FEED THE FUTURE INNOVATION LAB FOR LIVESTOCK SYSTEMS
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FEED THE FUTURE INNOVATION LAB FOR SMALL SCALE IRRIGATION

# IDENTIFICATION OF AREAS SUITED FOR FODDER PRODUCTION IN ETHIOPIA

## Background

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In Ethiopia, agriculture contributes more than a quarter of the gross domestic product and export earnings. Livestock is an integral part of the agricultural system in Ethiopia, accounting for about 40% of the agricultural domestic product (Amsalu and Addisu, 2014; Stapleton, 2016), and providing employment to over 30% of the agricultural labor force (Asresie and Zemedu 2015). Livestock serves as a source of food, cash income, and farm power for plowing and transportation. Despite Ethiopia's significant livestock population, the largest in Africa, productivity in the sector is constrained by pronounced seasonality of feed and fodder availability, an overall shortage and low quality of feed, weak market linkages, and a lack of access to basic veterinary services. Since livestock constitutes a large part of smallholders' livelihoods, developing a better feed and fodder production system would contribute to poverty reduction and social-ecological resilience by improving livestock productivity through addressing bottlenecks in the quantity and quality of feed. The Feed the Future Innovation Lab for Small Scale Irrigation at Texas A&M University has been collaborating with the Feed the Future Innovation Lab for Livestock Systems at the University of Florida to identify suitable sites for fodder production in Ethiopia using promising small-scale irrigation practices that could improve productivity, environmental sustainability, household income, and nutrition. The fodder crops studied include Napier (*Pennisetum purpureum*), alfalfa (*Medicago sativa*), and Desho (*Pennisetum glaucifolium*). The study also evaluates the irrigation potential of groundwater using simple water-lifting technologies.

## Assessing the feed production potential

The land that is potentially suitable for sustainable fodder production in Ethiopia was identified using a Global Information Systems (GIS)-based Multi-Criteria Evaluation technique. The analysis was done by mapping major factors affecting the suitability of the land for fodder production followed by reclassifying, assigning weights, and overlaying factors to develop a single-index fodder suitability map. The key factors were identified based on recommendations found in the literature and feedback from experts in the region (Akıncı et al., 2013; Chen et al., 2010; Mendas and Delali, 2012; Worqlul et al., 2015; Worqlul et al., 2017). The study considered biophysical factors such as climate (rainfall, evaporation), soil (soil texture, pH, soil depth), land use, and slope, while the socio-economic factors included access to market and feed demand, which were represented by proximity to paved roads and livestock density, respectively. The source and spatial resolution of the data is shown in Table 1. The fodder crop types for the study were selected by the International Livestock Research Institute using on-farm trials conducted by the Innovation Lab for Small Scale Irrigation and the potential for the aforementioned three fodder crops to fit well into different agro-ecological settings in Ethiopia. These crops may improve household income and nutrition, if scaled sustainably.

**Table 1: Source and spatial resolution of input data for the fodder suitability analysis.**

| Data | Source | Spatial resolution (m) |
|---|---|---|
| Land-use | Global Land Cover Datasets, 2010 | 30 |
| Soil | Africa Soil Information Service, 2015 | 250 |
| Soil pH | Africa Soil Information Service, 2015 | 250 |
| Soil depth | Africa Soil Information Service, 2015 | 250 |
| Digital Elevation Model (DEM) | Enhanced Shuttle Land Elevation Data from the United States Geological Survey, 2000 released in 2015 | 30 |
| Road network | Digital Chart of the World, 2006 | -- |
| MODIS potential evaporation (mm) | MOD16 Global Terrestrial Evapotranspiration Data Set (2000 – 2010) | 1,000 |
| Rainfall (mm/year) | Ethiopian National Meteorological Agency (ENMA) from 2000 to 2010 | -- |
| Fodder crop characteristics | FAO-EcoCrop database | -- |
| Livestock population density | Ethiopian Central Statistical Agency | -- |
| Potential borehole yield (l/s) | British Geological Survey, 2012 | 5000 |
| Groundwater storage (mm) | British Geological Survey, 2012 | 5000 |
| Groundwater depth (m) | British Geological Survey, 2012 | 5000 |

Groundwater data from the British Geological Survey (BGS) was used to evaluate irrigation potential of the groundwater using simple water lifting technologies such as pulley and bucket, rope and washer pump, and solar pump. In a previous study, the BGS depth to groundwater and potential borehole yield were compared to observed groundwater yield data in the central part of Ethiopia, and the result indicated a reasonable performance in capturing the observed potential borehole yield (Worqlul et al., 2017). The BGS's depth-to-groundwater and potential borehole yield data were overlaid to evaluate accessibility and potential borehole yield of the groundwater to cultivate fodder in the most suitable land. Data on crop characteristics such as absolute and optimal growing temperature, soil pH, and depth conditions were obtained from Ecocrop (2000) and FAO (2011) and are presented in Table 2.

**Table 2: Characteristics of selected fodder crops considered to estimate the potential production area in Ethiopia (Ecocrop, 2000; FAO, 2011).**

| Fodder | Optimal temperature (°C) | Absolute temperature (°C) | Optimal soil PH | Optimal soil depth (cm) | Optimal rainfall (mm) |
|---|---|---|---|---|---|
| Napier | 25 - 40 | 15 - 25 & 40 - 45 | 5.0 - 6.5 | > 150 | > 1500 |
| Alfalfa | 21 - 27 | 5 - 21 & 27 - 35 | 6.5 - 7.5 | > 150 | 600 - 1200 |
| Desho | 20 - 25 | 15-20 & 25 - 35 | 5.5 - 7.0 | 50 - 150 | 700 - 1200 |

## Identifying the land that is potentially suitable for irrigation

The analysis indicated that slope and soil properties (i.e., depth, pH) were the most important factors for the suitability of land for fodder production in Ethiopia. Those factors reflect the integrated effect of the role of land management and soil health on the suitability of land for fodder production. Road proximity and livestock population showed a modest influence on the land suitability for fodder production, while land use, rainfall deficit, soil texture, and temperature were the least important factors affecting the suitability of the land for fodder production. The preliminary suitability analysis showed that the suitability score ranged from 45% to 94%, 48% to 94%, and from 42% to 91% for Desho, Napier, and alfalfa, respectively. The smallest value represents the least suitable land and the highest value represents the most suitable land (Figure 1). A constraint map that excludes unsuitable areas such as bodies of water and protected areas was applied, and the most suitable land areas were identified with a user-defined threshold suitability value. The suitable land extracted for a variable threshold from 80% to 94% (with a 1% increment) from the preliminary suitability map and the respective area above the threshold was plotted (Figure1d). For example, at an 85% threshold, ~8.7% of the Ethiopian land (about 17,720 km$^2$) is highly suitable for Desho production through small scale irrigation followed by Napier (4%) and alfalfa (2%).

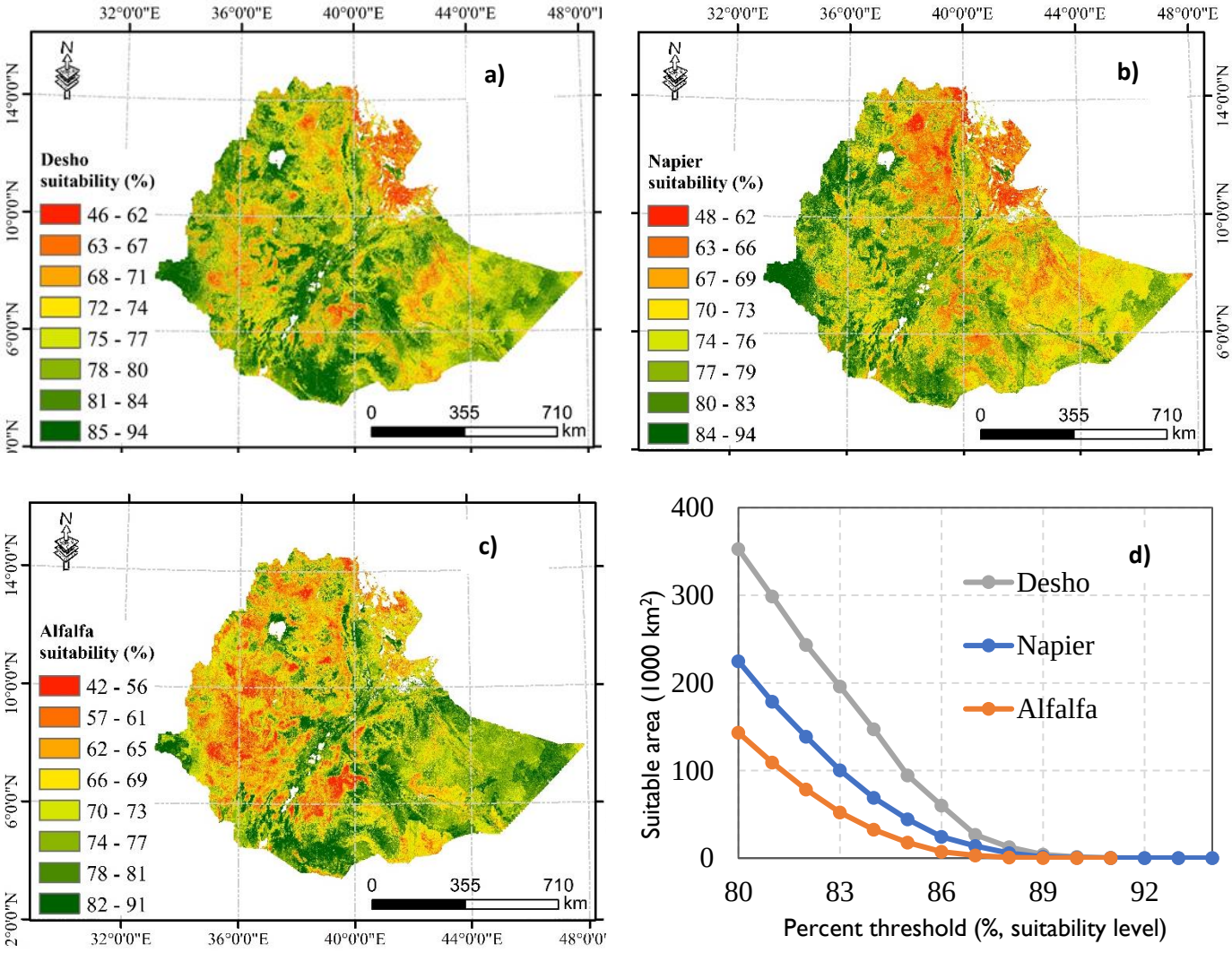


Figure 1: Suitability for irrigated fodder production for: (a) Desho, (b) Napier, and (c) Alfalfa. The figure 1d shows potential suitable irrigated fodder production (in 1000 km$^2$) at different threshold levels. The values in the map represent the level of suitability; the higher values represent the most suitable areas, and vice versa.

## Measuring Groundwater Availability and Potential Fodder Area

The average yield by species and per unit of groundwater in the highly suitable land is ~4.3 l/s; ~4 l/s; and ~5.8 l/s for Desho, Napier, and alfalfa, respectively. The depth to groundwater estimated using the BGS data indicated that, on average, Desho, Napier, and alfalfa could access groundwater at an average depth of 27 m, 17 m, and 22 m respectively. The groundwater assessment indicated a substantial potential and accessibility for small-scale fodder production in Ethiopia. Since rainfall variability in Ethiopia is high, groundwater can serve as a source of irrigation to buffer rainfall variability.

## Conclusions

The study estimated areas potentially suited for fodder production in Ethiopia, considering biophysical and socio-economic factors. The results indicate that there is substantial suitable land for fodder production in Ethiopia. The areas suitable for fodder production are also located in areas where there are sufficient groundwater resources, which could be accessed using simple water-lifting technologies. Sustainable use of the groundwater for fodder production will ease major livestock production constraints through producing better quality and quantity feeds. This study provides valuable insights for decision-makers, practitioners, and the private sector interested in scaling fodder production in Ethiopia.

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