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Gis Based Diagonastic Analyis of Doni Sifa Small Scale Irrigation Scheme: In Upper Awash Ethiopia

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Abstract

This study attempted to conduct ArcGIS based diagnostic analysis of Irrigation scheme with intention of introduction of wise use of limited natural resources in case of Upper Awash for irrigation purpose. Experimental site selection criteria were that Boset woreda was one of the most chronically food in-secure districts, availability of secondary data and organizational set up of the irrigation projects. As to the output, simple model to calculate weighted overlay analysis of irrigation suitability was conducted and mapped, and from the map 4454 ha area was identified to be in suitable range for irrigation. Rainfall data records of 10 years (2003-2012) and Awash River stream flow of 21 years (1975-1995) records were adjusted for missing data, checked for consistency by developing double mass curve using three adjacent stations, analyzed for 80% stream flow dependability and was found to be 23.78 m^3/s after giving allowance of 30% to downstream water use right. Finally, crop pattern of the study area was organized in CROPWAT 8.0 model along with necessary data such as climate, soil, and crop, cropping pattern. Maximum irrigation requirement with irrigation intensity of 100% was found to 137.5 mm/month in May from which net scheme supply design was calculated to be 5.67 m^3/s and assuming 80% application efficiency total scheme supply design was found to be 7.1 m^3/s .

Keywords: Diagnostic analysis; Weighted overlay analysis; Irrigation suitability; Scheme supply design

Introduction

In Ethiopia, rainfall is becoming more erratic and unreliable from time to time as a result of global climate change and manmade climate changing factors like that of disturbance of ecosystem, environmental degradation. Most rain falls intensively, often as convective storms, with very high rainfall intensity and extreme spatial and temporal variability. These rainfall patterns affect crop and livestock production and contribute to volatility in food prices, which ultimately affects overall economic development [1].

Oromia national region which is the largest states in Ethiopia with respect to population and areal coverage has relatively better natural set up, but suffering from food insecurity as one third of the region is low land prone to drought. Due to the drought and unreliability of rainfall, Fentale, Boset, Dodota-sire, Merti and Jeju were the chronically food in-secured districts in the region [2-3].

According to IWMI, (2007) due to lack of water storage, large spatial and temporal variations in rainfall, there is not enough water for most farmers to produce more than one time per year and also there are frequent crop failures due to dry spells and droughts which has resulted in a chronic food shortage currently facing the country.

Undoubtedly, irrigation plays an important role in food production, self-sufficiency and security, but potential increase in irrigation water and land resource is limited. Despite the higher risks in rainfed agriculture, it is widely accepted that the bulk of the world's food will continue to come from rainfed systems [4].

Therefore accelerated and sustainable development in agriculture sector needs transformation of rainfed agriculture to be irrigated agriculture. Irrigated agriculture with respect to other inputs like fertilizer etc., can secure food security and food self-sufficiency because it minimize the risk of inadequate and uneven distribution of rainfall and also enhance production of superior crops and growing of crops more than once in a year. Irrigable land and water resources are limited by nature. Better use of these limited resources, during planning and design, strong logistics to diagnostic opportunity and limitation by using integrated approach along with advancing technology like GIS in the field of Irrigation Engineering is needed to optimize the return from the project. So far in Ethiopia, such strong logistics, design and monitoring have received little attention by engineers, planners and policymakers.

Therefore, irrigation project planning and development policies need to become more strategic to bring higher returns from agricultural water as precipitation in rainfed areas is characterized by a low annual rainfall, and for unfavorable distribution over the crop's growing season, with high year-to-year fluctuations. Accordingly, by understanding the risk of rivers' stream discharge fluctuations a result of global climate change and inappropriate water management, selection of the best-fit land use and irrigation type is a pre-requisite for wise utilization of scarce physical resource of land and water. If the land and water resources are not wisely developed and properly managed, widespread and severe environmental and ecosystem disturbance is unavoidable. Not only this, but also community like Doni Sifa small scale irrigation suffers from severe drought and his brother famine from year to year even during good year because of late coming, failure in the middle of cropping season or early stopping of rainfall. This calls for a need to conduct detailed to semi-detailed study available potential of irrigable land, river stream and water management system studies and limitations.

Specific objectives

1. To investigate the suitability of irrigation land

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2. To characterize Awash river stream at or near the study area over cropping seasons
3. To develop optimized scheme design for the land in the acceptable suitability range

Material and Method

Study area

The study area is located in Boset woreda of Oromia Regional state. Boset woreda is found in between 8o25'00"- 8o50'00"N latitude and 39o15', 39o50'E longitude and shares borderlines with Fentale, Adama and Lume districts, Amhara Regional State and Arsi zone. Qombe Gugsa, Sifa Bate and Nura Hasse rural kebeles the specific study area are located in the upper valley of Awash river basin and 33 km North of Sodore town, 52 km from Adama, and 152 km from the capital city of the country, Ethiopia.

Water source and agro-climate of the study area

Awash River is the source of water for Doni Sifa irrigation project. The agro-climatological zone of the anticipated with having mean annual rainfall of 600 mm and with two cropping season namely belg from February to April and meker from June to September. The maximum temperature was observed from 32.4°C to 35°C in the months of February and May while the daily mean minimum temperature was ranging from 10.1°C to 15.6°C in the months of October and July with the mean annual temperature is 22.55°C. The evapotranspiration of the area was estimated as high as 1872 mm per year or 5.10 mm/day.

Materials used in the study

In the processes of land resource investigation, irrigation suitability analysis, Awash River stream analysis and diagnostic analysis of the Doni Sifa irrigation project were summarized in Table 1.

Irrigable land investigation and irrigation feasibility analysis

In delineation of study area, geo-referenced data (easting, northing and elevation) were captured and registered manually following border line of inspected irrigable land within the study area and captured data was converted into appropriate unit from degree; minute and second to only degree in rational form in excel spread sheets. Then appropriate database was established in Arc catalog which was part of AcrGIS.

After appropriate data base was created, the geo-referenced data in spread sheet was imported to Arc catalog where shape file was created. Shape file created on arc catalog was then displayed in Global mapper and there digital elevation model topography map were displayed along with the created shape file.

ArcGIS has edition room or facility to demarcate area of interest but to do so, geospatial analysis extensions should activated. Steps followed to edit were: first, edition tool was selected from tool bar then shape type (line, polyline, polygon etc.) was set according to the need then interconnecting neighborhoods points collected by GPS, displaying assigned labels in the ArcGIS work area. Then the created shape was masked on DEM, exported and saved in created database where it was used as a template for other analysis like area and slope calculation.

Material	Source
AcrGIS 10	Free download from ESR websites
CROPWAT 10	Free download from FAO website
Global mapper 11	download from http://www.globalmapper.com
Soil auger, samplers	Bako Agr. Mechanization Research Center
DEM, satellite image, topography sheet	Ethiopian Mapping Agency
GPS, water flow measuring device	Bako Agr. Mechanization Research Center

Table 1: Materials to be used and their sources.

Irrigation feasibility analysis

In irrigation feasibility analysis main factors are water availability and quality, slope, chemical and physical properties of soil, relative location of the water source for small scale irrigation, buffer area were considered and finally come up with the size of the land that can be brought under irrigation. The factors were reclassified and simple weighted overlay analysis was developed with the aid of ArcGIS 10 model which was displayed as map (Figure 1).

Soils and topography

The area was situated on an undulating alluvial plain with open vegetation. In the area surrounding the project site was affected by gully formation up to 10 m deep could be observed and after some depth the soil profile became sandy. The irrigable area lies between a hill to the north and Awash river to the south and southeast. More than 85% of the command area had slope less than 5%. The soil was mostly medium textured ranging from silt loam to sandy loam. The depth of the soils in the area varies from 3 cm to 16 cm.

The assessment of soils for irrigation involves using properties that are permanent in nature that cannot be changed or modified. Such properties include drainage, texture, depth, salinity, and alkalinity [5]. Even though salinity and alkalinity hazards possibly be improved by soil amendments or management practices, they could be considered as limiting factors in evaluating the soils for irrigation [6,7].

This is, just physically investigated, and some common observations like, general depth, color, combinations along with physical and chemical properties of selected sampling pits were examined and the result is summarized in Table 2.

Slope and size of the study area

The other factors in evaluation of land for irrigation purpose are

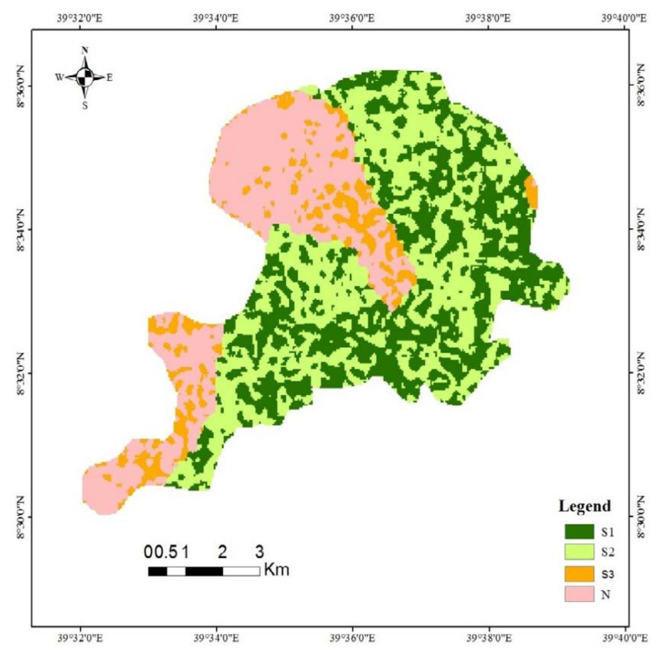

Figure 1: Model for weighted suitability factors analysis and output map.

Pit observed	No. sample	Profile depth (cm)	Location
I	1	0-150	At the beginning of command area
II	2	0-80, 80-170	North part of the command area
III	2	0-100,100-160	Near the boundary of the riverbank
IV	2	0-40, 40-160	At the alluvial part of the riverbank

Table 2: Selected sampling pits.

slope and area. Slope is the gradient of a surface and is commonly expressed as a percent. Slope is important for soil formation and management because of its influence on runoff, drainage, erosion and choice of irrigation types. 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, 2-5% suitable 5-8% marginally suitable for surface irrigation. But slopes, which are greater than 8%, are not generally recommended [8].

Precipitation and stream data analysis

Basically time series data processing was substantially the preliminary step followed in order for the hydrological analysis. In examination, the trend and homogeneity of precipitation and stream data over a season of precipitation in study area, precipitation data for the period of 10 years (2003-2012) were collected from National Metreology Agency of Ethiopia. Collected data can contain errors due to failures of measuring device or the recorder. So, before using the data for specific purpose, the data have to be checked and errors have to be removed. Therefore, simple arithmetic was used to estimate missing information both of rainfall and stream flow data records depending on the variability of the data. The variability of the data was checked by normal ratio method as developed by Paulhus and Kohlar. If the variability of the data is less (Px against Pa, b, c) is less 10% simple arithmetic method can be used to fill the missing data. Therefore, Tibila, Wonji and Below Koka dam stations were used.

$$P_x = \frac{NxP_a}{N_a} + \frac{NxP_b}{N_b} + \frac{NxP_c}{N_c}$$

where Px is precipitation, with missing records at station x and Pa, Pb and Pc were adjacent, Nx, Na, Nb and Nc station's precipitation values for long period of time for x, a, b and c stations. After missing data were filled, consistency of data was checked using double mass curve method and then frequency analysis of data was done

To prepare the stream flow and rainfall data for further application, their consistency was checked using double mass curve analysis. A plot of accumulated discharge/rainfall data at site of interest against the accumulated average at the surrounding stations is generally used to check consistency of stream flow/rainfall data. To check the degree of consistency, the value of coefficient of correlation, Nemec was used [9].

Precipitations data of 21 years (1975-1995) were set in descending order and the ranked and to calculate frequency analysis of stream flow data Weibull plotting formula was used as.

$$P = \frac{m}{N+1} x100$$

The relation between Probability P (%) and return period, T (Years) is:

$$T = \frac{1}{P}$$

Then both for rainfall and stream flow data, design values which 80% of rainfall or stream flow events have a chance of equalizing or exceedance.

Results and Discussion

Irrigable land investigation and slope analysis

In irrigable land investigation, after reconnaissance survey was conducted in the study area, possible irrigable land was delineated through digitization. Then, by clipping the generated shape file by mask to raster data or the so called digital elevation model, the project was enhanced for further analysis. After so doing, an area which was formerly under rainfed agriculture but having potential to be brought under irrigation was calculated along with the slope of which is key determinant in irrigation suitability analysis and method of irrigation to be adopted and the results are summarized in Table 3 and displayed in Figure 2 [10].

A cell or pixel of digital elevation model used was 20 × 20 m^2 and called count. Therefore to calculate the area of interest, counts are multiplied with its number that gave total area. Literally, 6678 ha in study area was in slope range of 0-8% while majority of the area was in the slope range of 0-5 which makes 83% of the total area. For sake of simplicity both rainfed agriculture land and irrigated agricultural land were included into interest area while irrigation suitability analysis was conducted only in rainfed agriculture as all pits developed and soil samples were taken (Table 2) and were out of irrigated area. A total area of 6678 ha was estimated from both irrigated and rainfed agriculture. As indicated, within the study area, there were two canals while the first canal designed to supply irrigation water to 250 ha out of which 195 ha area was developed for the irrigation but presently only 122 ha had been growing actively. The second canal was designed to supply 210 ha but presently supplying water to less than 40 ha only [11].

Therefore regarding slope of the study area 6,516 ha of the land could be brought under irrigation agriculture excluding areas that is

Value	Count (0.04ha)	Area ha	%
0-2%	72582	2903.28	42.7
2-5%	68583	2743.32	40.4
5-8%	25788	1031.52	15.2
>8%	2936	117.44	1.7

Table 3: Summarized information from slope map of the study area.

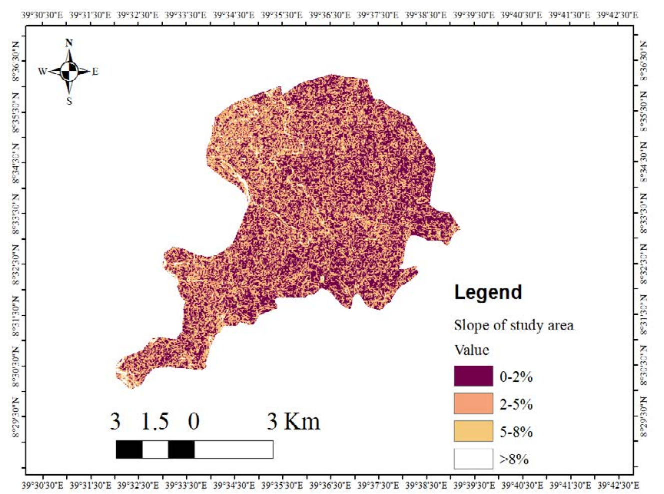

Figure 2: Slope map.

already under irrigation (162 ha); however, elevation and the relative location of water source and its buffer area are also decisive but this problems could be solved through better water abstraction method (gravity or lifted irrigation) and irrigation methods.

Suitability of the study area was categorized as 0-2% which was rated as highly suitable was 42.7% of the total area (2903.28), 2-5% that was rated as moderately suitable with 40.4% of the total area of the study area (2743.32 ha), and 5-8% that was rated as moderately not suitable was 15.2% of the total of the study area (1031.52 ha).

Soil of the study area

As can be seen from soil map, about 80.9% (5402.5ha) of the study area was productive soil of Vitric andosols and Lithosols where as 19.1% (1275.5 ha) of the land was of rocky surface or shallow soil.

Average moisture contents (v/v) at field capacity (FC) and permanent wilting points (PWP) were observed 24.6, 22.5 and 25.51% and 16.8, 17.2 and19.6%, respectively for the three location of the field. The average moisture content at FC and PWP were 20.7 and 14.25% (w/w). The pH was found in the range of 6.7 to 7.4. The pH value of the soil in the experimental site was almost in suitable range for crop production particularly for common crops production. The optimum soil pH for crop production was considered to be 6.5 to 7.0. The bulk density of the plots was 1.08, 1.0 and 1.25 for the three experimental sites and the electrical conductivity was in the acceptable range [12].

The average calcium content of the soil layer was 59, 72.8 and 56.5% for the three pits one to three respectively. The electrical conductivity of the soil of the study area was 0.04 mmhos/cm on average bases. An average organic carbon of the pits developed within the study area was 1.54, 0.33 and 0.57%. Total nitrogen of the soil layer also found to be 0.01, 0.04 and 0.06 on average Cation exchangeable capacity (Meq/100 g) which were 27.12, 24.58 and 27.6 while average phosphorus were 3.44, 6.38 and 13.18 and exchangeable sodium percentage was 1.48%. According all of the parameters could be rated as acceptable.

Location of water diversion points and buffer area

Elevation of water diversion points and its buffer area is also another important parameter in irrigation suitability analysis as it affects water obstruction. With this respect, the possible water diversion points were assessed and measurement at riverbed was observed by GPS. The study area was divided into four zones depending on the relative elevation of Awash river to the elevation of the whole study area [13].

During surveying, it was noticed that water diversion point for the study area, was about 1260 m.a.s.l and the elevation at command area of interest was in the ranges of 1187-1370 m a.s.l., (Figure 3). About 84.7% (5854 ha) of the study area was found in relative elevation range of (1187-1240 m) which could be brought under surface irrigation method. About 10.1% (824ha) of the study area was found to be above 1260 m above s.l.

Missing data and consistency analysis of rainfall data

In rainfall data analysis, Tibila and Wonji rainfall stations had missing rainfall data records as presented in (Table 4).

Therefore, to use this data for further application, missing data values were filled using simple arithmetic mean since rainfall records of all gauging stations did not vary more than 10%. The rainfall at Nura Hera and Below Koka dam station had no missing rainfall data records (Table 5). Tibila and Wonji were stations with missing rainfall data and filled. Similarly the double mass curve analysis of the Nura Hera rainfall stations revealed that the rainfall recorded at the stations are consistent with no significant change of slope on their perspective plots as presented in Figure 4. The correlation factor R2 was very close to 1 which implies that strong and direct relationship exists between adjacent stations (Table 6). This also suggests that the rainfall data recorded at these stations can be used directly for further analysis [14].

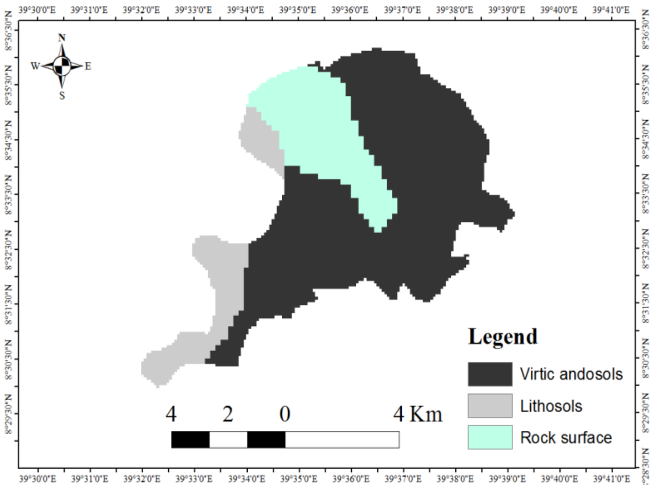

Figure 3: Soil map.

Location	Soil-depth (cm)	pH	Bulk-density (g/cm³)	Ece (ds/m)	FC (%)	PWP (%)	Soil-texture classes
Pit at head	0-20	7.1	1.04	0.66	22.53	14.6	Loam
	20-40	7.2	1.12	0.74	23.49	18.4	Loam
	40-60	7	1.01	0.63	27.78	17.3	Loam
Pit at mid	0-20	6.9	1.1	0.52	22.77	16	silt loam
	20-40	6.8	1.02	0.43	21.39	17.3	silt loam
	40-60	6.7	0.96	0.4	23.37	18.4	silt loam
Pit at tail	0-20	7.4	1.25	0.93	25.51	19.6	Loam

Table 4: Laboratory results of physical properties of soil of the study area.

Frequency analysis of rainfall data of study area

From frequency analysis, annual dependable rainfall at different probability levels along with their return periods were derived for Nura Hera, tibila, Wonji, and Below Koka Dam stations on average bases. 80% of the probability of exceedance was interpolated on monthly base for those stations and presented in Table 7. The design value was determined from the average of 80% monthly dependable rainfall of 10 years (2003-2012) and found to be 42.5 mm/year.

Irrigation need assessment

Rainfall of 10 years (2003-2012), 80% dependable rainfall was derived and from the 80% dependable rainfall effective rain considered as green water was estimated. Using CROPWAT 8.0 model, net irrigation requirement was generated using climate, soil, crop data and crop pattern as input. The processed rainfall data and crop evapotranspiration data (Table 8) of the study area indicated that the rainfall could not satisfy crop evapotranspiration through the year and supplemental irrigation would be needed.

Missing data, consistency and frequency analysis of stream flow data

In stream flow data analysis, Below Koka Dam, Wonji, Nura Hera

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Pit code	Soil parameters										
	CaCO3 (%)	E.C, mmhos/cm	O.C, (%)	T.N (%)	C.E.C (Meq/100 gm)	Av. P (ppm)	Esp (%)	Exchangeable base			
								Na+	K+	Ca++	Mg++
P1	59	0.04	1.54	0.01	27.12	3.44	1.48	0.27	2.4	9.97	3.46
P2	72.8	0.04	0.33	0.04	24.58	6.38	1.48	0.5	2	12.32	3.33
P3	56.5	0.03	0.57	0.06	27.6	13.18	1.48	0.42	2	10.06	3.13

Table 5: Laboratory results of chemical properties of Soil of the study area.

	Year (months) missed data records
Tibila	2003 (Jan-May), 2010 (Feb-Mar, Jul)
Wonji	2004 (Apr-Jun), 2008 (Aug-Nov)

Table 6: Missing data of rainfall.

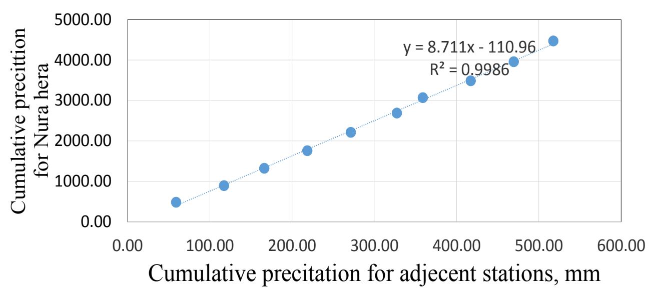

Figure 4: Double mass curve of Rainfall data at *Nura Hera* station.

Months	Jan	Feb	May	Apr	Ma	Jun	Jul	Aug	Sep	Oct	Nov	Dec
80% RF, mm	4.7	3.1	3.9	3.9	3.9	3.7	3.8	3.8	3.8	3.8	3.9	0.2

Table 7: Summary of monthly frequency analysis of rainfall of stations in the study area.

Months	Jan	Feb	May	Apr	Ma	Jun	Jul	Aug	Sep	Oct	Nov	Dec
80% RF	4.7	3.1	3.9	3.9	3.9	3.7	3.8	3.8	3.8	3.8	3.9	0.2
Eff. Rf	4.6	3.1	3.8	3.8	3.8	3.6	3.7	3.7	3.7	3.7	3.8	0.2
Etc,	97.6	47.8	59.4	80.9	137.5	69.5	30.8	60.3	107.6	41.2	77.5	99.1
Deficit	93	44.7	55.6	77.1	133.7	65.9	27.1	56.6	103.9	37.5	73.7	98.9
Note: Dep., dependability, RF, rainfall, Eff. RF, effective rainfall												

Table 8: Monthly deficit of rainfall to evapotranspiration in (mm/month).

stream flow gauging stations had missing stream flow data records as presented in Table 9. Therefore to use this data for further application, missing data values were filled.

To check for the consistency of the stream flow data, double mass curve was developed, and its analysis revealed that the stream flow recorded at the stations are consistent with no significant change of slope on their perspective plots as presented in Figure 5. The correlation factor R2 was found close to 1 which implies that strong and direct relationship exists between adjacent stations. This also suggests that like rainfall data analysis that stream flow data of these stations can be used directly for further analysis.

For steam frequency analysis of flow data Weibull plotting formula was used. 80% monthly probability level of flow were found to be 33.97m^3/s on average bases and considering downstream water use right of 30%, 23.78 m^3/s could be used as design value (Table 10) and Precipitation deficit of the study area was generated by CRPWAT-model (Table 11).

Soil physic-chemical properties and depth

The textures of the soils were classified as loam to silt loam. The soils were generally described as medium textured with range of bulk density of 0.96 to 1.24 g/cm^3. The pH of the soils ranged from 6.75 to 7.39 with sufficient organic matter. The effective depth of soils was in the range of 3 cm to10 cm for existing irrigation. All the selected fields were covered with onion crop. The average lengths of furrows were eight meters with average furrow spacing of 0.6 m. The farmers were applying irrigation water based on their traditional belief (onion gives more yield if watered more). Farmers were applying water regardless of the water requirements of the crop. The average intervals of applying irrigation water for onion on the three fields were 3-4 days.

Gauging station	Year(months) missed data records
Nura Hera	1975 (Jan-Mar), 1986 (Jan-Feb), 1982 (Jul), 1988 (Feb), 1993 (Aug)
Wonji	1992 (Feb-Mar), 1994 (Jun),
Below Koka Dam	1976 (Mar), 1987 (Jul), 1995 (Aug-Dec)

Table 9: Missing Stream Flow Records.

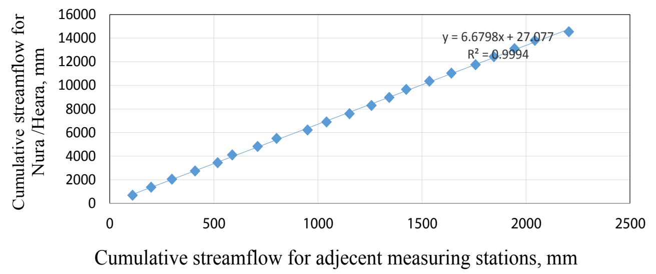

Figure 5: Double mass curve of stream flow of the study area.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
80% monthly dependable flow, m³/s	27.8	28.9	27	29.3	26.6	29.3	41.6	58.7	54.4	33.4	24.7	26

Table 10: Monthly dependable stream flow of Awash river at the study area.

The average moisture contents (v/v) at field capacity (FC) and permanent wilting points (PWP) were 21.15, 22.0 and 24.2% and 17.17, 18.72 and18.47%, respectively for the three fields located at head, middle and tail of the project (Table 10). The pH was found to be in the range of 6.89 to 7. The pH value of the soil in the experimental site was almost in suitable range for crop production particularly for onion production. The optimum soil pH for crop production is considered to be 6.5 to 7.0 (Prasad and Power, 1997).

Crop water requirement, scheduling and irrigation efficiencies for onion

In calculation of crop water requirement (CWR), irrigation water requirement (IWR) and Scheme supply (SS) of the existing irrigation projects and study area, crop area coverage in percent, soil data (soil class, maximum infiltration rate, and soil water holding capacity) and crop data (growing period, desolation, plant water stress response factor, effective root depth and optionally crop height) and cropping

Prec. deficit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Onion	102	9	-	-	-	-	-	-	-	-	-	-
Tomato	116	124.1	78.1	-	-	-	-	-	-	-	86.1	110
Pepper	102	8.5	-	-	-	-	-	-	-	-	68.3	89.3
Maize	127	89.4	2.6	-	-	-	-	-	-	-	72.4	108
S/cane	109	141	151.4	155.7	195.7	186.1	108.7	102	133	120.2	31.3	108
Mango	81	96.9	111.1	19.4	175.6	163.4	89.4	91.5	137.3	139.6	39.1	65.1
Orange	55	66.8	60.3	62	98.9	76.8	15.8	29.5	86.5	99.5	112	98.4
Onion	-	-	53.9	104.4	154.9	22.7	-	-	-	-	83	72.8
Tomato	-	-	-	11.7	81.4	114.9	88	91	57.1	-	-	-
Pepper	-	-	-	47.6	142.2	139.6	5.5	-	-	-	-	-
Maize	-	-	-	4.3	127.6	173.6	57	-	-	-	-	-
Onion	-	-	-	-	-	-	8	66.7	135.5	21.8	-	-
Pepper	-	-	-	-	-	-	12.1	17.8	129.5	140.6	-	-
Net scheme irrigation requirement												
mm/day	3	1.7	1.9	2.7	4.5	2.3	1	2	3.6	1.3	2.6	3.2
mm/month	98	48	59.7	81.3	**138.1**	70.1	31.2	60.5	107.7	41.1	77.6	99.3
Irr. A (%)	100	100	98	100	100	100	100	92	92	80	100	100

Table 11: Precipitation deficit of the study area.

Fields	Depth, cm	pH	BD, g/cm³	ECe, dSm	FC, %	PWP, %	Texture
Field H	0-20	7.21	1.06	0.66	22.61	15.82	Loam
	20-40	7.18	1.15	0.74	22.8	18.41	Loam
	40-60	6.89	1.06	0.64	21.05	17.28	Loam
Field M	0-20	6.9	0.98	0.53	21.95	18.73	silt loam
	20-40	6.75	1.01	0.43	21.41	17.97	silt loam
	40-60	6.91	0.96	0.4	22.62	18.73	silt loam
Field T	0-20	7.39	1.24	0.93	23.52	19.57	Loam
	20-40	7.23	1.03	0.67	24.25	18.98	Loam
	40-60	7.21	1.2	0.54	24.81	17.95	Loam

Table 12: Summary of soil data of existing irrigation.

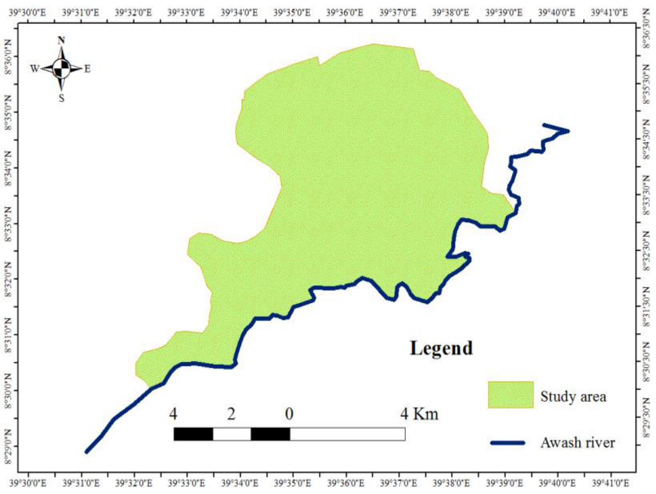

Figure 6: Awash River map.

pattern were used for CROPWAT model. Soil infiltration test was conducted on head and mid location of the irrigation project. Basic infiltration rate was derived from the soil infiltration test data and was found to be 10.9cm/hr. Therefore, the derived value was used as an input for CROPWAT 8.0 model during simulation of crop water requirement, irrigation scheduling and design of scheme supply (Table 12).

Surplus water from steam flow and rainfed farm land

Within the study area, the only source of irrigation water is Awash river and the map of study area and the Awash river is displayed in Figure 6. The important irrigation suitability factors were used in the simple model developed, calibrated and used in weighted overlay analysis of the project suitability (Figure 7). Therefore, after reclassifying, calibrating the weighted overlay analysis was conducted. The result was displayed in Figure 8. So, the weighted effect the determinant suitability factors are rated S1, S2, S3 and N with respective numerical value of 1087.43, 1234.91, 2292.86 and 2062.79 ha with total irrigable land of 4615 ha. Therefore land that can be brought under irrigation: Irrigable Land=LASR–LUSR–IL where LASR stands for land with acceptable suitability range, LUSR stands for land within unacceptable suitability range and IL, for irrigated land. Therefore irrigable land =6678–2062-162=4,454 ha.

In design of the scheme, data of planting, climate, crop and soil, cropping pattern of that particular area were a key factors. The study area is now under rainfed agriculture. Existing cropping pattern cannot be representative for irrigation need assessment as irrigation water need assessment conducted assuming that the study area was brought under irrigation (Figure 9). It is not doubtful that introduction of the irrigation will change the cropping pattern of the area. Having this fact as an input, cropping pattern at Doni irrigation project was taken as representative for the whole study area.

In the study area, there are generally three cropping seasons, two dry seasons (October-February, March-June) and one wet season (July-September). In assessment of irrigation water requirement, crop type and its dominancy in terms of area coverage was taken into consideration along with all relevant soil and crop data.

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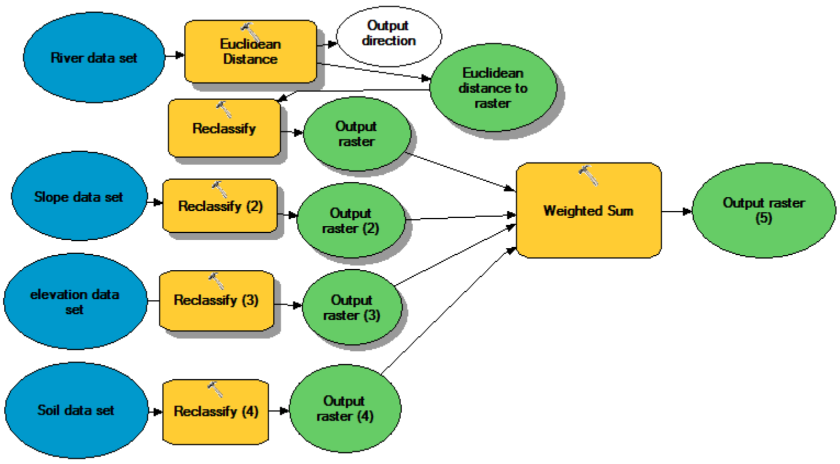

Figure 7: Weighted overlay analysis model.

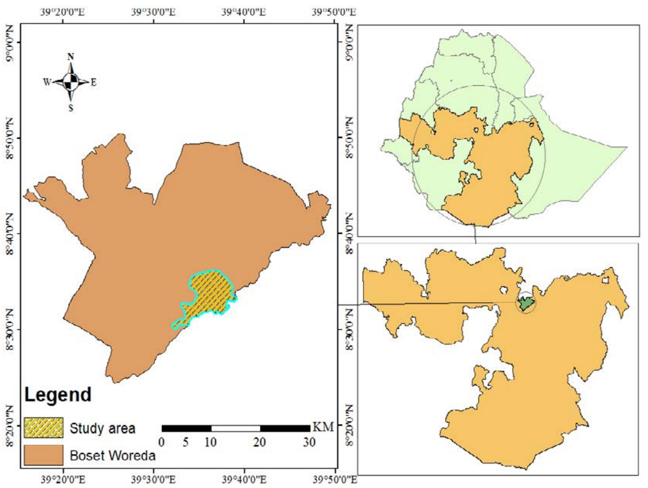

Figure 8: Location map of the study area.

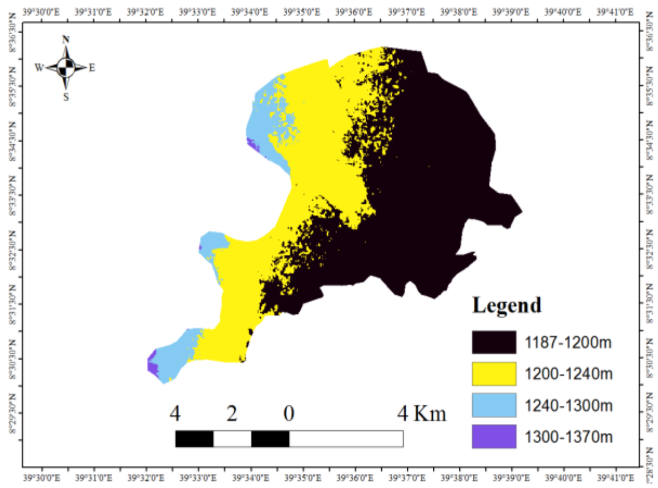

Figure 9: Reclassified relative elevation map of the study area.

Design irrigation scheme

From irrigation land suitability study, 4454 ha was found to be suitable for irrigation in the study area. From characterization of Awash River stream flow through frequency analysis of rainfall and stream flow at 80% probability level was estimated as 42.5 mm/year, 23.78m^3/s. From Table 9, with irrigation intensity of 100% irrigation requirement of the study area was found to be 137.5 mm/month in May allowance and 70% for downstream buffer area regime required.

Q (scheme design supply)= $\frac{AxD}{t}$

Area (A)=44540000 m^2, Water depth (D)=0.1375 m Time (t)= month (10 h working time)

=44540000x0.1375/(30×10×3600)=5.6706 m^3/s

Water availability is 23.78 m^3/s and water need is only 5.6706 m^3/s therefore, water supply is in excess of the water need. Therefore, we can that the availability of water from the river flow (23.78 m^3/s) is far more than the need of irrigation (5.67 m^3/s) of irrigable area (4,454 ha) of the scheme.

Conclusion

In the study area, the finding of this research show that irrigation was absolutely necessary as evapotranspiration was far greater than precipitation even in good year. The investigation on land that could be brought under irrigation was estimated as 4454 ha; however, not necessary for surface irrigation only. Awash River stream analysis near the study area also indicated that water was not the liming factor because the 80% dependable stream of the river was found more than 23.78 m^3/s and was far greater than irrigation requirement.

During observation, it was seen that recently working and failed scheme were not design realistically especially drainage land scape was not given due attention.

Recommendations

1. In the light of increasing national economy and environment protection, planning designing and constructing irrigation projects have comprehensive that show available potential and limitation; the irrigation development also has to be future sensitive.

2. Not only investing huge money in construction hydraulic structure; but also, enhancing farmers with basic skill and knowledge through training and follow up is essential.
3. Assigning DA (development agent) and office assistant for the water use association have a paramount importance to the improvement of irrigation projects and used as a mechanism to develop a healthy perception of farmers about irrigation and capacity build to enhance manage the project has to be given due attention. And close monitoring should be practiced than completely left the operation for the farmers. Especially issues like crop water requirements have to be given much emphasis.
4. The last but not is that the result of genuine research works should have some means to be collected, materialized and communicated to the end user. In this respect, concerned bodies (University, Research Institute etc.,) should have coordination and common data base of research to be shared.

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