Agricultural Suitability in India: Determining Optimal Locations for Rainfed Rice Production

Introduction

Rice is one of the principal crops produced and consumed in India. In 2010-2011 the land area planted with rice was 42.86 million hectares (13% of the total land area). In 2010 India was the second largest producer of rice in the world, with a harvest of 95.98 million tones. In 2010-2011 India exported 2.37 million tonnes of Basmati rice, valued at 113.55 billion rupees (2.1 billion current USD). Non-Basmati rice exports were significantly less, amounting to roughly 100 thousand tonnes and valued at 2.3 billion rupees (40 million current USD). Rice is a significant component of the Indian diet. In 2009-2010 annual rice consumption was estimated to be 74.7 kg per person in rural areas and 56.64 kg per person in urban areas. In 2009-2010, rice represented just over 50 percent of total cereal consumption.

In order to maximize the country's rice production, it would be ideal if the rice produced in India were grown on the agricultural lands most suited for rice cultivation. This study seeks to understand if the current rice production in India is grown on the land that is most suited for rice cultivation. This study will use GIS analysis to undertake a rice production suitability analysis and compare the result of that analysis with the current location of rice cropland. Given the stressed state of India's groundwater supply, the competing demands for surface water, and the fact that the majority of poor smallholders are not using irrigation, this analysis will focus on the suitability for rain-fed rice production.

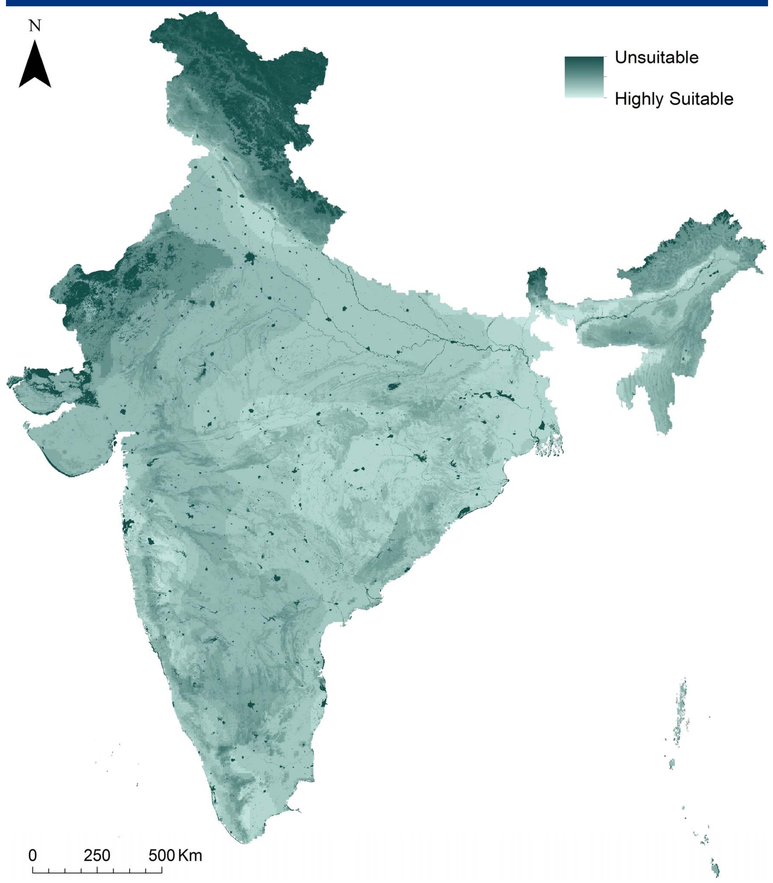
Methodology

There are five variables that were used to perform the rice production land suitability analysis: nutrient availability, elevation, slope, annual precipitation and current land cover. Each variable, except land cover, was reclassified 1-4, with 1 being the most suitable for rainfed rice production and 4 being the least suitable. The 1 through 4 classification system was selected based on the FAO guidelines for land use planning which employs a 1-4 classification ranging from Highly Suitable to Not Suitable.

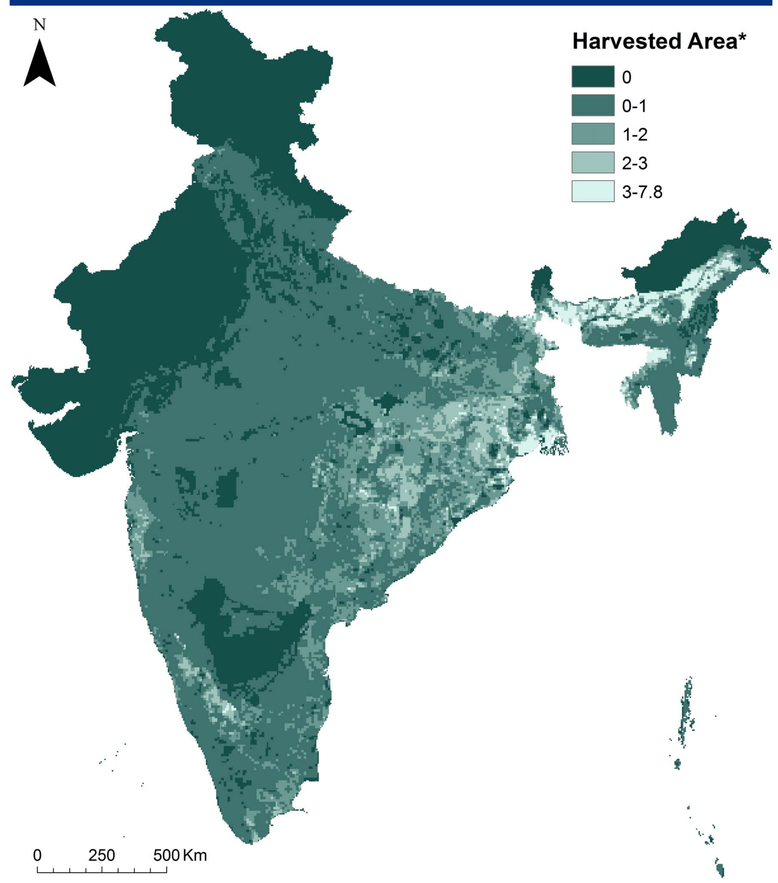
The elevation classification was selected because lower altitudes are more conducive to rice production. At higher altitudes colder temperatures restrict plant growth. The land cover classification (suitable or unsuitable) was intended to eliminate areas that were impossible for rice production. The areas classified as unsuitable are artificial areas, bare areas, water bodies and permanent snow and ice. The nutrient availability classification was defined by the FAO and refers to soil fertility. The precipitation classification was selected because of the importance of rainfall in strictly rainfed production systems. The slope classification was selected because flat surfaces are ideal for rice production as equal water dispersion and depth is critical.

After defining the 1-4 classification for each suitability variable, a suitability map of ideal land for rainfed rice production was created by combining the variable scores in each location. Locations with land cover that were unsuitable for rainfed rice production were automatically classified in the suitability analysis as unsuitable. Finally, the harvested area of rainfed rice in 2000 was used as the point of comparison for the suitability analysis output.

Land Suitability for Rainfed Rice Production



Rainfed Rice Production in 2000

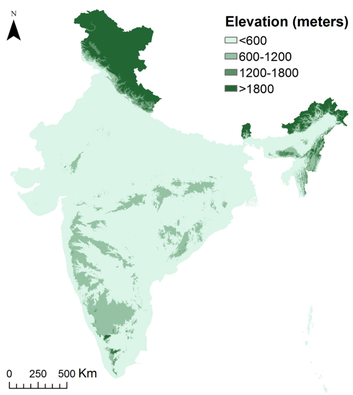


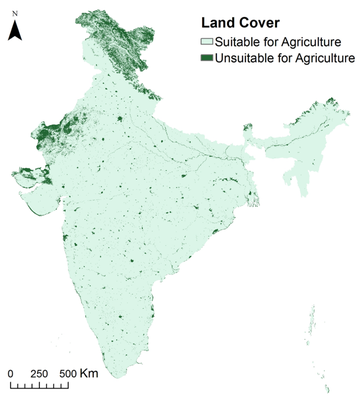
*The harvested area was mapped by plotting the square kilometers of rainfed rice harvested per grid. In this map the grids are 5 arc minutes. Therefore, the scale corresponds to the square kilometers harvested per every 25 square kilometers.

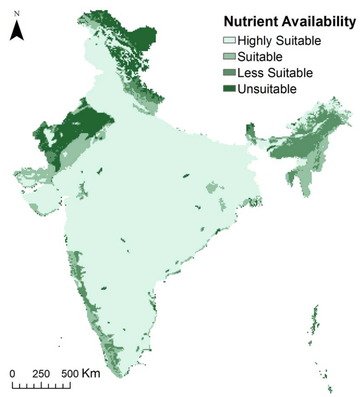
Results and Conclusions

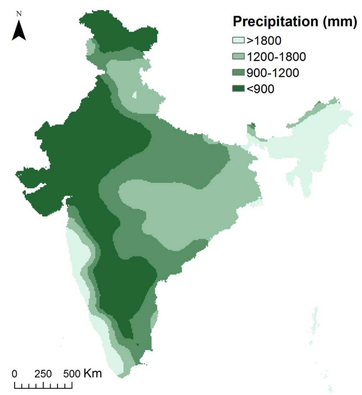
The results of this analysis are seen in the Land Suitability for Rainfed Rice Production map. In this map the most suitable areas for rainfed rice production are shaded in light green, while unsuitable areas are dark green. The five suitability variables are displayed in Variable Maps 1 -5.

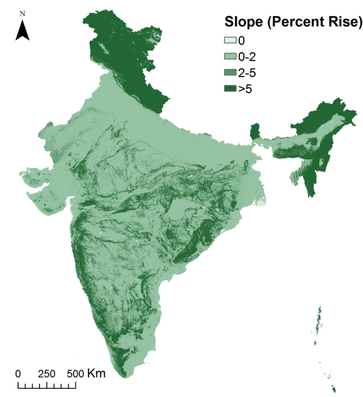
The land area that was identified as suitable for rainfed rice production is closely aligned with the actual land area planted to rainfed rice in 2000. Interestingly there appear to be areas in the central part of the country and in south-western Gujarat that are suitable for rainfed rice production, but did not harvest much or any rainfed rice in 2000. Perhaps there is another crop grown in these areas that is more suitable for the agro-ecological context, or perhaps rice production is irrigated. These results show that India is for the most part maximizing the cropland that is capable of producing rainfed rice; however, there are some areas where rainfed rice production could be successfully expanded. Future expansion of rainfed rice production in the areas where it is viable may become a necessity if groundwater sources in India continue to be contaminated or depleted.











Cartographer: Dana Goldman (May 2013)
Coordinate System: UTM WGS 1984 44N
Data Sources:

European Space Agency GlobCover 2009 (Global Land Cover Map) (http://due.esrin.esa.int/globcover/)
FAO/IIASA. Global Agro-Ecological Zones (GAEZ v3.0). FAO, Rome, Italy and IIASA, Laxenburg, Austria (2010). (http://gaez.fao.org/Main.html#)
Fekete, B. M. et al. "High-resolution fields of global runoff combining observed river discharge and simulated water balances" Global Biogeochemical Cycles, 16.3 (2002): 15-1 to 15-10.
Shuttle Radar Topography Mission (2012) (http://earthexplorer.usgs.gov/)

References:

FAO. "Guidelines for land-use planning" Food and Agriculture Organization, Rome (1996).
Government of India. "Agricultural Statistics at a Glance 2012" Ministry of Agriculture, Department of Agriculture and Cooperation, Directorate of Economics and Statistics (2012).
Mongkolsawat, C. et al. "A physical evaluation of land suitability for rice: A methodological study using GIS" In *Proceedings of the Asian Conference on Remote Sensing (ACRS'97)*, Kuala Lumpur, Malaysia (1997).