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Identification, Characterization and Mapping of Potential Irrigable Areas in Ziway Micro Watershed

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Abstract: Irrigation land suitability assessment and mapping for irrigation purpose is important to utilize the land resources efficiently. This study was initiated to assess, evaluate and develop map of the land resources which is potentially suitable for surface irrigation in ziway micro watershed by using Geographic Information System (GIS). The evaluation of land in terms of the suitability classes was based FAO guideline for land evaluation. Multi-criteria decision evaluation method and suitability factors were used such as, soil data, slope, land use/cover for evaluate the physical land characteristics of the study area of surface irrigation and suitability map was developed. After evaluating the physical land capability for surface irrigation, irrigation suitability map was developed. The weighted overlay analysis gave 70.1 and 13.3% of the study area is lies in the range of very high suitable to marginally suitable for irrigation. Thus, the overall suitability shows that potentially irrigable land suitable for surface irrigation is about 83.4% of the area. Therefore, based on results, farmers, decision makers, investors, planners and policymakers at the local, regional and national levels and the government should invest in those suitable areas for irrigation.

Keywords: Slope, Land Suitability, Suitability Factors, Irrigation Potential, GIS

1. Introduction

Agriculture is the core driver for Ethiopia's growth, development and long-term food security. About 15 to 17 percent of Government of Ethiopia's (GOE's) expenditures are committed to the sector, agriculture directly supports 85 percent of the population's livelihoods, 43 percent of gross domestic product (GDP) and over 80 percent of export value [2].

The development of irrigation and agricultural water management holds significant potential to improve productivity and reduce vulnerability to climactic volatility in any country. Although Ethiopia has abundant rainfall (based on grid-based average annual rainfall and the land area, estimates that Ethiopia receives about 980 billion (~1 trillion) cubic meters (m^3) of rain a year [14] and water resources, its agricultural system does not yet fully benefit from the technologies of water management and irrigation.

In Ethiopia, limited number of reports and investigations were made to assess the irrigation potential based on the physical land and water resources [9]. Small scale studies conducted on soils of the country seem to be inadequate in providing basic soil information that can help to make decision on proper utilization of resources.

The principle purpose of agriculture land suitability evaluation is to predict the potential and limitation of the land for crop production [12]. Agricultural land suitability for irrigation assessment is defined as the process of land performance assessment when the land is used for alternative kinds of irrigations cited in Hoseini [8]. The principle purpose of the agricultural land suitability for irrigation evaluation is to predict the potential land and its limitation for kinds of irrigation methods Abdel Rahman MAE cited in Hoseini [8].

The concept of land sustainability implies the development and implementation of systems of land use, evaluation and management which will sustain individual and community benefits now and in the future. The degradation of land resource,

due to over exploitation and misuse along with consequent economic, social and environmental impacts has intensified the pressure on the land resource of the country [3].

In order to ensure food security, providing comprehensive, reliable and timely information on land suitability is very important for a country like Ethiopia with growing population who largely depend on rain fed and irrigated agriculture for their livelihoods [7]. Land suitability assessment is a valuable tool for land use planning in major countries of the world [11].

Land evaluation is an identification of parcel of land for various land uses (cropping, grazing, and irrigation) which are physically acceptable, environmentally friend and financially profitable [4]; it supports the process of decision-making land to perform based on its potential [15].

Land evaluation, thus, presents itself as a suitable technique for identifying the different land use options for purposes of decision-making at all levels of governance [1]. Land evaluation, using a scientific method, is essential to recognize the potential and limitation of a given land for specific use in terms of its suitability, and certifies its sustainable use. Land suitability assessment plays an important role in maintaining and developing land use on a spatial basis. It identifies the levels and geographical patterns of biophysical constraints and evaluates potential capacity of land and its sustainable use [15].

Future increase in food production to supply a growing population must result from new irrigation projects that should be technically and environmentally well planned. However, new potential lands, suitable for irrigation with good quality of water are scarce resources. It will contribute to local problems of soils for irrigation and providing basic information on the land and sound land management method for irrigation projects. In addition, knowledge and experience which will be gained from this study could be transferred to other similar areas of the country in order to assist the on-going irrigation projects. Therefore, the activity initiated with the objectives of to develop land suitability map of slope, soil, land use/cover, to identify suitable areas for surface irrigation and to generate information on potential land of irrigation in the area.

2. Material and Methods

2.1. Study Area

Ziway micro watershed is located in the mid rift valley, Ethiopia, which covers about 540 km^2. The watershed is located with altitude ranging from 1560 to 1800 m + MSL (mean sea level). The maximum and minimum temperature ranges between 30.2 and 12.8°C.

2.2. Selection of Criteria

Different criteria were selected for evaluating land suitability for irrigation in the study area. These criteria were selected based on extensive literature review of potential factors affecting surface irrigation in the study area.

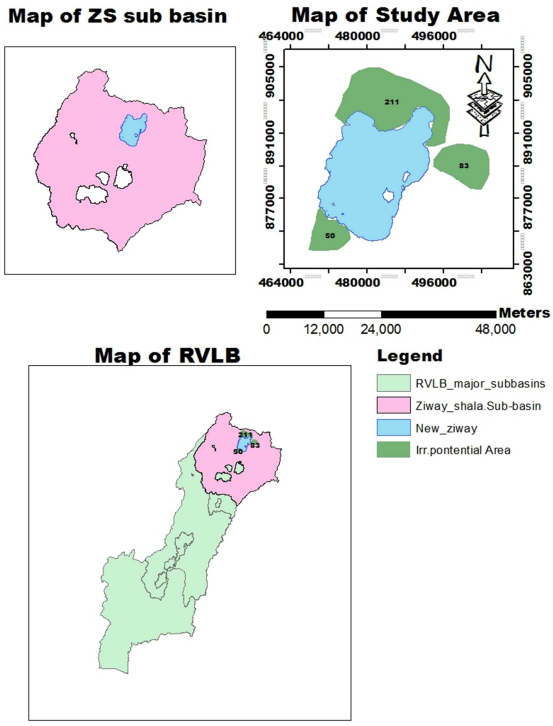

Figure 1. *Study area.*

2.3. Data Sources and Collection

The most important data for this study were soil data extracted from Ethio-Soil, slope was derived from Ethio-DEM 30 meter resolution, and The Landsat 7 ETM 2019 image was used to classify land use land cover of the study area. Data for river or water source was obtained from ministry of water resource.

2.4. Data Preparation for Spatial Analysis

Slope, soil, land use and water source data were aggregated to produce suitability map for surface irrigation in watershed.

2.5. Method of Data Analysis

The soil suitability class's classifications were based on FAO class and soils of the study area were classified in ArcGIS10.2. The suitability classes of the soil type classification were based on the properties and their suitability for surface irrigation.

Landsat 7 ETM+ of 2019 image was used to prepare land use/ cover map of the study area through GIS software. In the process unsupervised classification was used. After classifying land use land cover, suitability classes were determined based on literature and basically FAO guideline.

2.6. Identification of Potential Irrigable Sites

The investigation of suitable sites for surface irrigation was carried out based on slope, soil types and depth of soil, drainage suitability and distance from source to water supply. Further, the slope was classified based on FAO guidelines [5].

The slope suitability classes were identified with highly

suitable, moderately suitable, marginally suitable and not suitable for surface irrigation, respectively. For irrigation suitability analysis the major soil types were identified in the micro watershed.

3. Result and Discussion

3.1. Land Suitability for Potential Irrigation

3.1.1. Slope Suitability Analysis of the Micro Watershed

Based on the analysis of slope were the main evaluation factors for surface irrigation suitability analysis because it affects water flow, the fertility of soil profile, depth of irrigation and drainage of the watershed. By using FAO guidelines FAO, [6] the slope map of the river basin was reclassified into five suitability classes namely: (i) highly suitable; (ii) moderately suitable; (iii) marginally suitable; (iv) suitable; and (v) not suitable.

Slope of study area were identified and mapped. The slopes of study area were classified into 4. 0-2% of slope is covered more area of watershed. 8-15% of slope is covered least area of watershed.

The slopes less than approximately 8% are in general, considered suitable for irrigation development. Slope has a strong effect on the cultivation of crops. As steepness increases, the use of machinery becomes limiting, and establishment and management costs increase as more erosion prevention measures become necessary.

According to Nethononda [10] slopes less than approximately 8% are in general, considered suitable for irrigation development. Slope has a strong effect on the cultivation of crops. As steepness increases, the use of machinery becomes limiting, and establishment and management costs increase as more erosion prevention measures become necessary [16].

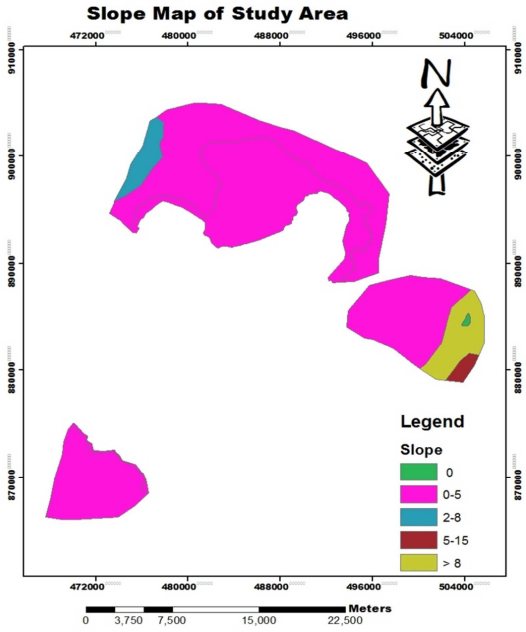

Figure 2. *Slope map of the study area.*

Table 1. *Suitability classes of slope.*

No	Slope range	Code	Suitability classes
1	0 – 2%	S1	Highly suitable
2	2 – 5%	S2	Moderately
3	5 – 8%	S3	Marginally suitable
4	8 – 15%	S4	Not suitable

The result shows that 80.6% of the total micro watershed area is in the range of highly to moderately suitable for surface irrigation (figure 2). The remaining 15.1% of the micro watershed is classified as not suitable for surface irrigation.

As indicated in Figure 2, (highly) suitable represents slope 0-2%, (moderately suitable), represents slope 2-5%, (marginally suitable) represents slope range 5-8% and (currently not suitable) represents slope range 8-15%.

3.1.2. Soil Suitability

The soil suitability analysis was done using the weightage of each factor (slope, soil type, depth and drainage) to obtain potential irrigable sites. The major soil type groups identified in the micro watershed area were Andosols, Fluvisols, Luvisols, Nitosols and Solonetz (figure 3). From Figure 3, it is evident that most of the part of the micro watershed soil is categorized as highly to moderately suitable (85%).

Ziway micro watershed is covered by 5 major soils. Which are Andosols, Fluvisols, Luvisols, Nitosols and Solonetz. Most part of the soils was covered by Andosols followed by Fluvisols.

Major soil of study area were identified and mapped. Soil depth was also considered for evaluate soil suitability for surface irrigation suitability analysis.

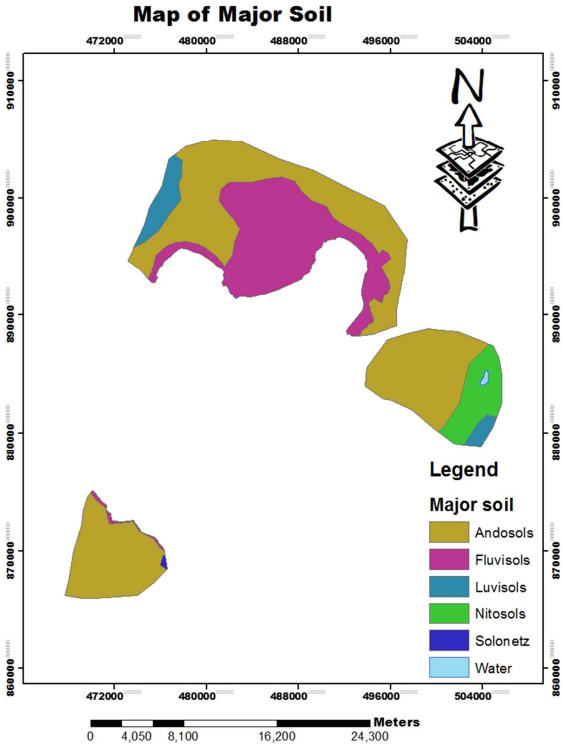

Figure 3. *Soil map of the study area.*

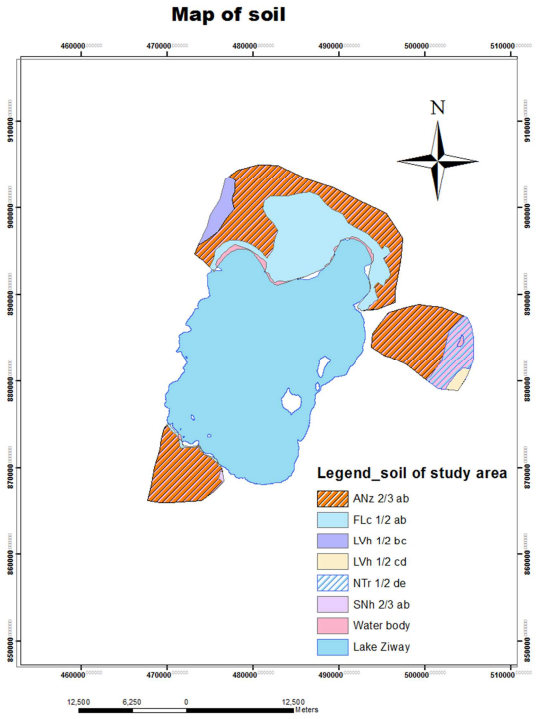

Figure 4. *Soil type map of the study area.*

3.1.3. Land Use Map of the Area

Land use and land cover influences irrigation practice to prepare the land for agriculture. Therefore it was taken as one input for the evaluation of land qualities for irrigation for the area. From satellite image of 2019 unsupervised classification, five LULC classes were identified namely, forestland, scrub/bush land, water body, agriculture and open area.

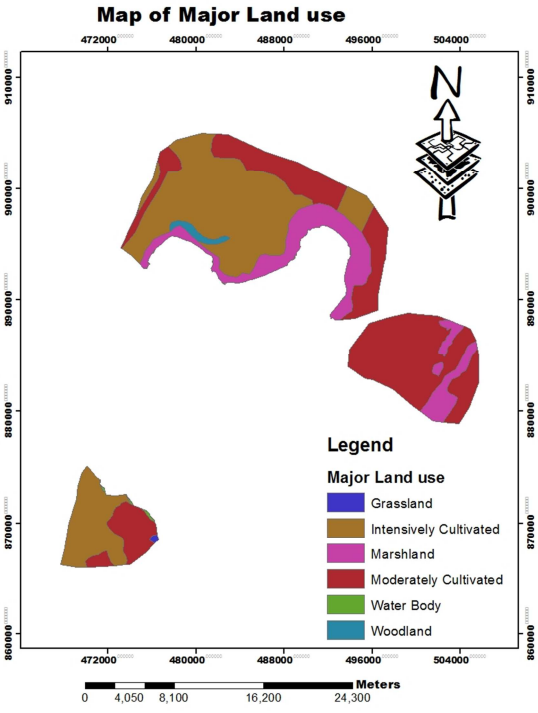

Figure 5. *Land use/land covers map of the study area.*

Major land use of study area were identified and mapped. Ziway micro watershed is covered by 5 major land uses. Which are Grassland, Intensively cultivated Land, Marshland, Moderately Cultivated Land and wood land. Most part of the watershed covered by intensively cultivated followed by MCL. The land use/cover classifications have a strong agreement according to Rahman [13].

As indicated in the Figure, the land use land cover classes of the study area, agricultural land is classified as highly suitable, open areas and shrub/bush land are moderately suitable, forest land is marginally suitable and water body are not suitable for surface irrigation. The decision was made based on literature and the assumption that the agricultural lands can be used to irrigation without limitation and shrub/bush and open areas land can be used with less limitation. The forested area and water body were classified as marginally and not suitable for surface irrigation respectively.

3.2. Surface Irrigation Suitability Area

For potential surface irrigation suitability analysis in the area of micro watershed a multi criteria decision making approach were used. The main physical land resources criteria were soil type, slope, land use /cover and rivers maps of watershed. Then taking slope, land use and river proximity/ distance from the river, weighted overlay analysis was done in Arc GIS10.2.

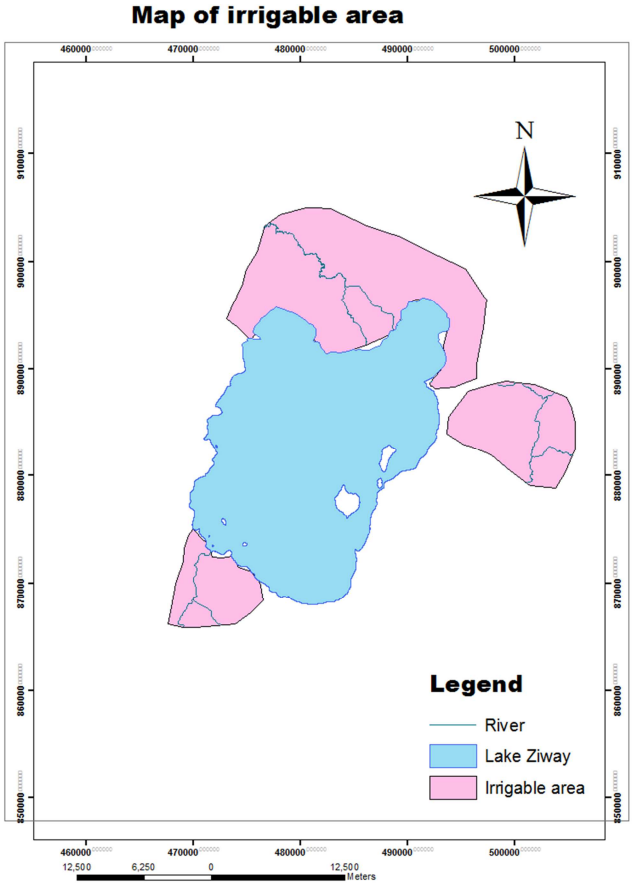

Figure 6. *Irrigation suitability map of the study area.*

Slope was given more weight than river proximity and land use/cover as the most limiting factor for surface irrigation based on the literature. Accordingly in the weighted overlay analysis slope was given 40%, River proximity was given, 30% and land use was given 30%, the suitability analysis model displayed that was used in weighted overlay process.

4. Conclusion

In Ethiopia there are potential lands for irrigation to maximize the productivity of land so as to increase food security of the ever growing population of the country. However, irrigation practice is at lowest level in the country. Therefore, the irrigation potential of the watershed in ziway lake micro watershed was assessed in this study.

The study results indicated that about 70.1% highly suitable and 13.3% marginally suitable of the study area for surface irrigation based on the soil and slope of the area, respectively. The suitability analysis using a weighted overlay of the above factors shows that potentially irrigable land suitable for surface irrigation is about 83.4% of the area.

5. Recommendation

In order to identify the potential areas for surface irrigation soils, slope, land use and water sources were used as criteria and based on all these suitability factors areas suitable for surface irrigation were identified.

Based on the finding the following recommendations were given that the farmers in low laying areas in vicinity to different permanent ground water and rivers can practice surface irrigation and maximize their agricultural productivity.

Acknowledgements

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