8 model and the area covered by the selected crop(Rabia, 2016). Data from the Bule Hora meteorological station were used to calculate ETc./CWR because all stations can be classified as lowland or midland depending on altitude, i.e. lowland with elevations ranging from 0-1300m a.s.l, midland with elevations ranging from 1300 – 2350m a.s.l, and highland with elevations greater than 2350m a.s.l. 2020.

RESULTS AND DISCUSSION

Land Suitability Assessment Result

Figure 3 depicts the factors influencing agricultural land suitability in the study area. Soil drainage received a high weight (percentage of influence) (40 percent) in the weighted overlay analysis because it is a determinant factor in the evaluation of the given area for irrigation development. Based on the analytical hierarchy process, the remaining 60% was divided among the four remaining factors. According to the results of the irrigation suitability model's weighted overlay analysis, 3.1 percent of the total area is covered by a highly suitable class (S1), 57.2 percent by a moderately suitable class (S2), 39.6 percent by a marginally suitable class (S3), and 0.1 percent by an unsuitable class (N) (Figure 2). In these studies, the selected irrigation area was highly suitable and moderately suitable for the watershed (S2 and S1) due to the small irrigation limitation. The two classes, highly suitable and moderately suitable, cover approximately 60.3 percent of the total area of watersheds.

Water Resources Assessment Result

According to the output of the arc swat tool, watershed delineation results in seven watersheds within the zone administration boundary (figure 4Following an assessment of the land's irrigation suitability, it is critical to investigate irrigation water availability in the study area for crop production. Using the method proposed by Monjardin, the irrigation capability of river catchments in the study area was determined by comparing the irrigation requirements of the identified land suitable for irrigation with the available mean monthly flows in the river catchments (Monjardin et al., 2017). (See Table 5). According to the results of these analyses, total irrigation water demand exceeded available streamflow from April to November. Because each watershed's gross irrigation water requirement exceeds its monthly available water, the effective irrigable area must be calculated for each watershed using minimum flows and area.

Irrigation Water Demand For Selected Crops

The five crops selected to be evaluated for irrigated agricultural development in the watershed were maize, barley, wheat, Teff, and grain. Based on data from agricultural offices in west Guji zones, different percentages of area coverage were adopted for each crop, such as maize (35%), barley (12%), wheat (20%), Teff (18%), and grains (15%). Using equation nine, the crop wat.8 results were used to calculate growth water requirements (9). The results provide a general overview of monthly water demands for maize, barley, wheat, Teff, and grains during their full growth stage for seven months (Table 7). After calculating gross irrigation water requirements, they were compared to available surface water (Table 5).

CONCLUSIONS

This study's primary goal was to identify irrigation potential in the West Guji zone. The irrigation assessment included a land suitability assessment based on a variety of criteria, a water resource assessment for both gauged and unguided catchments, and a calculation of the gross irrigation water requirement of dominant crops commonly grown in the zone. Based on the specified suitable criteria, potentially irrigable land was identified using an irrigation suitability model analysis that included weighting of all data sets such as soil texture, drainage, depth, slope, and land use/cover. The majority of zones were suitable for irrigation in terms of land suitability, with 60.3 percent of the watershed falling into highly suitable to moderately suitable classes (S1&S2) in terms of slope, soil, and land use/cover.

The five crops that were selected to be evaluated for irrigated agriculture development in the watershed were maize, barley, wheat, Teff, and grains. This percentage of area coverage was adopted for each crop based on data taken from agricultural offices in the West Guji zones, such that 35% maize, barley 12%, wheat 20%, Teff 18%, and grains 15%. The results from crop wat.8 were used to obtain growth water requirements.

In addition to land suitability, determining surface water availability is an important factor in determining the irrigation potential of a specific area. The runoff coefficient method was used to assess water resources at un-gauged sites based on streamflow discharge, and the results are presented monthly. The gross irrigation water requirements in most river catchments exceeded the available water. As a result, the effective irrigable area must be determined using the lowest effective flow. By using the minimum available flow and the effective irrigable area in the Zone was 1402ha**.** Since this study was primarily concerned with irrigation potential, regardless of the type of irrigation. The researcher suggests that more research should focus on irrigation methods such as surface and drip irrigation, as well as further analysis of water and soil quality for irrigation.

Acknowledgements

I would like to thank almighty God for his mercy upon me and my family. Next, I thank my family for their advice and care while I was stressed while doing this research. Finally, I would like to thank the reviewers and the editors for their valuable and constructive suggestions.

Conflict of Interest

The authors declare that they have no conflict of interest

REFERENCES

Adamu, F. M. (2017) assessment of surface water and land resource potential for surface irrigation: case study of gumara watershed Tana sub basin north Gondar.

Allen, R. G. (2006) 'FAO Irrigation and Drainage Paper Crop by', (56).

Ashine, E. T. (2019) *Surface Water Potential Assessment and Demand*.

Assefa, T. *et al.* (2018) 'Assessment of suitable areas for home gardens for irrigation potential, water availability, and water-lifting technologies', *Water (Switzerland)*, 10(4), pp. 1–21. doi: 10.3390/w10040495.

Awulachew, S. B. (2010) 'Irrigation potential in Ethiopia Constraints and opportunities for enhancing Irrigation potential in Ethiopia Constraints and opportunities for enhancing the system International Water Management Institute Teklu Erkossa and Regassa E . Namara', *ResearchGate*, 1(January), p. 60.

Awulachew, S. B. and Ayana, M. (2011) 'Performance OF irrigation: An assessment at different scales in ethiopia', *Experimental Agriculture*, 47(S1), pp. 57–69. doi: 10.1017/S0014479710000955.

Awulachew, S. B., Demissie, S. S. and Ragas, F. (2019) 'Water management intervention analysis in the Nile Basin Ill " Ill ' lll "', (April).

Belete, Y., Kebede, H. and Biru, E. (2011) 'Small-Scale Irrigation Situation Analysis and Capacity Needs Assessment':, *Natural Resources Management Directorate*, (October), p. 44.

Bousquet, M. *et al.* (1995) 'Assessment of irrigation potential in Africa', pp. 115–126.

Edmealem Temesgen Ebstu (2018) *Assessment Of Surface Irrigation Potential In Gilgel Abbay*.

FAO (2007) *Land evaluation Towards a revised framework Land evaluation*, *land and water discussion paer*.

FAO (2013) *Save and Grow: Cassava, A Guide to Sustainable Production Intensification*, *Save and grow: cassava, a guide to sustainable production intensification*.

Ganole, K. (2010) 'Gis-Based Surface Irrigation Potential Assessment of River Catchments for Irrgation Development', (April).

Herzberg, R. *et al.* (2019) 'Multi-criteria decision analysis for the land evaluation of potential agricultural land use types in a hilly area of Central Vietnam', *Land*, 8(6). doi: 10.3390/land8060090.

Journal, T. *et al.* (2014) 'Bagheri , S ., Turkoglu , M ., Abedini , A ., 2014 . Phytoplankton and Nutrient Variations in the Iranian Waters of the Caspian Sea (Guilan region) during Phytoplankton and Nutrient Variations in the Iranian Waters of the Caspian Sea (Guilan region) d', (March). doi: 10.4194/1303-2712-v14.

Kim, N. W., Shin, M.-J. and Lee, J. E. (2016) 'Application of runoff coefficient and rainfall-intensity-ratio to analyze the relationship between storm patterns and flood responses', *Hydrology and Earth System Sciences Discussions*, 0(May), pp. 1–48. doi: 10.5194/hess-2016-194.

Leenaars, J. G. ., Oostrum, A. J. M. van and Gonzalez, M. R. (2014) 'Africa Soil Profiles Database, Version 1.2. A Compilation of Geo-Referenced and Standardised Legacy Soil Profile Data for Sub-Saharan Africa (with Dataset). ISRIC Report 2014/01. Africa Soil Information Service (AfSIS) Project. ISRIC – World Soil Informat', (October 2015), pp. 51–57.

Mamo, A. (Bahir D. I. O. T. S. O. R. A. P. S. F. O. C. A. W. R. E. (2020) 'Gis- Based Surface Irrigation Potentialassessment in Sehala'.

Mandal, B., Dolui, G. and Satpathy, S. (2018) 'Land suitability assessment for potential surface irrigation of river catchment for irrigation development in Kansai watershed, Purulia, West Bengal, India', *Sustainable Water Resources Management*, 4(4), pp. 699–714. doi: 10.1007/s40899-017-0155-y.

Mayol, M. D. (2015) 'an Assessment of Surface Water Resources and its Allocation: Case Study of Bahr el-Jebel River Sub-Basin South Sudan', (September), pp. 0–111.

Monjardin, C. E. F., Uy, F. A. A. and Tan, F. J. (2017) 'Estimation of River Discharge at Ungauged Catchment using GIS Map Correlation Method as Applied in Sta. Lucia River in Mauban, Quezon, Philippines', *IOP Conference Series: Materials Science and Engineering*, 216(1). doi: 10.1088/1757-899X/216/1/012045.

Nasir GT*, T. A. and T. A. (2019) 'Irrigation & Drainage Systems Engineering Irrigation Potential Assessment on Shaya River Sub-Basin in Bale Zone ', 8(1), pp. 1–7. doi: 10.4172/2168-9768.1000225.

Nations, U. *et al.* (2007) *Water Resources and Irrigation Development in Ethiopia*.

OIAD (2018) *Oromia Irrigation Potential Assessment Awash Basin Irrigation Engineering Final Report, OIDA*, *report*.

Oudin, L. *et al.* (2008) 'Spatial proximity, physical similarity, regression and ungaged catchments: A comparison of regionalization approaches based on 913 French catchments', *Water Resources Research*, 44(3), pp. 1–15. doi: 10.1029/2007WR006240.

Rabia, A. H. (2016) 'A GIS based land suitability assessment for agricultural planning in Kilte Awulaelo district , Ethiopia .', (January).

Rezaei-Moghaddam K, K. E. (2008) 'A multiple criteria evalu-ation of sustainable agricultural development model s using AHP', *Environ Dev Sustain*, pp. 10:407–426.

Saaty (2006) 'Fundamentals of decision making and priority theory with the analytic hierarchy process."', *RWS Publications USA*, p. 6.

Saaty, T. L. (2001) 'Fundamentals of the Analytic Hierarchy Process', in *Fundamentals of the Analytic Hierarchy Process*, pp. 15–35.

Swain, J. B. and Patra, K. C. (2017) 'Streamflow Estimation in Ungauged Catchments Using Regional Flow Duration Curve: Comparative Study', *Journal of Hydrologic Engineering*, 22(7), p. 04017010. doi: 10.1061/(asce)he.1943-5584.0001509.

Tesfaye, Y. (2014) *'GIS - based Land Suitability Assessment for Surface Irrigation and Mapping: The Case of Azule Catchment, Arsi Zone, Oromia Region, Ethiopia'*.

Vaidya, O. S. (2019) 'Analytic Hierarchy Process : An Overview of Applications Analytic hierarchy process : An overview of applications', (April). doi: 10.1016/j.ejor.2004.04.028.

Yavuz, F. (2016) 'AHP and GIS based land suitability analysis for Cihanbeyli (Turkey) County'. doi: 10.1007/s12665-016-5558-9.

***Table 1.* Soil suitability rating factor, OWWDSE,2017**

factors	Factor rating			
Soil suitability class	S1	S2	S3	N
Depth (cm)	>120	100-120	50-100	<50
texture	C	Si-CL, CL	SL	Coarse sand
Drainage class	Well drain	imperfect	poor	Very poor

Source. Oromia water work design supervision and enterprise (OWWDSE), 2017

C: Clay, Si-CL:Silt Clay Loam, CL Clay Loam , SL Silt Loam

***Table 2.* Slope classification for irrigation suitability, OWWDSE,2017**

	Slope classification for surface irrigation	
No	Slope %	Rating factor
1	0-5	S1
2	2-8	S2
3	5-15	S3
4	>15	N

***Table 3.* AHP scales for paired comparisons (Stay ,2001)**

Intensity of Importance	Definition
1	Equal importance
2	Equal to Moderate importance
3	Moderate importance
4	Moderate to strong importance.
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to Extremely strong importance
9	Extreme importance

Table.4. Random index (RI)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

Table 5. Comparison of Gross irrigation water requirement and available water((m^3/s)

Watersheds	command area (ha)	flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8001	available	1.9	1.9	2.1	1.9	1.8	1.8	2.0	1.9	2.2	2.0	1.9	2.0
		gross.irr. req	0.0	0.0	0.0	3.3	4.7	7.3	7.1	5.2	4.7	2.7	0.0	0.0
2	65720	available	8.8	8.6	8.5	8.1	8.4	9.2	8.6	8.4	8.4	8.8	8.7	9.3
			0.0	0.0	0.0	26.8	38.9	59.6	58.4	42.6	38.9	21.9	0.0	
3	91180	available	1.5	1.4	1.6	1.8	1.6	1.6	1.6	1.9	2.1	1.6	1.5	1.3
			0.0	0.0	0.0	37.1	54.0	82.7	81.0	59.1	54.0	30.4	0.0	0.0
4	103920	available	5.0	4.9	4.9	4.8	4.9	5.0	5.0	5.1	5.1	5.1	4.9	5.2
			0.0	0.0	0.0	42.3	61.6	94.3	92.4	67.4	61.6	34.6	0.0	0.0
5	49660	available	4.3	1.1	1.1	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1
			0.0	0.0	0.0	20.2	29.4	45.1	44.1	32.2	29.4	16.6	0.0	0.0
6	151120	available	1.4	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.4
			0.0	0.0	0.0	61.6	89.6	137.1	134.3	97.9	89.6	50.4	0.0	0.0
7	189410	available	1.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
			0.0	0.0	0.0	77.2	112.2	171.9	168.4	122.8	112.2	63.1	0.0	0.0

Table 6. **Pairwise comparison matrix and eigenvector**

factors	Soil drainage	Soil depth	Texture	Slope	Land cover
Soil drainage	1	3	3	5	5
Soil depth	1/3	1	3	5	7
Texture	1/3	1/3	1	3	7
Slope	2/5	4/5	2/3	1	5
Land cover	2/5	2/7	1/7	4/5	1

Table 7. Gross irrigation water requirement of dominant crop (m^3/s)

Subwatershed	command area (ha)		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8001	0	0	0	3.3	4.7	7.3	7.1	5.2	4.7	2.7	0	0
2	65720	0	0	0	26.8	38.9	59.6	58.4	42.6	38.9	21.9	0	0
3	91180	0	0	0	37.1	54.0	82.7	81.0	59.1	54.0	30.4	0	0
4	103920	0	0	0	42.3	61.6	94.3	92.4	67.4	61.6	34.6	0	0
5	49660	0	0	0	20.2	29.4	45.1	44.1	32.2	29.4	16.6	0	0
6	151120	0	0	0	61.6	89.6	137.1	134.3	97.9	89.6	50.4	0	0
7	189410	0	0	0	77.2	112.2	171.9	168.4	122.8	112.2	63.1	0	0

Table 8. **Weighted value of criterion**

Factors	weighted value
Slope	0.16
Land cover	0.06
Soil drainage	0.40
Soil depth	0.25
Texture	0.13
Sum	1
CR	0.09

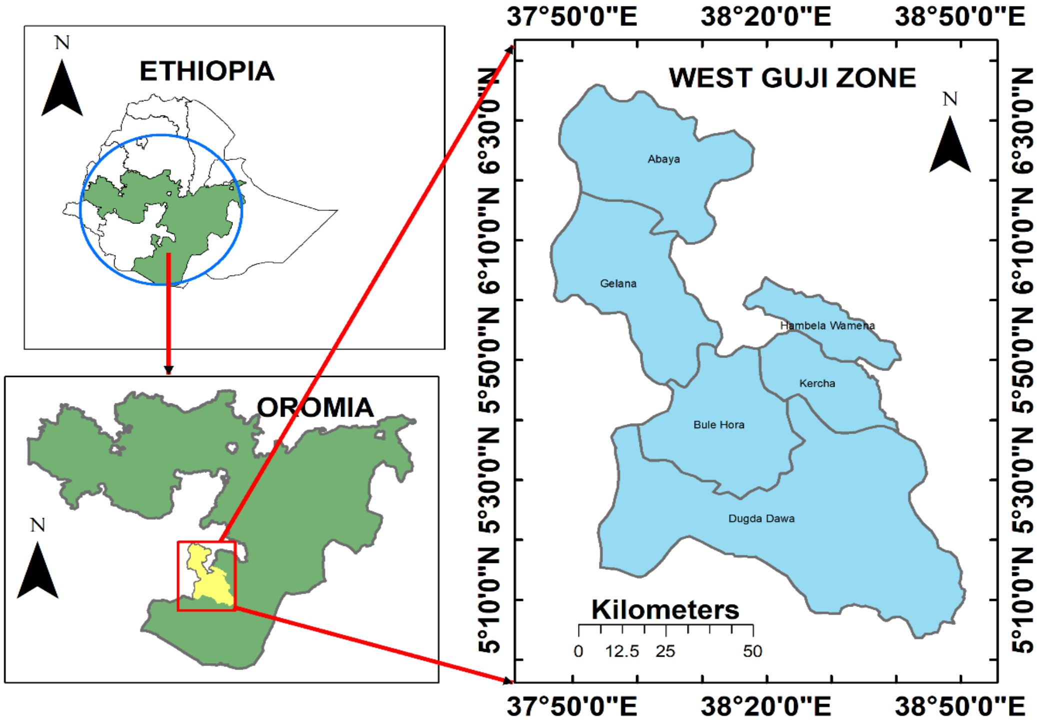


Figure 1. location map of study area.

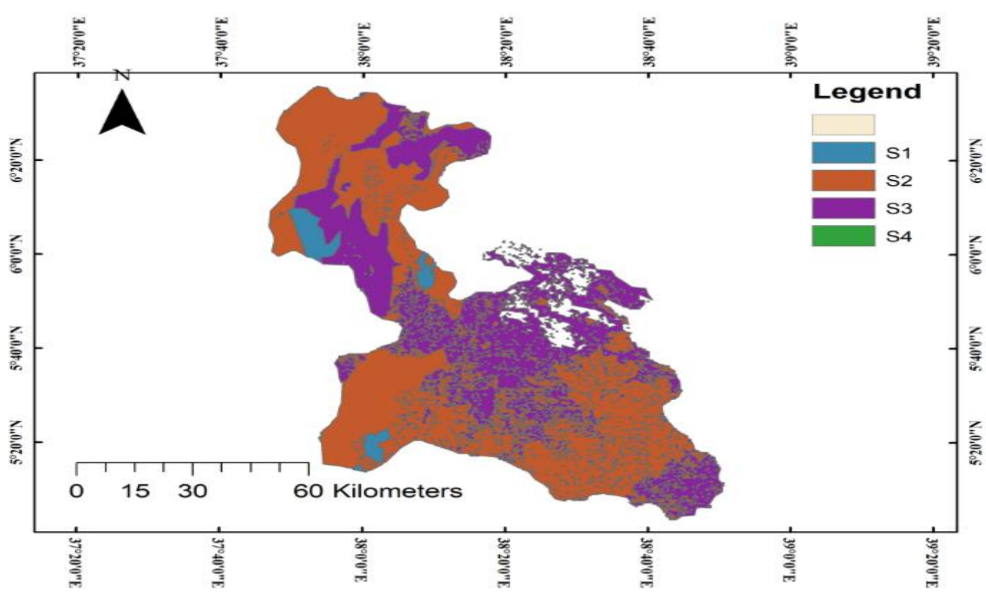
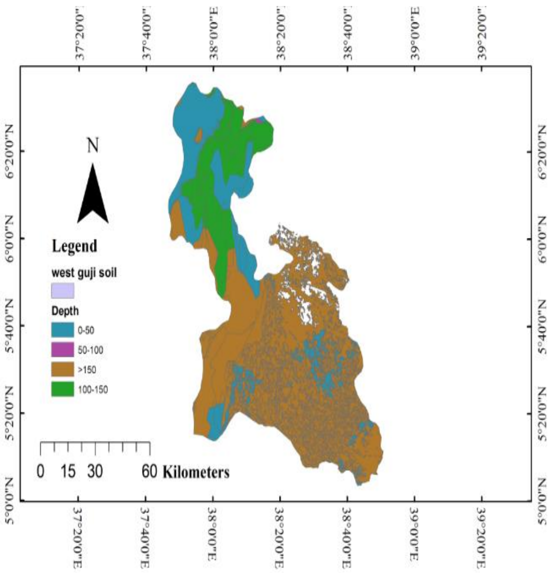
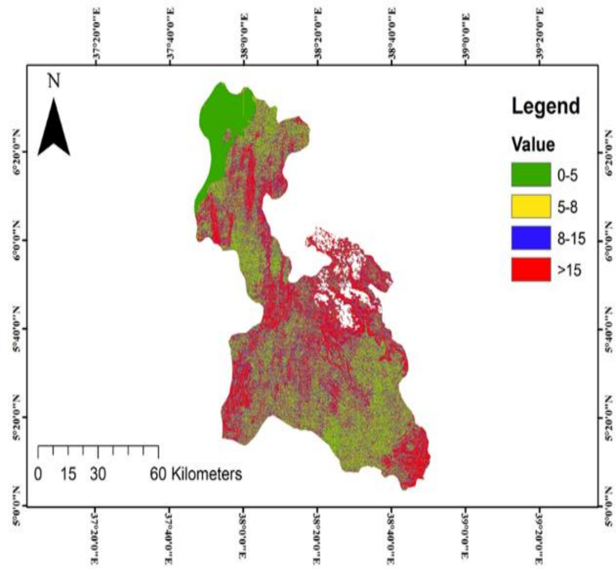


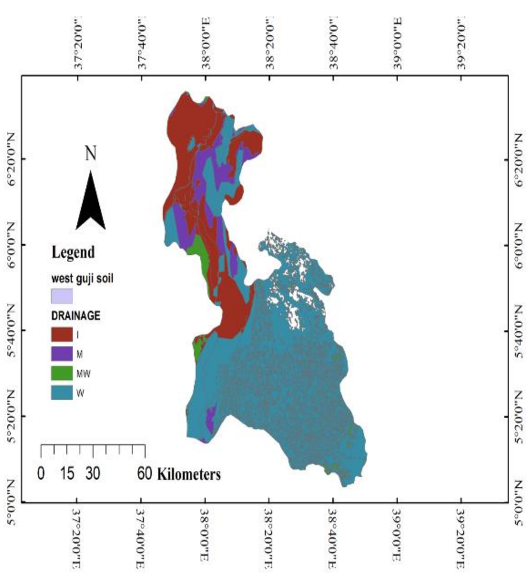
Figure 2. **Over suitability map**


N
Legend
west guji soil
Depth
0-50
50-100
>150
100-150
0 15 30 60 Kilometers

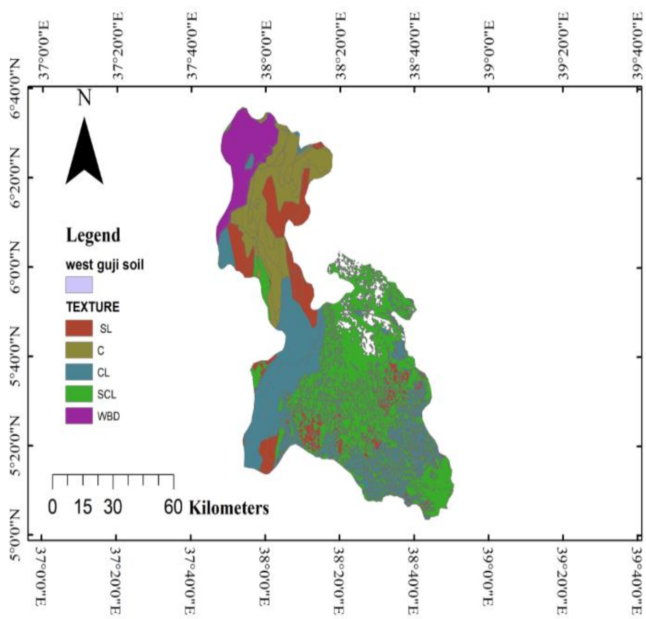
(a)


N
Legend
Value
0-5
5-8
8-15
>15
0 15 30 60 Kilometers

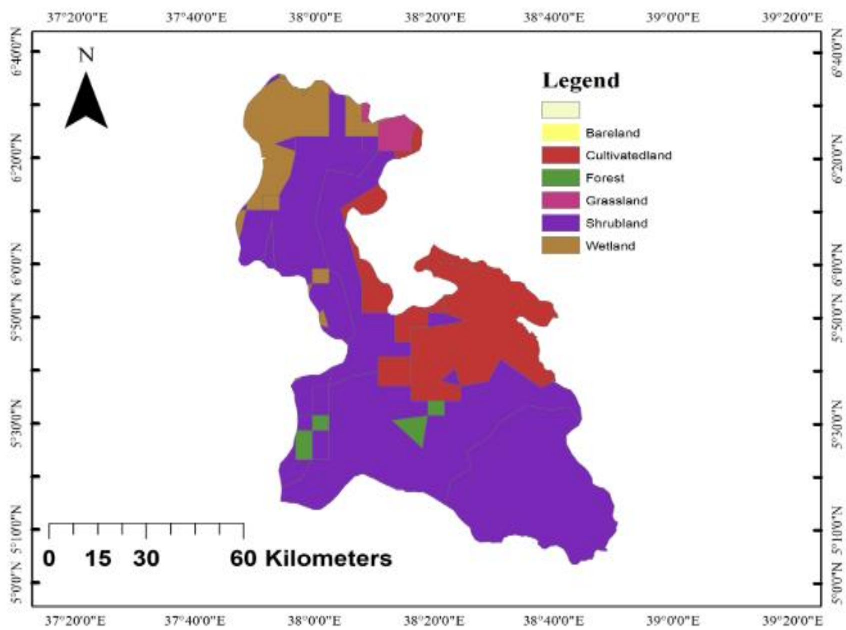
(b)


N
Legend
west guji soil
DRAINAGE
I
M
MW
W
0 15 30 60 Kilometers

(c)


N
Legend
west guji soil
TEXTURE
SL
C
CL
SCL
WBD
0 15 30 60 Kilometers

(d)



(e)

Figure 3. **Land suitability factors, (a) soil depth, (b) slope, (c) drainage, (d) soil texture class, (e) land use land cover.**

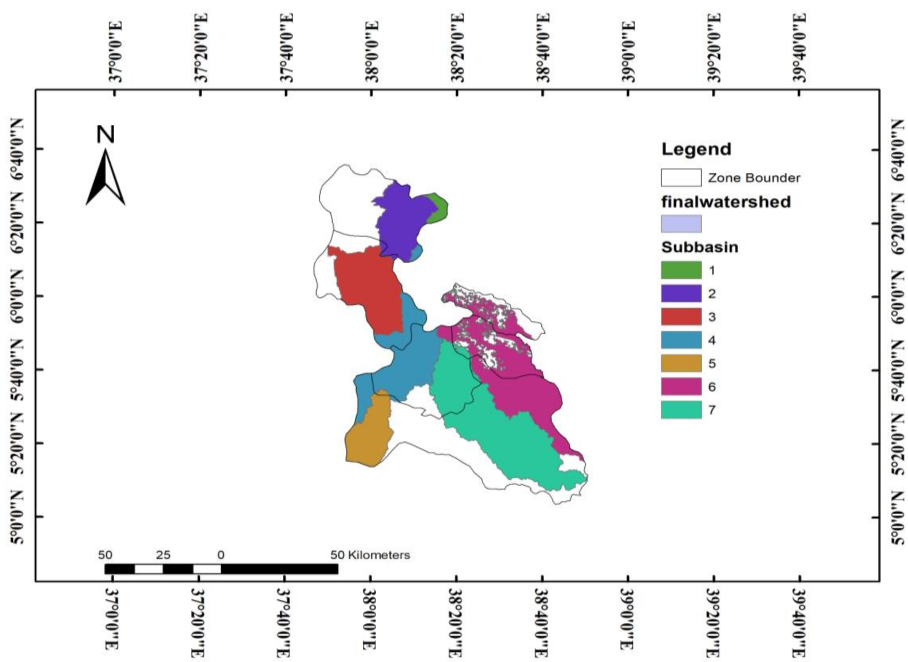


Figure 4. Sub watersheds