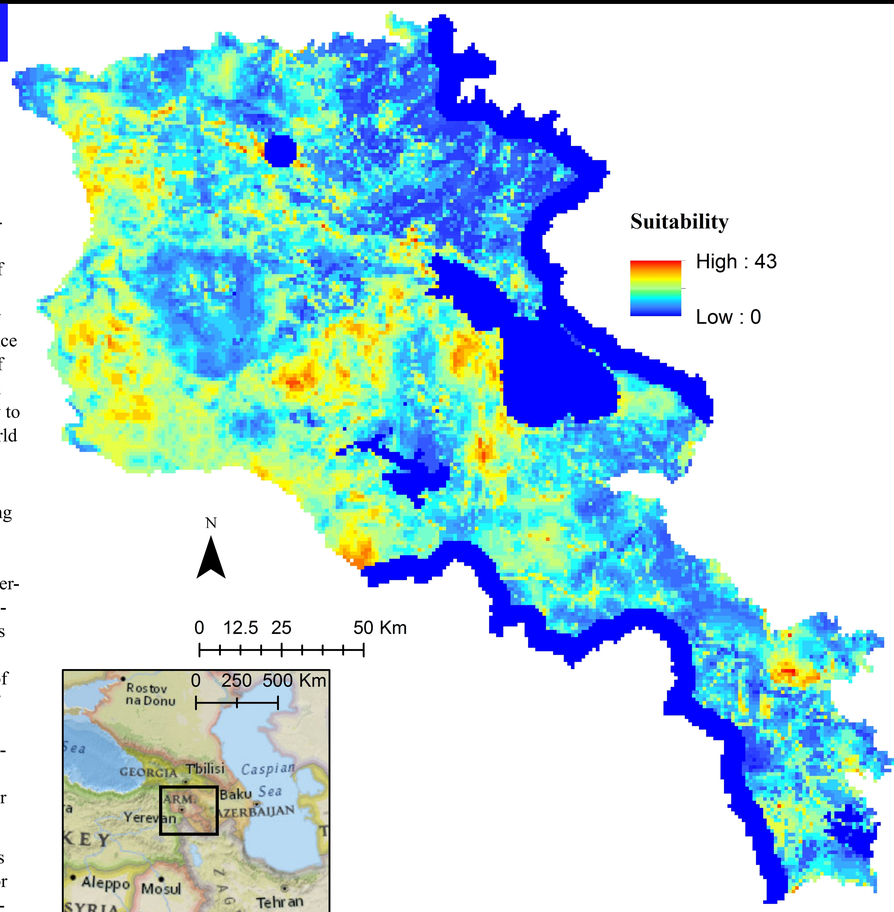
Wind Suitability in Armenia: Determining Optimal Wind Farm Locations

Project Overview

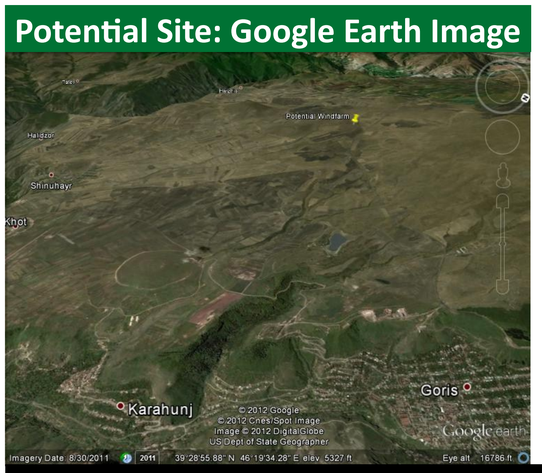
Armenia, a small country that emerged from the collapse of the Soviet Union, faces some of the most extreme geopolitical and economic challenges of any country in the world. The country, already suffering from the abrupt severing of its links with Moscow, fought a devastating war in the early 1990s with it's neighbor Azerbaijan that led to the closure of it's borders with Turkey and Azerbaijan. With no domestic fossil fuel resources, Armenia relies on the entirety of its oil and gas supplies from Russia and Iran. This makes its supply vulnerable to geopolitical instability and creates a strong political and economic dependence on its larger neighbors. Furthermore, roughly 40% of Armenia's electricity consumption is derived from an aging nuclear power plant that is considered by many to be the most dangerous nuclear power plant in the world still in active use.[1]

A partial solution lies in renewable energy. Armenia has so far made relatively little progress in developing its renewable energy potential, yet renewable energy could provide a clean, reliable, and politically salient way to improve Armenia's energy problem. Wind energy in particular could generate a large amount of electricity relative to Armenia's small population, yet thus far only one small wind farm exists. Pushkin Pass in Lori region currently has four turbines and capacity of just 2.64 MW – though the project design calls for 27 total, which would then create a capacity of about 20 MW.[2] This GIS project will attempt to analyze the potential for further wind energy developments in the country and determine the most effective locations for future installations.

The primary spatial question that this project attempts to answer is: Where are the most suitable locations for future wind farms in Armenia? There are notable constraints when operating in Armenia that this project will take into account. One of these is the active hostilities on the Armenia-Azerbaijan border. Because of sniping and occasional military raids, a wind farm cannot be constructed too close to this border. Using this factor, as well as twelve others including wind speed, gradient, proximity to power substations, national grid, forest coverage, etc., a suitability map was produced showing optimal places for wind farm placement in Armenia.



Potential Site: Google Earth Image



Methodology

To determine the suitability for a wind farm in Armenia, thirteen main factors were identified as being primary determinants: Wind speed, gradient, forest coverage, state nature preserves, lakes, proximity to the national grid, power substations, cultural heritage sites, active use airports, settlements, major roads, existing wind facilities, and the military contact line. The data for these files was either found online in a GIS compatible format (vector or raster shapefiles), was digitized from existing digital images (in the case of electricity substations and national grid), or the coordinates were found, put into a spreadsheet, and imported as a point vector shapefile. The exception to this being the military contact line, which was taken from a line shapefile of Armenia's borders, was split using the editor tool, and the relevant borders with active hostilities made into a new shapefile.

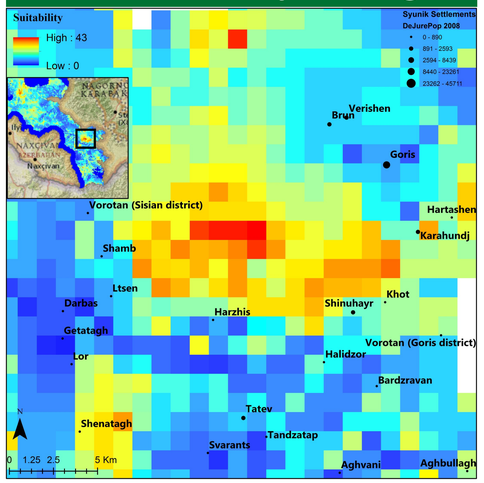
All shapefiles in this project were projected into WGS 1984 UTM Zone 38N. The Euclidean distance for these shapefiles was found, and raster files produced. The raster files were then reclassed according to the logic of the project. Most of the files received a score from 1 (least suitable) to 5 (most suitable). Gradient and Wind Speed were scored from 0 to 5. Binary scores were given to Forest Coverage (1 and 5), Lakes (0 and 1), Contact Line (0 and 1), Pushkin Pass Wind Farm Area (0 and 1), and State Nature Preserves (0 and 1). Exact offset values and more detailed scoring information can be viewed in the accompanying report.

A formula for determining the optimal wind location was then produced. The decision was made to weight Wind Speed an extra 30% in recognition that it is the single most important factor in determining optimal wind farm location. The formula used is:

((Wind Speed)*1.3+(Gradient)+(National Grid)+(Power Substations)+(Cultural Heritage Sites)+(Airports)+(Settlements)+(Major Roads)+(Forest Coverage))*(Lakes)*(State Nature Reserves)*(Pushkin Pass Wind Farm Area)*(Contact Line)

The binary {0,1} factors were multiplied in the formula to produce zero-value suitability area; essentially creating exclusion zones. This calculation was carried out using the map algebra tool in the spatial analyst tool set. Using this methodology, the resulting wind farm suitability map for Armenia seen on this poster was produced.

Potential Site in Syunik Region



Project Findings

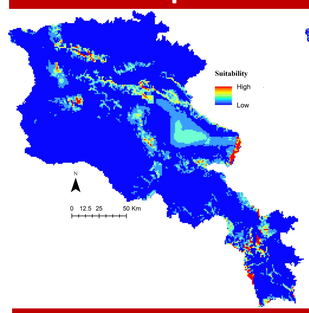
Using the suitability map produced, a clear optimal location for a wind farm was determined. The location is in Syunik region in Southern Armenia, about five kilometers north-east from the village Harzhis and 7.5 kilometers south-west from the city of Goris. The combined area of this optimal location (including very suitable surroundings) is about six square kilometers. The number of turbines greatly depends on the type, but taking a mid-size Lagerweij 750KW turbine with a rotor diameter of 50 meters (the same turbines that are at Pushkin Pass wind farm, this area could potentially contain 60 turbines producing about 45MW power. However, this project is limited in that it determines the best placement of the turbine, not the economic feasibility of the project. Further analysis is needed to determine if electricity produced from a wind farm would be at grid parity to the electricity produced in Armenia from other sources and if not, what level of subsidies would be necessary to make the project sustainable. Overall however, it is advised for Armenia to seek to develop this resource and other renewable energy projects as well to ensure its long term energy security, as well as providing for a more sustainable energy future.

Pushkin Pass Wind Farm, Armenia

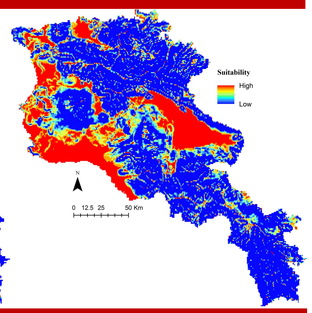
http://en.wikipedia.org/wiki/File:Wind_Power_in_Armenia_at_Pushkin_Pass.jpg

Factor Maps

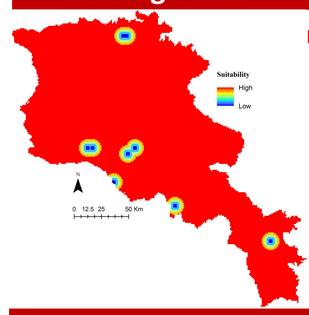
Wind Speed



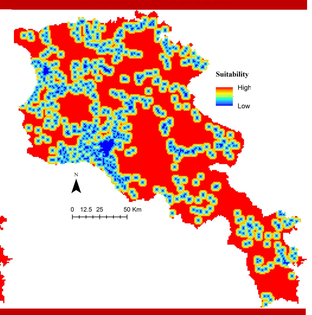
Gradient



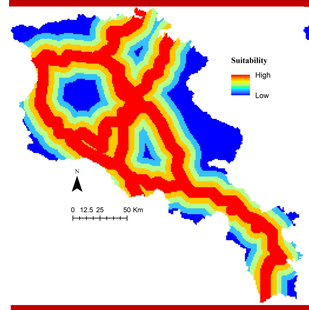
Heritage Sites



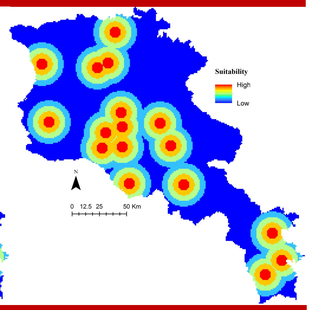
Settlements



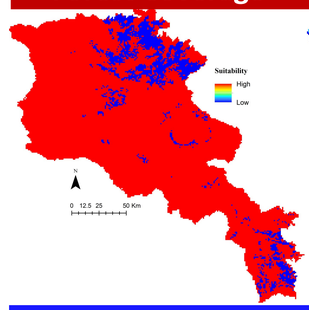
National Grid



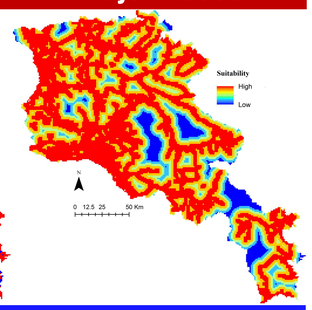
Power Substations



Forest Coverage



Major Roads



Factor Maps Not Pictured: Airports, Contact Line, Lakes, State Nature Reserves, Pushkin Pass Wind Farm

Project by: David Murphy
Projection: WGS 1984 UTM Zone 38N
Data Sources: Acopian Center, NREL, diva-gis.org, UNESCO, The Airport Guide, FlightSim.com, Geni.org

1. Lavelle, Marianne, and Josie Garthwaite. "Is Armenia's Nuclear Plan the World's Most Dangerous?" National Geographic, 11 Apr. 2011.
2. Den Boon, Hank. "Wind Power Project." Government of Armenia.

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