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Land Suitability Evaluation For Sorghum Crop in the Ibb Governorate, Republic of Yemen Using Remote Sensing And GIS Techniques

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Abstract: Land evaluation is the process of making predictions of land performance over time based on specific types of uses. These predictions are then used as a guide in strategic land use decision making. Therefore, the primarily traditional bases of land evaluation are soil resource inventories, commonly known as soil surveys. The vital task of land evaluation is to identify the levels and geographical patterns of biophysical constraints and hence, land suitability for a given purpose. This paper presents a spatial modelling procedure for land suitability evaluation of rainfed sorghum crop using available biophysical information. Moreover, this study was undertaken to develop a physical land suitability method using GIS and remote sensing technologies in arid and semiarid ecosystems such as that of Ibb Governorate at Highland region of the southwestern Yemen. It aimed to provide a simple example of how GIS and remote sensing technologies can be applied to detect the types of potential land suitability of agriculture in the study area. In addition, it intended to design an information system for land resource assessment. Accordingly, this study reveals that the nearly 5 % of the study area is highly suitable, 25 % is moderately suitable, 31 % marginally suitable, 24 currently unsuitable as well as 15 % permanently not suitable for the production of sorghum.

Key words: remote sensing, geographic information system, land suitability evaluation.

INTRODUCTION

Land evaluation, as defined by Van Diepen *et al*. (1991) and Rossiter (1996), is the process of making predictions of land performance over time based on specific types of uses. These predictions are, then, used as a guide in the strategic land use decision making. Therefore, the primarily traditional bases of land evaluation are soil resource inventories, commonly known as soil surveys. These have been conducted for more than a hundred year period in Russia, the USA and Hungary, and for a period of, at least, fifty years in most of the other parts of the world (Bouma *et al*. 1999, Yaalon & Berkowicz 1997, Zinck 1995). Soils are affected by landforms, and through their developmental accessions and features, they in turn influence geomorphic evolution (Schaetzl & Anderson 2005). In addition, according to Bibby *et al*. (1991) and Klingebiel (1991), they were initially used mainly to support rural land use decision making, in particular decisions regarding the matching of production systems (crops, varieties, rotations, fertilization and other land practices, conservation measures) to soil types. This support became a system in the land capability approach where soil types were grouped into general classes of land use based on their ability of sustainability. The degree of suitability for a land use, regardless of the economic conditions, is indicated by a physical suitability evaluation (Rossiter & Van Wambeke 1997). Thus, the process of land suitability classification is the assessment and categorization of specific areas of land in terms of their suitability for defined uses (FAO 1976). Overall, land evaluation, as defined by Beek (1978), is a process of matching a series of selected land qualities and comparing them with land use requirements. The ever increasing demands for increasing food grain production could be met through systematic survey of the soils, evaluating their potentials for wide range of land use options and formulating land use plans which were economically viable, socially acceptable and environmentally sound (Sathish & Niranjana 2010). The evaluation of the suitability of a territory to a given crop is a complex multidisciplinary procedure. Many of suitability evaluation procedures in use are adaptations to the local conditions of the Framework for Land Evaluation FAO (1976), and focus on the severity of land

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limitations related to crops and land use. The distinction between the classes is based on the rise of the costs for the reduction or elimination of these limitations (Madrau *et al*. 2009). Thus, generated data is integrated in GIS to obtain different thematic information for using in land evaluation techniques.

The use of remote sensing techniques has become increasingly important in describing a variety of satellite-derived data sets and their application to understand changes in the landscape (Kouchoukos 2001). The traditional methods of survey are time- consuming, labor-intensive and expensive to generate data. With the advent of remote sensing the database generation became fast, cost effective and reliable (Sathish & Niranjana 2010). Since land suitability analysis requires the use of different kinds of data and information (soil, climate, land use, topography, etc.), the geographic information system (GIS) offers a flexible and powerful tool than conventional data processing systems, as it provides a means of taking large volumes of different kinds of data sets and manipulating and combining the data sets into new data sets which can be displayed in the form of thematic maps (Foote & M. 1996, Marble & Amundson 1988). The topographic characteristics, the climatic conditions and the soil quality of an area are the most important determinant parameters of the land suitability evaluation. The use of GIS allows the construction of models from which a new thematic map (e.g. land suitability map) can be produced from a set of thematic maps. (Harasheh 1994). Other uses of GIS include efficient storage, management, and analysis of spatial and non-spatial data (Giap *et al*. 2005, Kapetsky *et al*. 1987, Rajitha *et al*. 2007). In addition, GIS functions help to manage spatial data and to visualize evaluation results (Chen *et al*. 2003, Liu *et al*. 2005, Wu *et al*. 2004). Thus ,generated data is integrated in GIS to obtain different thematic information for using in land evaluation techniques. The combined use of remote sensing and GIS provides better prospects of environmental monitoring and forecasting over wider areas within a limited time span (Singh 2000).

The basic soil data and information on soil suitability of crops were lacking to take up proper planning in the study area. It is necessary to evaluate the soil in a given agro-ecological unit for crop production under defined management system (Rasheed & Venugopal 2009). Accordingly, specific soil survey was, thus, carried out to support the land evaluation. Hence, in the present investigation, potentials and limitations of soils were assessed using satellite data along with conventional field survey. The basic data on soils was, then, used for studying the land suitability for sorghum crop using FAO approach (1976) in a GIS environment. The FAO framework (1976) to the land evaluation was used in the present study to know the consequences of applying the specified management to a particular parcel of land so that a choice could be made from the alternatives.

The present study was undertaken to develop a new qualitative land suitability method using GIS and remote sensing technologies in arid and semiarid ecosystems such as that of IBB Governorate at Highland region of the southwestern Yemen. It aimed to provide a simple and humble example of how RS and GIS techniques can be applicable to detect the types of potential land suitability for agriculture of the study area. Besides, to design of an information system for land resource assessment. The paper will identify the kinds of data input into GIS and how this data are used to produce useful interpretive maps

MATERIALS AND METHODS

IBB Governorate (the study area) is situated in the southwestern part of the Highland Region of Yemen, between 360,000m-460,000m E and 1,500,000m-1,600,000m N (43º40’-44º37’ and 13º45’-13o25’). It is defined as that section of the southwestern highlands, with a distance of about 200 Km from the Sana’a, the capital of Yemen, (Figure 1) with total population of 2,131,861 inhabitants. The present study was conducted in an area about 5300 km^2, during 2008. The elevation ranging between 500 and more than 3000m above the sea level. It is considered as one of the most important rainfed agriculture in the highland region, and could be defined as an area that depends basically on rainfall water and partly on irrigation systems for crop production and was developed since many centuries based on intricate systems of man-made terraces. To be more specific, the study area is located in semi-arid zone. Annual rainfall generally varies between 300 and 900 mm, with some years having exceptionally high rainfall exceeding 1200 mm. The average total amount of potential evapotranspiration is estimated at 1450 mm/year. The mean monthly maximum temperature varies between 23.4ºC during the cold months and 28.9 ºC during the warm month of June. The mean monthly minimum temperature varies between 5.5 ºC during winter and 12.8 ºC during the wet month of July. The normal growing period for the study area lasts 170-190 days from April until October with sometimes a relatively dry interval of about two decades during June. The mean daily relative humidity varies between 68 to 76 %. The average number of sunshine is 6.3 hr/day during July-August and 7-9 hr/day during the other months of the year.

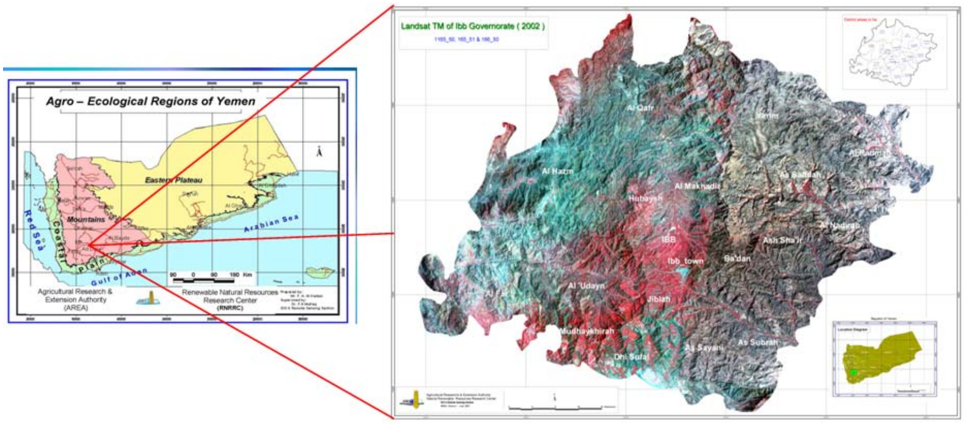


Fig. 1: Location diagram of the study area.

Most of the study area is of Tertiary and recent Quaternary Volcanic origin, through old cretaceous, Jurassic and Precambrian Sedimentary and Basic Rocks might outcrops locally. The morphological features of the whole country as well as the study area formed largely as a result of the tectonic and volcanic activities period (Van der Gun *et al*. 1995). The agriculture in the study area uses traditional to semi-mechanized techniques and equipment. The power supply is usually tractors. Rainfall water is the main water resource of the region where gravity irrigation is predominant. The following methods and materials were used and followed.

This study used a satellite remote sensing Landsat-5 TM, acquired June 2001 with spatial resolution of 30 meters on June 2001 and Topo. sheets 1:50,000 scale. The digital data were processed for geometric and radiometric corrections using ERDAS image processing software. Later a standard false color-composite image was generated using Landsat TM band 4, 3 and 2 (visible and near infrared images). A number of softwares such as Arc GIS version 9.0, ERDAS Imagine version 9.1, Microsoft office processing tools (Excel, word) and capture software. The study was applied both visual and digital Landsat image interpretation in order to generate soil, land use and land degradation maps respectively. The field equipment and tools used for fieldwork includes soil auger, Garmin 12 XL (GPS) receiver, slope meter, Digital Camera, Munsell color chart (USDA 1994), soil knife, hammer, shovel, 30 meters measuring tape and pH and EC kits.

Methodology:

Basically, the research methodology consists of office study (pre and post-fieldwork) and actual fieldwork survey for investigation and data collection. The pre-fieldwork phase involved review of published literature such as books, technical reports and journals. Internet explorer was used to look for relevant data to consolidate land resources theme, besides, visiting the concerned institutions and all stakeholders involved with land resources issues. The fieldwork survey was carried out to investigate land resources across the study area. In this phase, the semi-detailed soil survey was carried out, where numerous ground observations were carried out to map the soils, classify, identify their main properties and distribution using soil pits which were normally dig down up to 150cm depth. Data sheets were used to record the soil information and characteristic. 96 soil profiles and around 60 auger and mini pits observations were conducted during this fieldwork to determine soil properties and to check the boundary of soil mapping units. At each soil site, a GPS reading was used to pinpoint the locations. The soil observations were made at regular intervals along east to west and south to north to investigate soils on the different land units. Each soil site and observation includes a description of site (parent materials, landform, land element, topography, vegetation and land use), and information on the soil (texture, drainage, depth, color, surface stones, human interference, etc.). The soil profiles were described according to the FAO guidelines for soil description (FAO 1976). The soils classified according to the Soil Taxonomy of United States Department of Agriculture (USDA 2003) and correlated with the World Soil Reference Base (FAO *et al*. 1998). The soil was classified to the family level. All soil profiles were sampled by horizons for chemical analysis. A total number of 341 soil samples from the 96 soil profile were collected. All soils samples were delivered to the laboratory of Renewable Natural Resources Research Center (RNRRC)/AREA for physical and chemical analysis.

During the post-fieldwork phase all data and information gathered from the field survey were organized to be analyzed and graphically represented in tubular and graphic forms. For thematic maps production, methodology used in this research consists of: (a) analysis of satellite data, (b) use of available GIS softwares (c) preparation of thematic maps such as Digital Elevation Model (DEM) (based on topographic data and grid format at 90m contour interval), slope map (slope classes are established in accordance with the Guidelines for Soil Profile Description by FAO (2006), soil map (Based on all profiles description and observations data available for the soil mapping units together with the analytical data), land use map, land degradation map (which produced based on interpretation and classification of the previously mentioned satellite image in conjunction with topo sheets) and rainfall distribution, (d) generation of land suitability evaluation map for the selected sorghum crop, and (e) calculation of area under different suitability classes. The conceptual framework of overall methodology followed is illustrated in Figure 2.

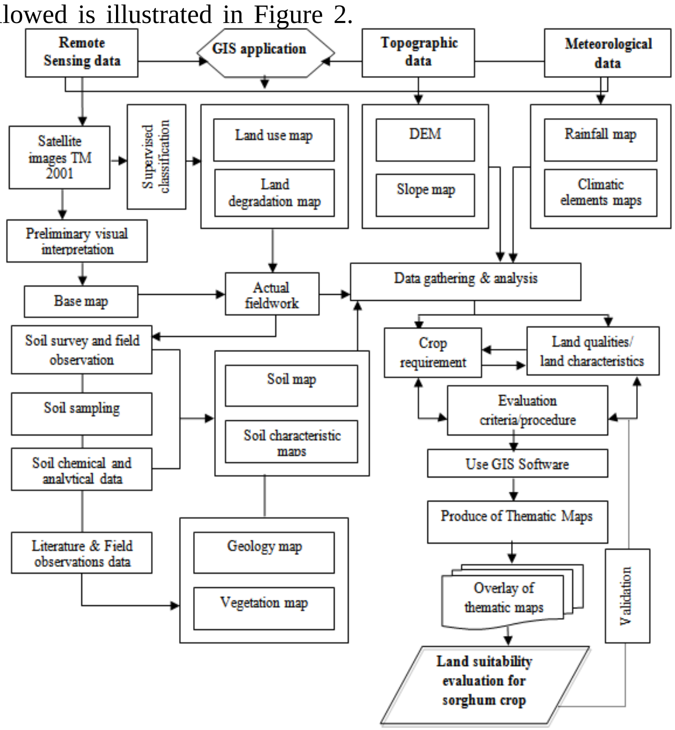
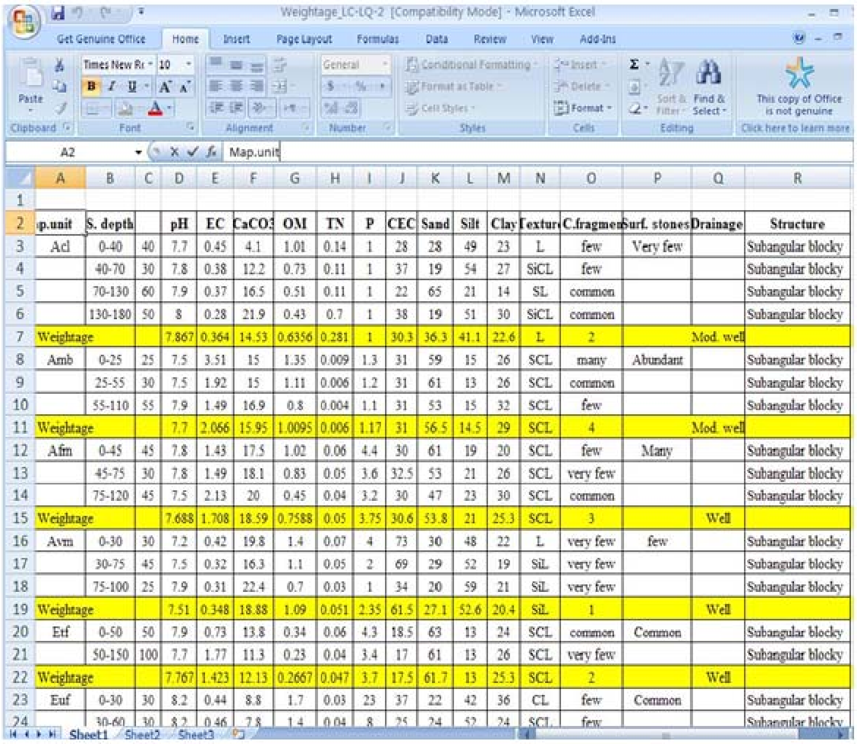


Fig. 2: Conceptual framework of the research methodology.

Model Construction:

The land suitability model was constructed using GIS capabilities and modelling functions. The ESRI ArcGIS application was selected for this purpose due to its wide prevalence in environmental applications. The Model Builder is an ESRI tool that assists the creation and management of spatial models which are automated and self-documenting. According to ESRI (2000), a model is defined as a set of spatial processes, such as overlay, in which the input data are converted into an output map. The advantage of the spatial model in the Model Builder is easy to build, run, save and modify. The GIS Model Builder was used to organize and integrate spatial processes to model the land suitability in the study area. Soil, climate, erosion hazard and slope are factors which are important for land suitability for the selected crop in the study area. Those factors were integrated into the GIS environment as information layers and, then, overlaid to produce overall land suitability assessment of land utilization type. The land suitability evaluation for the study area based on the FAO framework was developed. A number of land qualities and land characteristics were selected and placed into four groups, namely; climate, soil, erosion hazard and topography. However, the variables were selected as basic parameters for land evaluation involved soil depth, pH, electric conductivity, calcium carbonate, organic matter, total nitrogen, available phosphorus, cation exchange capacity, soil texture, surface stones and drainage (Figure 3).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2	p.unit	S. depth		pH	EC	CaCO3	OM	TN	P	CEC	Sand	Silt	Clay	Texture	C.fragmen	Surf. stones	Drainage	Structure
3	Acl	0-40	40	7.7	0.45	4.1	1.01	0.14	1	28	28	49	23	L	few	Very few		Subangular blocky
4		40-70	30	7.8	0.38	12.2	0.73	0.11	1	37	19	54	27	SiCL	few			Subangular blocky
5		70-130	60	7.9	0.37	16.5	0.51	0.11	1	22	65	21	14	SL	common			Subangular blocky
6		130-180	50	8	0.28	21.9	0.43	0.7	1	38	19	51	30	SiCL	common			Subangular blocky
7	Weightage			7.867	0.364	14.53	0.6356	0.281	1	30.3	36.3	41.1	22.6	L	2		Mod. well	
8	Amb	0-25	25	7.5	3.51	15	1.35	0.009	1.3	31	59	15	26	SCL	many	Abundant		Subangular blocky
9		25-55	30	7.5	1.92	15	1.11	0.006	1.2	31	61	13	26	SCL	common			Subangular blocky
10		55-110	55	7.9	1.49	16.9	0.8	0.004	1.1	31	53	15	32	SCL	few			Subangular blocky
11	Weightage			7.7	2.066	15.95	1.0095	0.006	1.17	31	56.5	14.5	29	SCL	4		Mod. well	
12	Afm	0-45	45	7.8	1.43	17.5	1.02	0.06	4.4	30	61	19	20	SCL	few	Many		Subangular blocky
13		45-75	30	7.8	1.49	18.1	0.83	0.05	3.6	32.5	53	21	26	SCL	very few			Subangular blocky
14		75-120	45	7.5	2.13	20	0.45	0.04	3.2	30	47	23	30	SCL	common			Subangular blocky
15	Weightage			7.688	1.708	18.59	0.7588	0.05	3.75	30.6	53.8	21	25.3	SCL	3		Well	
16	Avm	0-30	30	7.2	0.42	19.8	1.4	0.07	4	73	30	48	22	L	very few	few		Subangular blocky
17		30-75	45	7.5	0.32	16.3	1.1	0.05	2	69	29	52	19	SiL	very few			Subangular blocky
18		75-100	25	7.9	0.31	22.4	0.7	0.03	1	34	20	59	21	SiL	very few			Subangular blocky
19	Weightage			7.51	0.348	18.88	1.09	0.051	2.35	61.5	27.1	52.6	20.4	SiL	1		Well	
20	Etf	0-50	50	7.9	0.73	13.8	0.34	0.06	4.3	18.5	63	13	24	SCL	common	Common		Subangular blocky
21		50-150	100	7.7	1.77	11.3	0.23	0.04	3.4	17	61	13	26	SCL	very few			Subangular blocky
22	Weightage			7.767	1.423	12.13	0.2667	0.047	3.7	17.5	61.7	13	25.3	SCL	2		Well	
23	Euf	0-30	30	8.2	0.44	8.8	1.7	0.03	23	37	22	42	36	CL	few	Common		Subangular blocky
24		30-60	30	8.2	0.46	7.8	1.4	0.04	8	25	24	52	24	SCL	few			Subangular blocky

Fig. 3: Database for Soil types

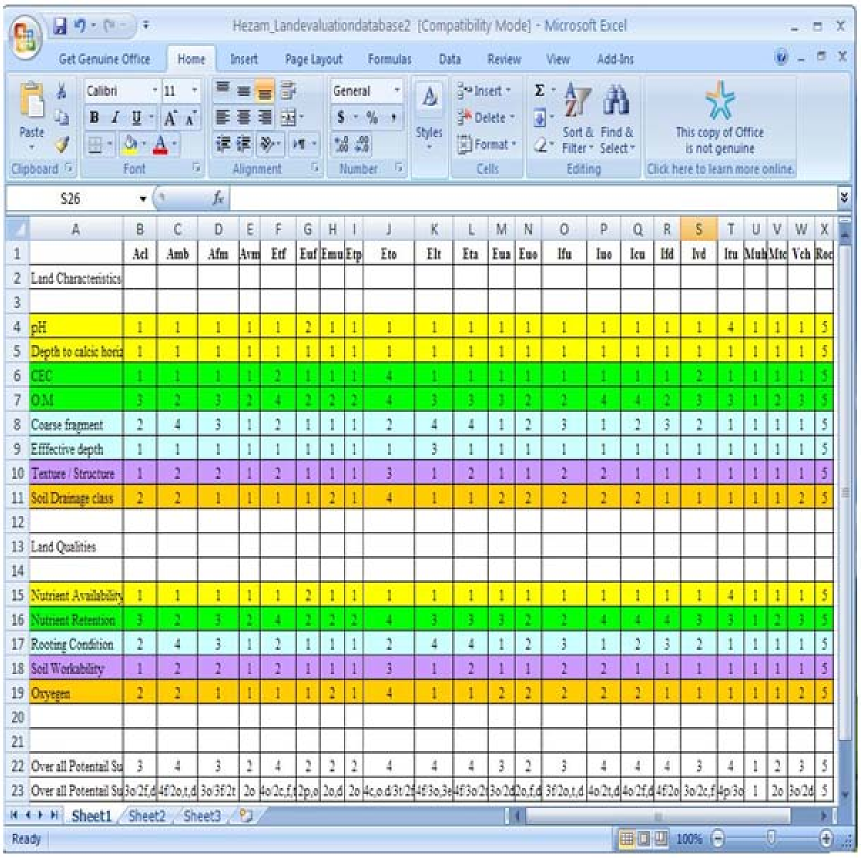
Matching land use requirements with land natural resources is an essential part of land suitability classification. The manual matching procedures involve many repetitive calculations. This approach can, therefore, take a time if a large number of alternatives are to be compared. Furthermore, manual suitability assessments are time-consuming and are likely to produce errors (Sahibin & Adams 1998). Therefore, the application of an automated method of land evaluation comes as a natural development. Computers have been applied to land evaluation at many different levels. One of the most significant developments has the integration of GIS within the land evaluation process (Table 1).

Table 1: Crop requirements for sorghum, general (Sorghum bicolour)

	CLASSES AND DEGREES OF LIMITATION					
		S1	S2	S3		N
RATING SCALE	100 95	95 85	85 60	60 40	40 25	25 0
		Climatic requirements (during growing season)				
Rainfall (mm)	500-700	400-500 700-900	300-400 > 900	150-130	-	< 150
Mean temperature (°C)	24-26	21-24 26-32	18-21 > 32	15-18	-	< 15
Relative humidity %	VL, LL, MM	MH	-	VH	-	-
		Soil requirements				
Drainage	WE	MW	IM	POa	POd	PO
Depth (cm)	>100	80-100	50-80	30-50	-	< 10
Texture	SiL,L,CL	SiCL,SCL	SiC,C	LS	-	S
Coarse fragment (%)	0-3	3_15	15-35	-	-	> 50
PH (H2O)	6.0-7.0	7.0-8.2	8.2-8.3	8.3-8.5	-	> 8.5
CEC (cmol/kg)	> 24	16-24	> 16	-	-	-
OC (%)	> 0.8	0.4-0.8	< 0.4	-	-	-
ECe (dS/m)	0-4	4_8	8_12	12_16	16-20	> 20
ESP	0-10	10_20	20-28	28-35	-	> 35
$CaCO_3$ (%)	3_20	20-30	30-45	45-75	-	> 75
Gypsum (%)	0-3	3_5	5_10	10_20	-	> 20

Source Adopted from Wen (1997).

The land suitability evaluation for sorghum crop was performed based on the parametric approach of FAO (1976). The evaluation was carried using several parameters, wherein every soil mapping unit was rated as per limitation technique. The criteria used in assessing soil suitability for sorghum crop is shown in Figure 4, which indicates that the suitability analysis was calculated in a spreadsheet model, The overall suitability of the soil was determined based on the degree and the number of limitations for a particular unit. The suitability classes were, then, used in Arc GIS software to generate land suitability maps and area statistics.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1		Acl	Amb	Afm	Avm	Etf	Euf	Emu	Etp	Eto	Elt	Eta	Eua	Euo	Ifu	Iuo	Icu	Ifd	Ivd	Iru	Muh	Mtc	Vch	Roc
2	Land Characteristics																							
3																								
4	pH	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	5
5	Depth to calcic horiz	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5
6	CEC	1	1	1	1	2	1	1	1	4	1	1	1	1	1	1	1	1	2	1	1	1	1	5
7	OM	3	2	3	2	4	2	2	2	4	3	3	3	2	2	4	4	2	3	3	1	2	3	5
8	Coarse fragment	2	4	3	1	2	1	1	1	2	4	4	1	2	3	1	2	3	2	1	1	1	1	5
9	Effiective depth	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	5
10	Texture / Structure	1	2	2	1	2	1	1	1	3	1	2	1	1	2	2	1	1	1	1	1	1	1	5
11	Soil Drainage class	2	2	1	1	1	1	2	1	4	1	1	2	2	2	2	2	1	1	1	1	1	2	5
12																								
13	Land Qualities																							
14																								
15	Nutrient Availability	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	5
16	Nutrient Retention	3	2	3	2	4	2	2	2	4	3	3	3	2	2	4	4	4	3	3	1	2	3	5
17	Rooting Condition	2	4	3	1	2	1	1	1	2	4	4	1	2	3	1	2	3	2	1	1	1	1	5
18	Soil Workability	1	2	2	1	2	1	1	1	3	1	2	1	1	2	2	1	1	1	1	1	1	1	5
19	Oxyegen	2	2	1	1	1	1	2	1	4	1	1	2	2	2	2	2	1	1	1	1	1	2	5
20																								
21																								
22	Over all Potentail Su	3	4	3	2	4	2	2	2	4	4	4	3	2	3	4	4	4	3	4	1	2	3	5
23	Over all Potentail Su	3o/2f,d	4f2o,t,d	3o/3f/2t	2o	4o/2c,f,t	2p,o	2o,d	2o	4c,o,d/3t/2f	4f/3o,3e	4f/3o/2t	3o/2d	2o,f,d	3f/2o,t,d	4o/2t,d	4o/2f,d	4f/2o	3o/2c,f	4p/3o	1	2o	3o/2d	5

Fig. 4: Spreadsheet Model for land suitability assessment

The land suitability model was developed using a weighed overlay method in the GIS to produce a land suitability classification in the study area. The final step in the process is to allow these weighting values to be varied, both to investigate model sensitivity, and also to allow the deviation of the final model configuration. The final land suitability results are presented and assessed for previously mentioned thematic maps (Figures 5 and 6).

RESULTS AND DISCUSSION

The weighted overlay technique was used to produce the land suitability for sorghum crop (Figure 3. This approach is a technique for applying a common scale of values to diverse and dissimilar input in order to create an integrated analysis. The weighted overlay process allows for the consideration of geographic problems which may often require the analysis of different factors such is the case with land suitability analysis. These factors may not be equally important. The weighted overlay approach allows different weights to be applied to different thematic layers. During the first run of the model, equal weighting were applied to each layer (soil, climate, erosion, and slope). The results are shown in Table (2) and Figure (8) with the area covered by each land suitability class shown as a percentage. The output data is a raster (grid) file containing the suitability classes. Each cell in a grid stores a number which indicates the suitability class for that cell.

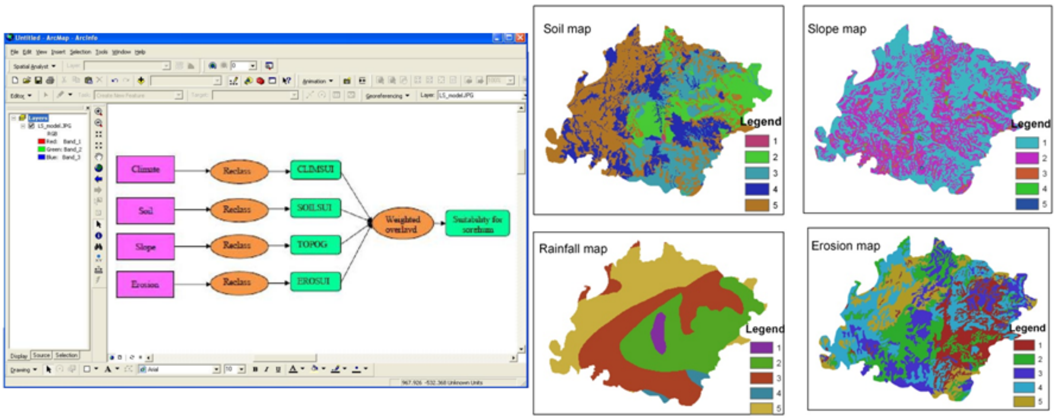


Fig. 5: The weighted overlay method and the Model Builder in the GIS

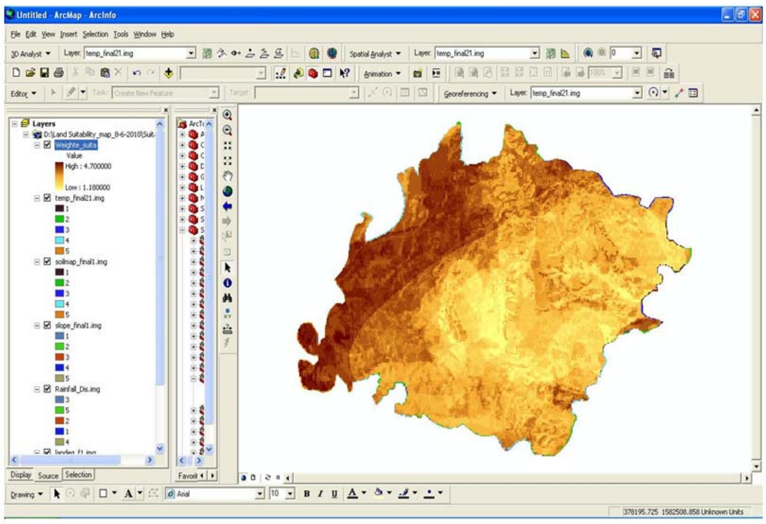


Fig. 6: Land suitability model in Arc GIS

Figures 7 and 8 indicate that nearly 5 % of the study area is highly suitable, 25 % is moderately suitable, 31 % marginally suitable, 24 curently unsuitable and 15 % permenantly not suitable for sorghum production. However, further economic evaluation is needed to identify the economic potential of each crop.

Table 2: Percentage land suitability classes for sorghum crop, equal land quality weighted

Crop	Suitability Classes in the study area %				
	Highly Suitable S1 %	Moderately Suitable S2 %	Marginally Suitable S3%	Currently not Suitable N1%	Permanently not Suitable N2 %
Sorghum	5	25	31	24	15

Hence, land classed as highly suitable is the best land for the crop production, moderately suitable land is clearly fit for the use but has limitations, and marginally suitable land falls near to (but above) the limit for suitability. Land that is not suitable is clearly impractical to overcome or not at an acceptable form due to the terrain slope condition and the soil type characteristics. Based on the results of soil analysis data and after interviewing the farmers and information collected from the field, it was found that the study area is facing a serious problem of certain ecological and socio-economic factors such as terrain and soils, land use practices and management, which in turn affects the productivity of the soil.

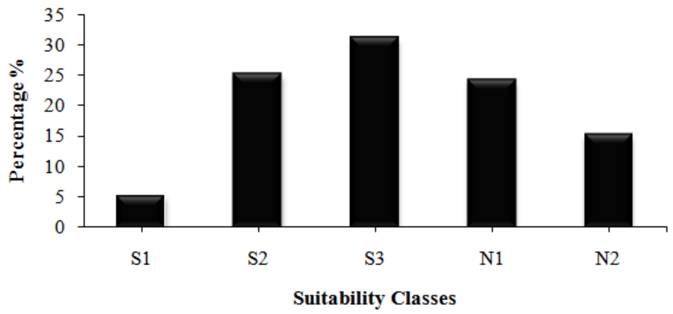


Fig. 7: Percentage land suitability classes for sorghum crop in the study area

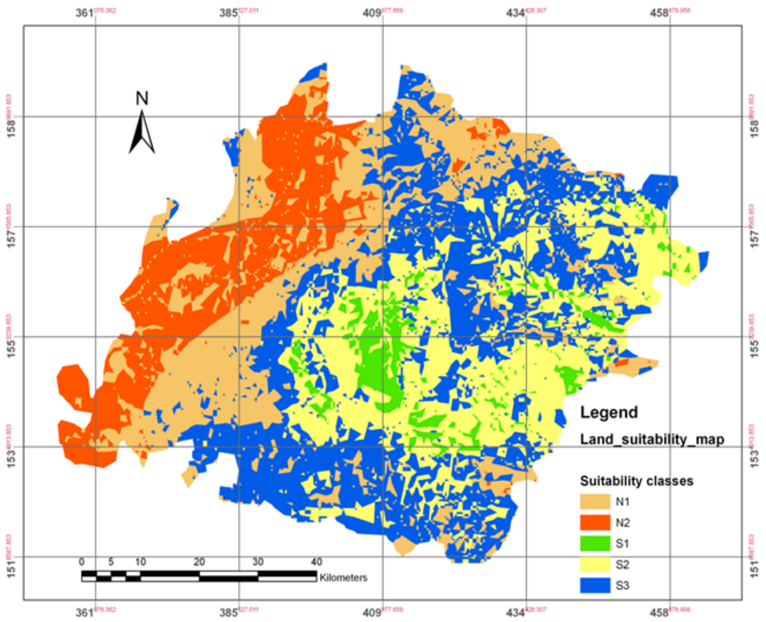


Fig. 8: Land suitability map for Sorghum crop in the study area

For the model validation, it is widely accepted that the validation and accuracy of physical land evaluation that uses a qualitative method is not possible (FAO 1983, Rossiter, D.G. 1996). One of the methods that could be used for validation is investigating if the selected crops already produced in the region and then a subjective comparison could be made. If the conditions existing in a region reflect the results in a logical and acceptable manner, the findings become more viable. Therefore, qualitative data (rather than quantitative) regarding the yields obtained in the study area, gathered during previous study by the first author and verified during this study has been used to validate the results. As a result, local knowledge indicates that the high rainfed area around IBB City, locating at the middle of the study area, is the high potential area to produce sorghum crop. The soils in this area are mainly Mollisols and Inceptisols which are considered as good soil types since they are rich in nutrient elements. The outputs of the model indicated that this area is ranked in the highly suitable classes for sorghum crop. In addition, the local experts' judgments and knowledge were consulted to validate the results of the model. The model outputs for the selected crop were viewed by the local experts. The expert's opinions, which based on experience in the local context, revealed that the results of the model are in agreement with what is expected of the land in the study area. This was vitally important since the ratings of different land qualities are mainly based on experience and judgement in the study area. This is considered as a quality control measure for the land evaluation process as a whole.

Generally, the results of this investigation can be integrated into an area management plan aimed at improving the lifestyle of the farmers and protecting the natural environment.

Conclusion:

The study has identified the different suitability classes of land for cultivation of the sorghum crops in the study area. The methodology adopted for this study was to map the suitability classes based on the crop edaphic suitability and crop climatic suitability using the FAO framework for Land Evaluation. the application of an automated method of land evaluation comes as a natural development. Computers have been applied to land evaluation at many different levels. One of the most significant developments has been the integration of GIS within the land evaluation process. The land suitability model was developed using weighed overlay method in the GIS to produce a land suitability classification in the study area. The land suitability classes derived in this study were validated through field cross checking with crop information collected from the various concerned stockholders.

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