Assessing Irrigation Potential and Land Suitability in Ethiopia

Abeyou W. Worqlul[1], Javier Osorio[1], Jaehak Jeong[1], Thomas Gerik[1], Yihun T. Dile[2], R. Srinivasan[2] and, Neville Clark[3]

[1] Texas AgriLife Research, Temple, Texas, USA

[2]Texas A&M University, College Station, Texas, USA

[3]The Norman Borlaug Institute for International Agriculture, Texas A&M AgriLife Research, College Station, Texas

Introduction

Although a detailed study on groundwater resources in Ethiopia is not available, a recent study by MacDonald et al. (2012) reported that the renewable groundwater storage in Africa is 100 times more than the annual renewable freshwater resources. An advantage of groundwater for irrigation of crops over surface water is its reliability and its tempered response to drought and variability in weather. Also, groundwater quality is typically better that surface water, requiring less treatment for human or livestock use. In Ethiopia, for example; groundwater is almost exclusively used for drinking water; and its use for irrigation of crops is limited. However, the need to increase food production in Ethiopia and other developing countries is reaching critical levels. It is important we more closely examine the groundwater resources in Ethiopia and suitability potential of land for irrigation using groundwater.

Description of Study Area

This study was carried out in the Federal Democratic Republic of Ethiopia located between 3°00' to 15°00'N and 32°00' to 48°00'E in the Eastern part of Africa (Figure 1). Rainfall in Ethiopia is highly variable with topography; the highland receives moderate rainfall (1200 mm) with minimal temperature variation while the lowland in the Afar and Somali region receives less than 500 mm/year with a much greater temperature variation.

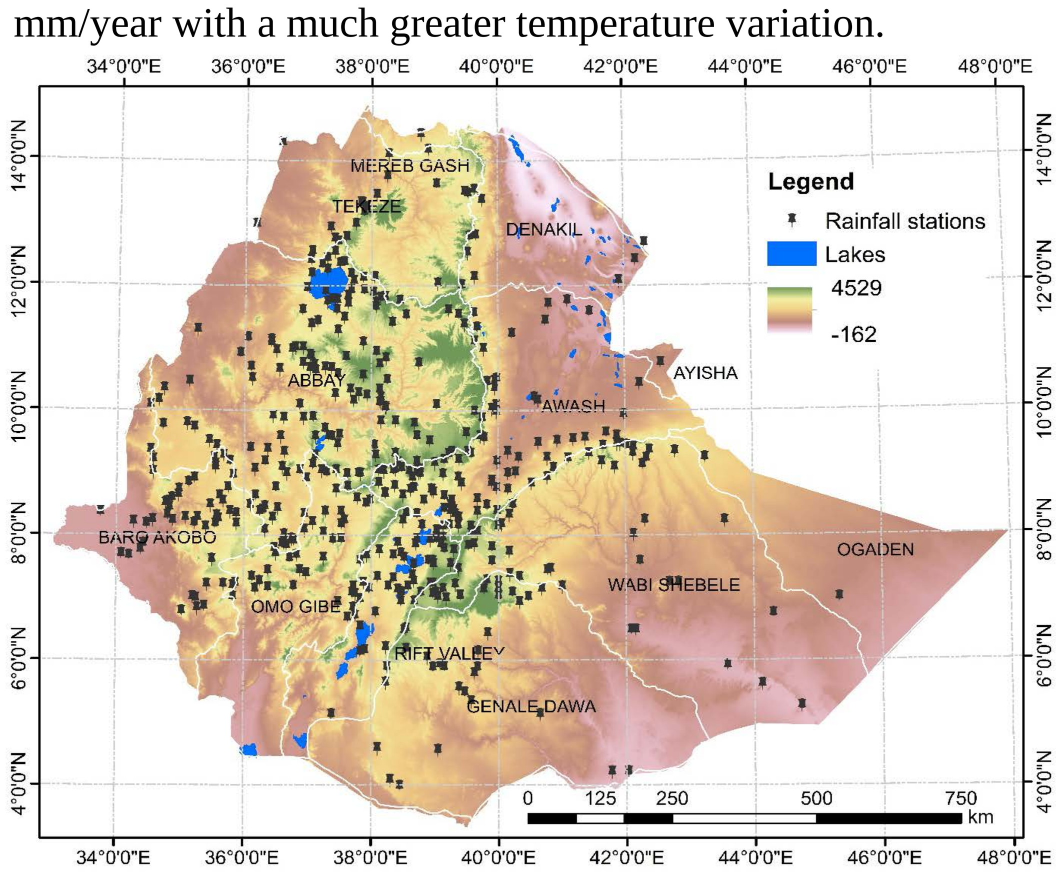

Figure 1: A map of Ethiopia showing lakes and rainfall stations with a background of 30 m resolution DEM.

Method

Potential land in Ethiopia suitable for irrigation using groundwater was identified using GIS-based Multi-Criteria Evaluation (MCE) techniques. The land suitability was determined by developing and assigning weight to the key factors that affect the irrigation potential of the land from groundwater using a 1 km grid. The factors used were identified from literature and from experts in the region (Akıncı et al., 2013; Chen et al., 2010; Mendas and Delali, 2012; Worqlul et al., 2015). Factors considered included physical land features (land use, soil and slope), climate characteristics (rainfall and evapotranspiration), and market access (proximity to roads and access to market).

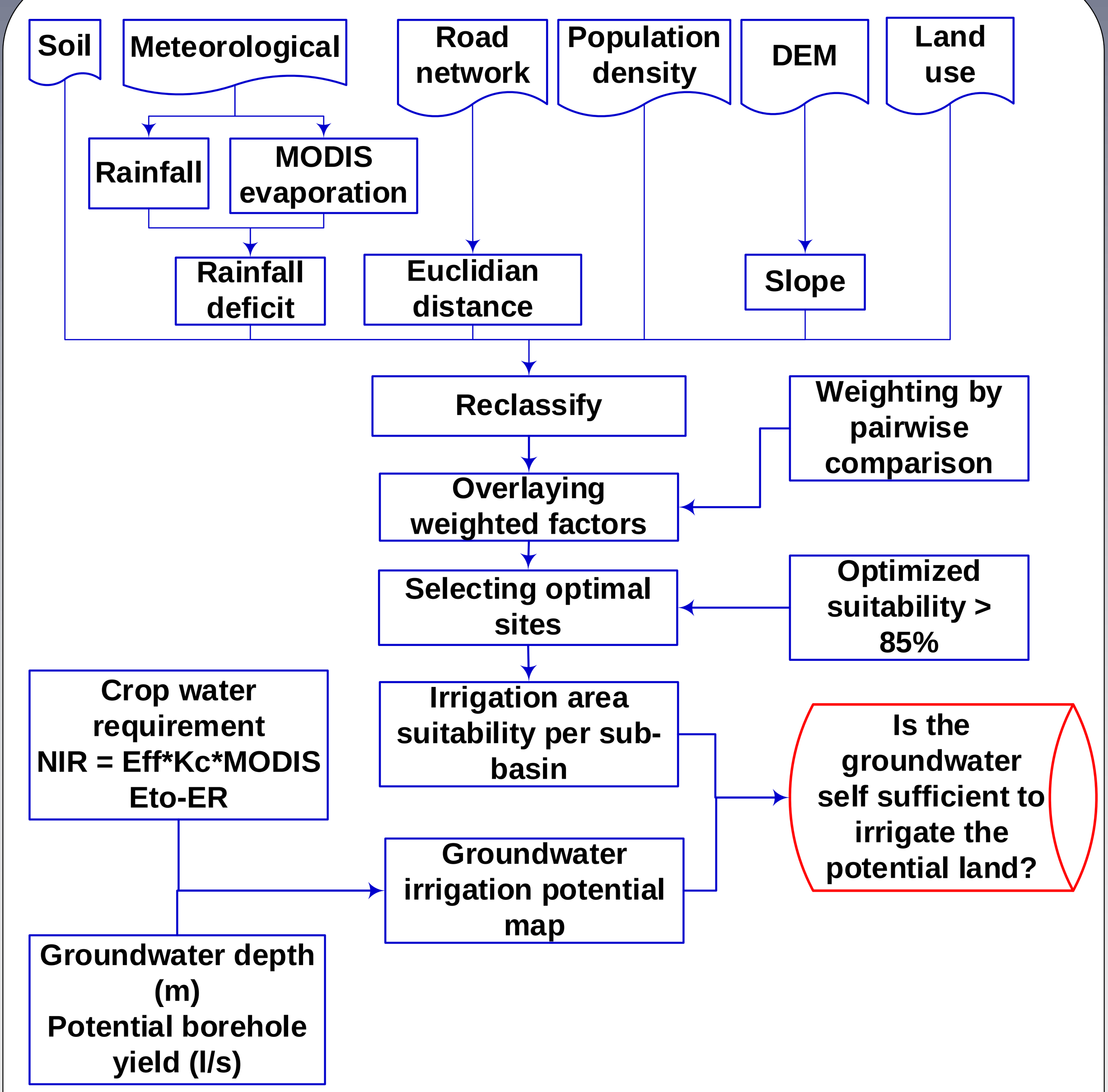

Figure 2: Schematic diagram of the methodology applied

Land suitability classes

The land suitability classes were based on FAO (1976 and 1981) framework; the land suitability map is classified into two classes i.e. Suitable and Not Suitable (see Table 1, a slightly modified version of the FAO land suitability classification).

Table 1: Land suitability classes FAO (1976 & 1981)

Highly Suitable: S1	Land without significant limitations.
Moderately suitable: S2	Land that is clearly suitable but which has limitations
Marginally suitable: S3	Land with limitations so severe that benefits are reduced
Currently not suitable: S4 (N1)	Land that cannot support the land use on a sustained basis.

Weighing of factors

The pair-wise comparison matrix was used to weight the factors. Six of the major factors were compared one to one and scored using a scale of Saaty (1977) see (Table 2).

Table 2: Weighting by pairwise comparison technique

Factors	Soil	Land use	Population density	Road proximity	Rain deficit	Slope	Weight (%)
Soil	1	2	1/3	1/2	2	1/3	12
Land use	1/2	1	1/4	2	1/5	1/3	8
Population density	3	4	1	3	1/4	1/2	18
Road Proximity	2	1/2	1/3	1	1/5	1/3	9
Rainfall deficit	1/2	5	4	5	1	1/2	24
Slope	3	3	2	3	2	1	29

Reclassified weighted factor maps

The weights of the factors were distributed to the different levels of suitability classes by an equal interval ranging technique. Figure 3 shows the factors and reclassified factors used for the land suitability analysis.

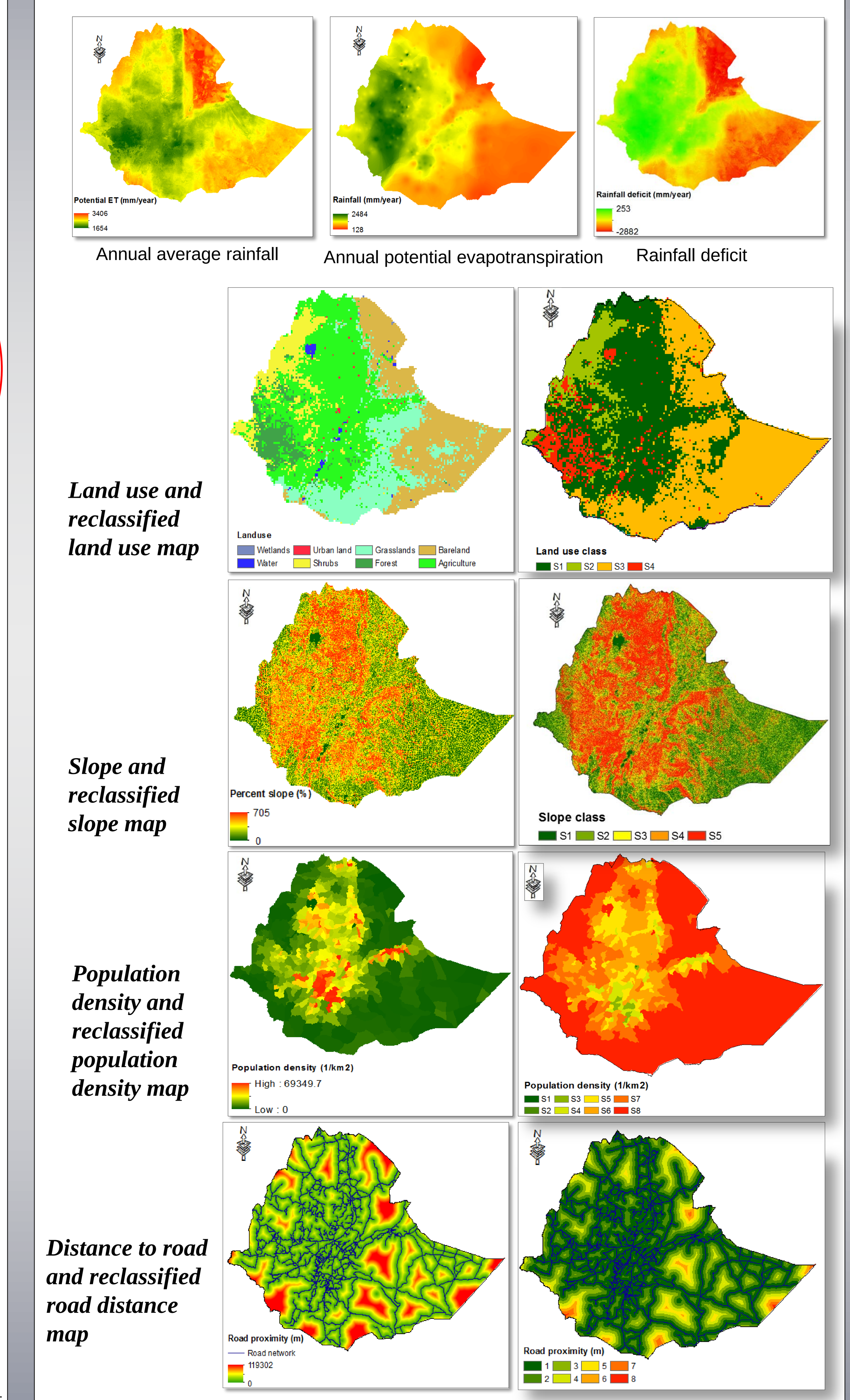

Figure 3: Land suitability factors and reclassified maps

Results

Preliminary Land Suitability for Surface Irrigation

The preliminary land suitable area was computed by using the Weighted Overlay analysis tool. The preliminary suitability map value ranges from 30 to 97%. The result indicated thousands of suitable polygons with area ranging from 1 to 500 km². Nearly 5.3 % or 60,025 km² has suitable value of greater than 85% (Figure 4).

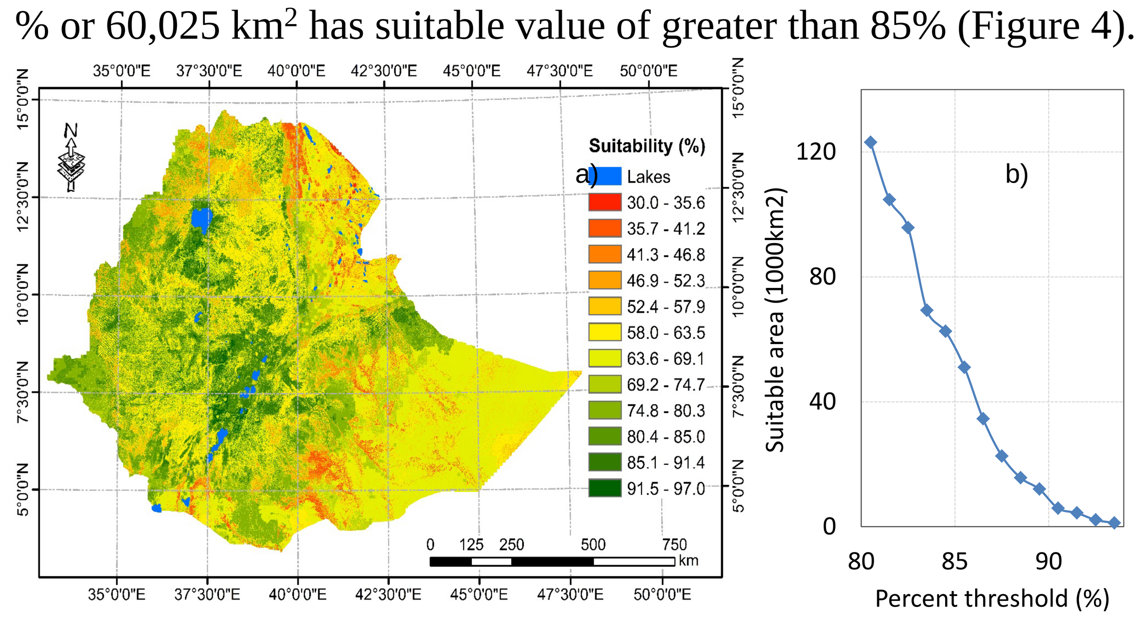

Figure 4: (a) A preliminary suitable land map for surface irrigation and (b) Suitable area for a variable threshold number.

Groundwater Availability

The groundwater storage has a higher spatial variability ranging from 1,000 to 50,000 mm/year with a depth varying from 7 to 250 m below the surface. However, only a fraction of this subsurface potential water is available for extraction through wells. The aquifer productivity map indicates the borehole yields ranges from 0.1 to 20 l/s. The majority of the land (47%) has aquifer potential yield between 1 to 5 l/s, where 14% of the land has the highest aquifer potential yield between 5 to 20 l/s. The potential borehole yield is very low for large-scale irrigation.

The irrigation potential of the groundwater was estimated as the ratio of the potential average borehole yield and the total crop water requirement (CWR) of the dominant crop in the area for the growing season.

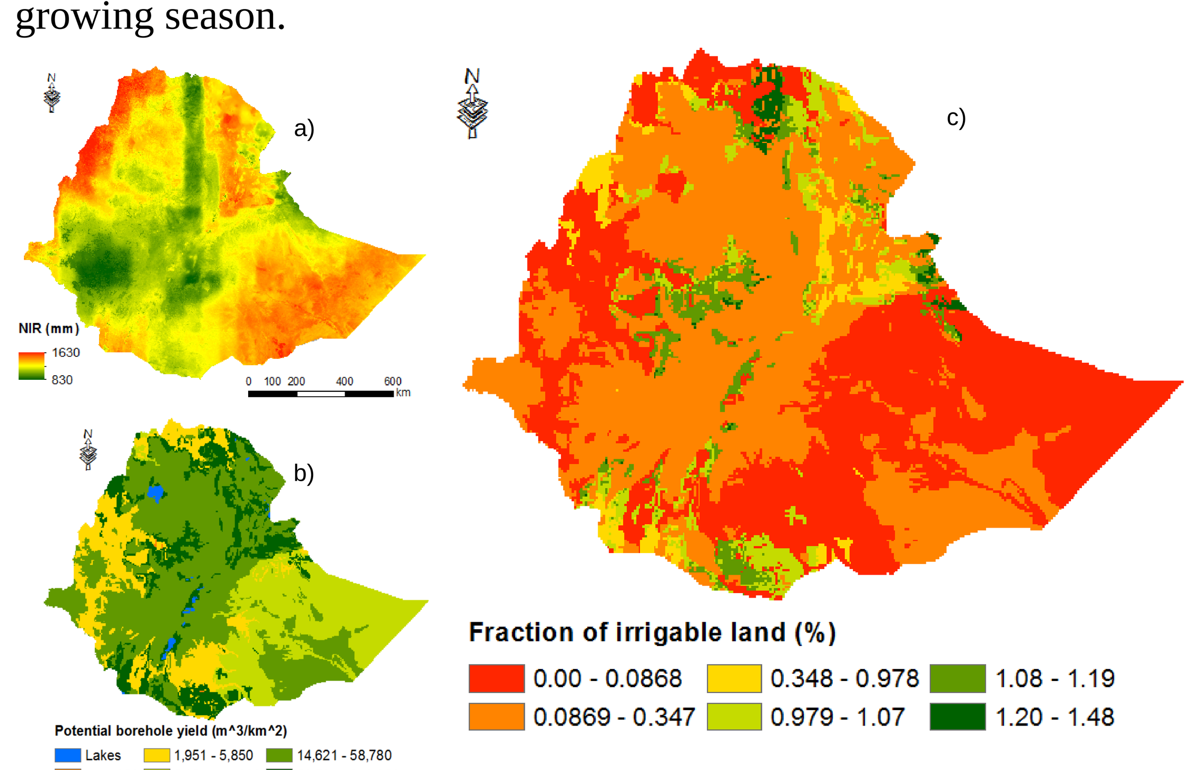

Figure 5: a) Net irrigation requirement, b) potential ground water yield and c) fraction of irrigable land

Conclusion

The study indicated approximately 6.0 million ha of land is suitable for surface irrigation in Ethiopia. A larger portion of the suitable land is located in Abbay, Rift Valley, Omo Ghibe, and Awash River basins. The study also indicated that the Abbay, Baro Akobo, Omo Ghibe, and Rift Valley have a shallow groundwater access within 20 m from the surface. The comparison between available groundwater and total crop water requirement indicated that the basins groundwater is not self-sufficient to irrigate all the suitable lands, instead, they will irrigate a smaller portion of the suitable land (~10%).

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