

# The Utility of Least Cost Path Analysis for Predicting Optimal Routes to the Border for Libyans Fleeing Violence

## BACKGROUND

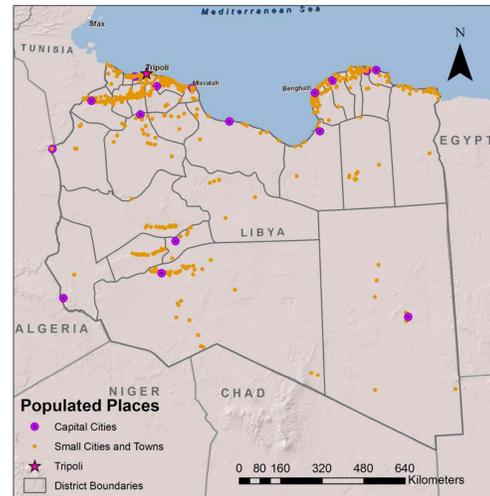


Figure 1: Study area for modeling possible movement routes of people fleeing conflict in remote areas

The recent uprisings across the Arab world, while widely heralded as a stride towards democracy for many nations, have left hundreds of thousands of people displaced from Libya alone. Up-to-date information about the movement of people in conflict-affected countries is a challenge to obtain, yet is critical to understand for timely humanitarian response. As violent clashes between Muammar Gaddafi's government and rebel forces to gain control of various areas spread through the country, it becomes increasingly likely most of the country will be affected. Spatial analysis with GIS could yield useful information regarding the optimal routes for Libyans fleeing violence to reach international borders.

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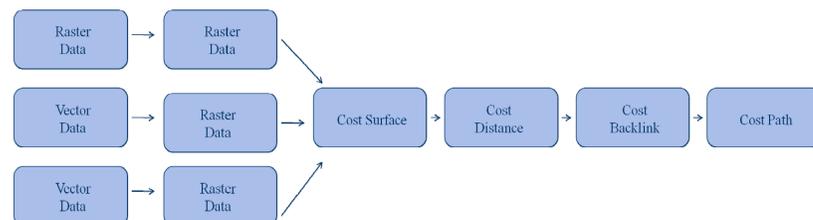
## Objectives

The purpose of this project was to use spatial analysis to explore some of the most important environmental factors that influence what path a Libyan might take when fleeing violence, and from this consideration to determine the least-cost path of escape from a conflict-affected area. For the sake of this analysis, which is merely to demonstrate how ArcGIS tools can be applied to predict possible paths of human migration between two points, the town of Suknah in Al Jufrah district was chosen to be the hypothetical starting point of a fleeing population and the destination was chosen to be the city of Ghadamis, the city located closest to the Debdeb border crossing into Algeria.

## METHODOLOGY

In order to determine the least-cost path out of Suknah, a number of variables that likely impact ease of movement by people on foot were considered. The ones finally included in the analysis were:

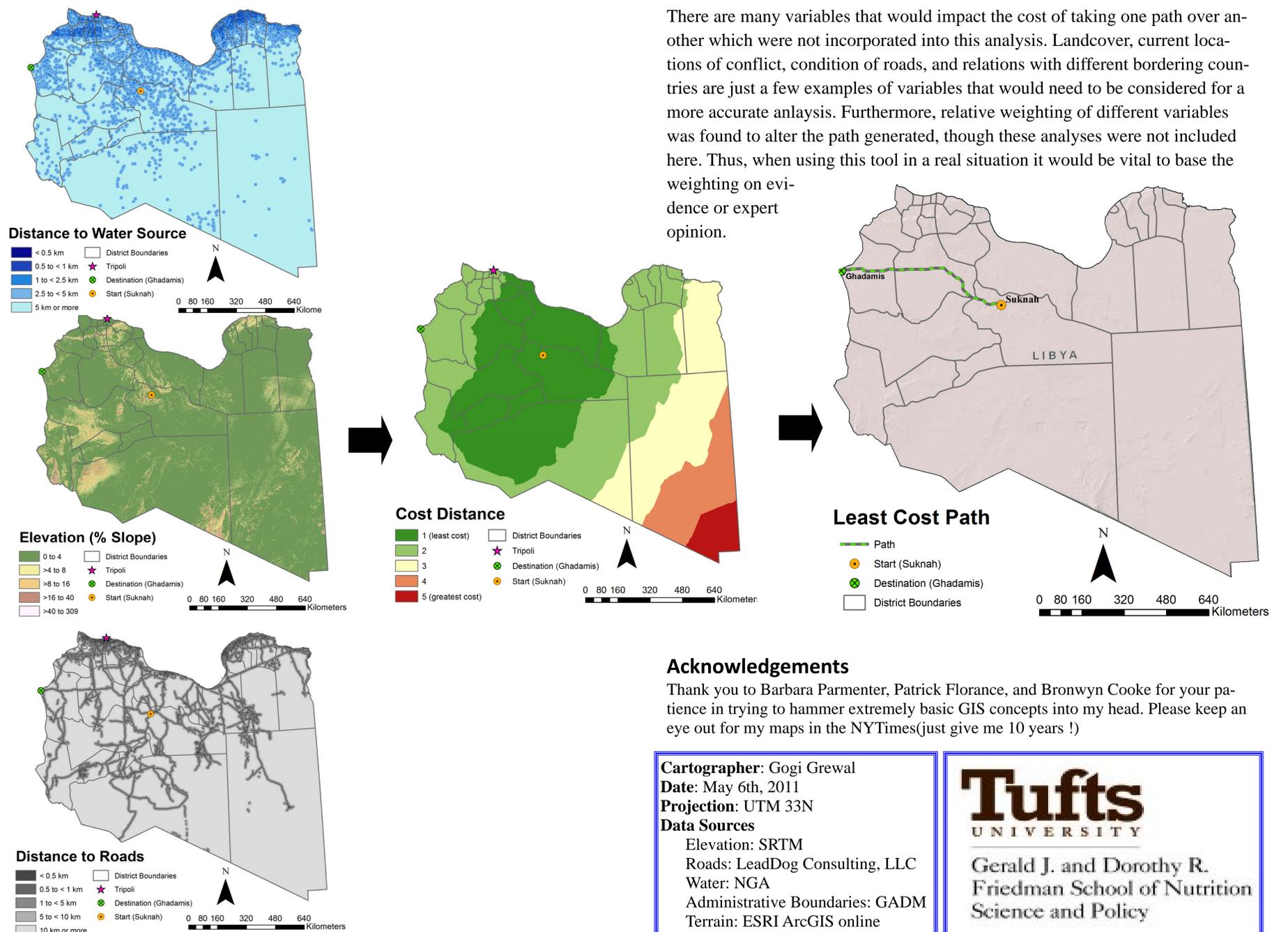
1. Proximity to drinking water sources (weighted as 55%)
2. Elevation (weighted as 10%)
3. Proximity to roads (weighted as 35%)



Slope was calculated as percent rise and then classified based on breakpoints thought to be reflective of ease or difficulty for walking. Distance to roads and

drinking water sources were then mapped, and all layers were converted to raster and reclassified into categories to prepare for cost analysis. The *weighted overlay* tool was used to calculate the weighted value of each cell in each of these three raster files. The output was then used to create a *cost-surface*, which produced a separate raster depicting the values of all three variables for each 500m cell. This raster was fed into a *cost-distance analysis*, which is a necessary input for a *cost-path analysis*. The final step before conducting the least-cost path analysis was to create a *cost backlink raster*. Once the least-cost path analysis was conducted, the path generated was converted into a line vector for display on the final map.

## RESULTS



As one would expect, the least cost path very closely mirrors the main available road between Suknah and Ghadamis. Given the arid climate and sparse population density in large parts of the country, the results of the analysis are not as unpredictable as they might be in a location with more variability. Least cost path analysis has the potential to be a valuable tool in preparation for humanitarian emergencies. With high-quality data inputs, optimal escape routes could be mapped for populations in certain areas that are considered at high risk for conflict, analogous to but more comprehensive than a "fire escape" plan. The tool may also be useful for predicting routes that migrating people take during an emergency, which holds implications for planning of humanitarian interventions.

## Limitations

There are many variables that would impact the cost of taking one path over another which were not incorporated into this analysis. Landcover, current locations of conflict, condition of roads, and relations with different bordering countries are just a few examples of variables that would need to be considered for a more accurate analysis. Furthermore, relative weighting of different variables was found to alter the path generated, though these analyses were not included here. Thus, when using this tool in a real situation it would be vital to base the weighting on evidence or expert opinion.

## Acknowledgements

Thank you to Barbara Parmenter, Patrick Florance, and Bronwyn Cooke for your patience in trying to hammer extremely basic GIS concepts into my head. Please keep an eye out for my maps in the NYTimes(just give me 10 years !)

**Cartographer:** Gogi Grewal

**Date:** May 6th, 2011

**Projection:** UTM 33N

**Data Sources**

Elevation: SRTM

Roads: LeadDog Consulting, LLC

Water: NGA

Administrative Boundaries: GADM

Terrain: ESRI ArcGIS online

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