Smuggling Through Transcaucasia

Mapping Lawful and Illicit Border Crossing Regions within the South Caucasus

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Abstract

To identify, and verify all potential illicit border crossings within the Transcaucasia region.

Introduction

Within the scope of GIS there has been very little research done on any of the three defined counties of the South Caucuses region (Georgia, Armenia, Azerbaijan). This is due to many varying factors that are attributed to the area. All of which have their roots in the collapse of the Soviet Union. Since then the region has had the challenge of trying to develop its own sense of national unity (coming from years as Soviet Republic), dealing with various closed or restricted borders, strong external geopolitical neighbors (Iran, Turkey, and Russia), corrupt officials, emerging a hub for drug trafficking to Europe, and even two full out wars. These factors along with the physical terrain of the area leaves the South Caucasus as a perfect study area for locating illicit border crossings which help facilitate the smuggling of illegal goods.

Study Area

- Three countries & three break away region: Georgia (South Ossetia, Abkhazia), Armenia, Azerbaijan (Nagorno-Karabakh).
- Closed Borders:
  - Armenia-Azerbaijan
  - Armenia-Turkey
- Restricted Border: Georgia-Russia
- Mountainous North & flat southeast.

Data

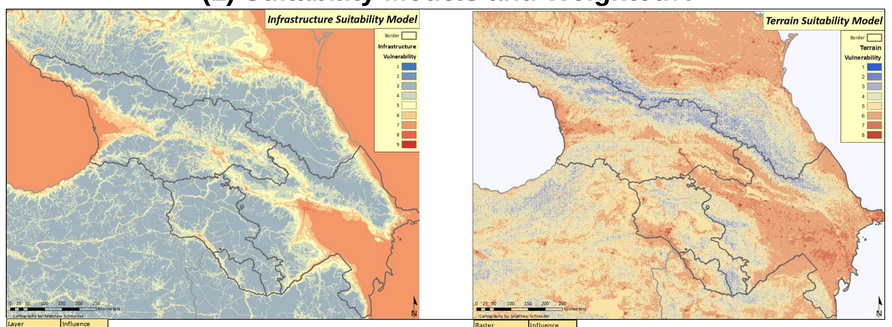
Below are the data that were used within the project

Data Source	Data Type	Data Quality	Country Covered	Link
Silk Road Travel Guide	Location of Various Border crossings	Points are approximates of site locations	Georgia, Azerbaijan, Armenia	http://caravanistan.com/border-crossings/
Natural Earth	Polyline of disputed area	Generally follows borders	Georgia, Azerbaijan, Armenia	http://www.naturalearthdata.com/
Geofabrik	OpenStreet Map Extracts	Fairly accurate, Very detailed	Georgia, Azerbaijan, Russia, Iran, Turkey	http://download.geofabrik.de/
Landscan	Population data	Fairly accurate population raster	Georgia, Azerbaijan, Armenia, Russia, Iran, Turkey	http://www.lib.umd.edu/gov-info-gis/news/geoblog1
GeoCommunity	Various GIS data for world	Fairly accurate, used to supplement other data	Armenia	http://data.geocomm.com/
U.S. Dept. of State	International Border data	Very accurate GIS border Data	Georgia, Azerbaijan, Armenia, Russia, Iran, Turkey	https://hiu.state.gov/data/data.aspx
USGS	Terrain Data	Very accurate 7.5 arc data	Georgia, Azerbaijan, Armenia, Russia, Iran, Turkey	http://earthexplorer.usgs.gov/
USGS	Land Cover	0.5km MODIS-based Land Cover	Georgia, Azerbaijan, Armenia, Russia, Iran, Turkey	http://earthexplorer.usgs.gov/
USGS	Max average green veg. fraction 2001-2012	1km MODIS-based max Green Veg. Fraction	Georgia, Azerbaijan, Armenia, Russia, Iran, Turkey	http://earthexplorer.usgs.gov/

Methods

The project can be broken down into three parts. First the *Terrain Suitability model conducts a weighted overlay of reclassified slope, population, vegetation, and land cover data. Second the Infrastructure model conducts a cost distance on road, stream, rail, helpers (bridges, ferry's, etc.), and Avoidances (police station, border check points, etc.) based off the areas terrain (DEM). These cost distance outputs are then reclassified and weighted together. Third the two outputs obtained from the two models described above are weighted together to get a final Border Vulnerability raster. Values equal to 1 are least vulnerable to illegal border crossings while values of 9 are the most vulnerable. The whole process listed above is outlined in figure 4 to the right.*

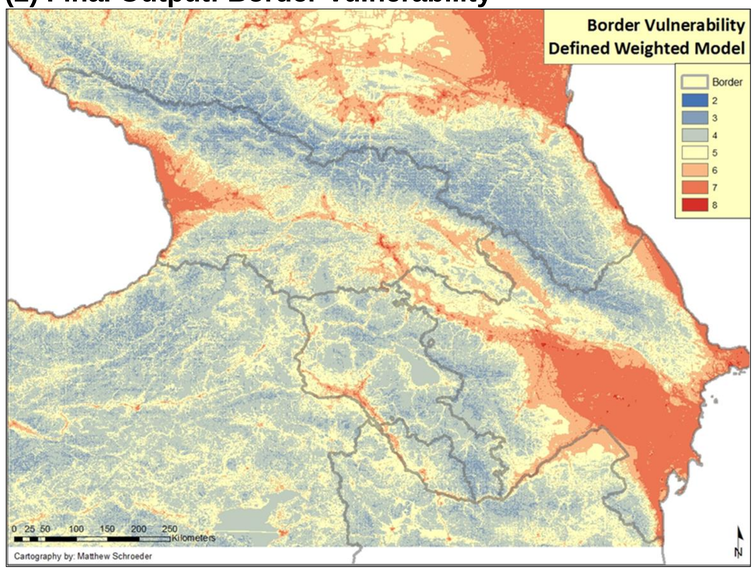
(1) Suitability Models and Weighted%



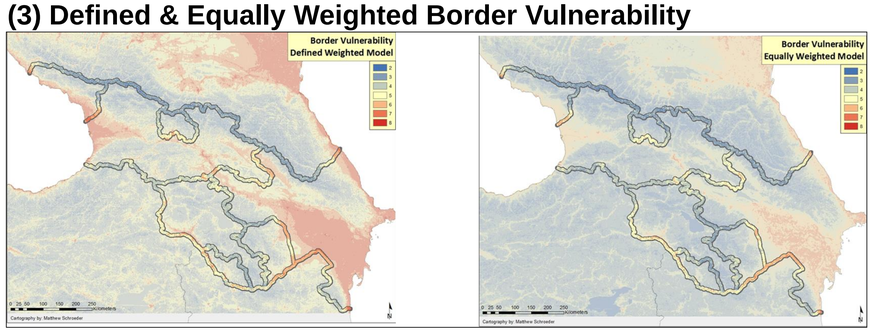
Layer	Influence
Road	25%
Rail	25%
Avoiders	20%
Helpers	20%
Streams	10%
Total	100%

Raster	Influence
Degree-Slope	45%
Land Cover	30%
Max Vegitation	18%
Population	7%
Total	100%

(2) Final Output: Border Vulnerability



(3) Defined & Equally Weighted Border Vulnerability



(4) Methods Used

Data	Data Type	Process One	Data Output
Slope	Raster	Reclassified 1-9	Raster (Reclass)1
Population Density	Raster	Reclassified 1-9	Raster (Reclass)2
Land Cover	Raster	Reclassified 1-9	Raster (Reclass)3
Vegetation greenness	Raster	Reclassified 1-9	Raster (Reclass)4
Road	Polyline	Cost Distance	Raster (Cost) Road
Avoidances	Point	Cost Distance	Raster (Cost) Avoid
Rail	Polyline	Cost Distance	Raster (Cost) Rail
Helpers	Point	Cost Distance	Raster (Cost) Help
Stream	Polyline	Cost Distance	Raster (Cost) Stream

Data	Process Two	Data Output	Process Three	Data Output	Process Four	Data Output
Raster (Reclass) 1-4	Weighted Overlay	Terrain Suitability	---------->	Terrain Suitability	*Raster Calc* **or** *Weighted Overaly*	Border Vulnerability Raster
Raster (Cost) Road	Reclassified	Cost (Reclass)1	Weighted Overlay	Infrastructure Suitability	^	
Raster (Cost) Avoid	Reclassified	Cost (Reclass)2	^			
Raster (Cost) Rail	Reclassified	Cost (Reclass)3	^			
Raster (Cost) Help	Reclassified	Cost (Reclass)4	^			
Raster (Cost) Stream	Reclassified	Cost (Reclass)5	^			

Results and Discussion

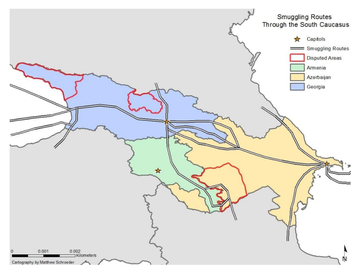
From viewing the maps to the right it can be seen that the Georgia–Russian Border is largely inaccessible due to the steep mountainous ranges of that area. Based on a 4km buffer (on each side of the border) it was found that the Georgian-Russian border had the lowest mean value which was 3.46. From viewing the maps and analyzing the data it was also found that the Nagorno-Karabakh border with Iran is the most vulnerable to illegal border crossings with a mean value of 5.28. You will also notice that the Azerbaijan border with Iran is one of the few with any values of 8 while the Georgian Russian border is one of the few with any values of 2. Overall this project brought in a great deal of data that could be harvested, analyzed and further help border control agents to better understand their borders.

Mean of Defined Weighted Buffered Raster Values						
	Georgia	Azerbaijan	Armenia	Russia	Iran	Turkey
Georgia		5.06	4.50	3.46		4.24
Azerbaijan	5.06		4.16	3.91	5.28	
Armenia	4.50	4.16			4.80	5.05

Defined Weighted - 4km Buffered - Vulnerability Raster												
	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	VARIETY	MAJORITY	MINORITY	MEDIAN
Nagorno-Karabakh	198,560.00	6,433,344.00	3	8	5	4.701	0.9647	933445	6	4	8	5
South Ossetia	119,330.00	3,866,292.00	2	7	5	4.278	0.9322	510484	6	4	7	4
Abkhazia	118,316.00	3,833,438.40	2	7	5	4.120	1.2528	487513	6	3	2	4
Georgia	506,352.00	16,405,804.80	2	7	5	4.037	0.9794	2044388	6	4	7	4
Azerbaijan	670,069.00	21,720,395.60	2	8	6	4.602	0.9934	3087633	7	4	2	4
Armenia	421,216.00	13,647,398.40	3	8	5	4.404	0.7648	1855146	6	4	8	4
All Borders	1,161,792.00	37,642,060.80	2	8	6	4.348	1.0215	5051955	7	4	8	4
All With Disputed	1,359,685.00	44,053,794.00	2	8	6	4.400	1.0364	5983268	7	4	8	4

km2 Area - Defined Weighted								
Border	2	3	4	5	6	7	8	SUM
Georgia Russia	276.50	4,874.55	2,903.04	360.51	136.40	41.89	-	8,592.90
Georgia Azerbaijan	-	51.19	700.39	1,769.82	995.20	8.04	-	3,524.63
Georgia Armenia	-	21.51	1,095.80	561.36	175.41	10.69	-	1,864.78
Georgia Turkey	-	177.29	1,626.09	640.32	70.76	1.94	-	2,516.41
Azerbaijan Armenia	-	1,087.73	5,368.49	2,099.65	202.27	4.86	-	8,763.00
Azerbaijan Russia	5.73	1,317.81	1,131.31	365.99	240.67	70.18	-	3,131.69
Azerbaijan Iran	-	113.98	1,331.45	2,063.30	2,541.52	415.92	7.52	6,473.68
Armenia Iran	-	6.35	172.59	207.68	71.12	9.56	-	467.31
Armenia Turkey	-	7.35	532.46	1,608.44	617.35	35.19	0.06	2,795.86
Sum	282.24	7,657.77	14,861.62	9,672.08	5,050.71	598.27	7.58	38,130.26

From comparing the border vulnerability output (figure 2) with a map pulled from the quarterly Journal (pictured below) you can see several similarities. The below map depicts what Arasli, Jahangir's research found to be smuggling routes through the South Caucus region. While viewing figure 2 you can see a clear link from Azerbaijan and Georgia which is one of two main routes for smugglers to take. You will also notice the weak Nagorno-Karabakh Iranian border which is the other route taken by smugglers. Although this final border vulnerability output isn't as detailed as was originally planned its application does show a lot of promise for future work.



Conclusion

By running various datasets through the two suitability models and finally the Border vulnerability model it was found that the Iranian border with Nagorno-Karabakh and Azerbaijan are the most vulnerable to illicit border crossings. It was also found that the Russian border with Georgia and Azerbaijan are the least vulnerable to illicit border crossings. Also it was found that the border vulnerability output lines up with past research conducted on smuggling routes thorough the defined study area.

Future research should look conducting further research into illicit border crossings which would greatly help define a accurate weighing system. Also higher accuracy data and faster computing should be used to obtain a more accurate and detailed result.