If You Fix it, They Will Come

Exploring relationships between seasonal travel time to markets and prevalence of underweight in Ethiopian children

Introduction

Ethiopia is a landlocked country, located in the horn of Africa. It typically has a tropical climate, with a rainy season occurring from June to September.

Figure 1. Location of Ethiopia and study area

In 1997, the Ethiopian Road Authority (ERA) embarked on an ambitious Road Sector Development Programme, aimed at restoring and expanding the existing road network. Part of the focus of the program was to improve rural roads, with objectives of providing access to areas that had agricultural potential, areas that were considered to have a deficit of food, and areas that were neglected.[1] As over 81% of Ethiopians were rural in 2013, the potential impact of improving rural roads was great.[2] The program showed impressive progress by 2009, with the proportion of rural roads in good condition increasing to 50% from 21% at program start.[3]

Though many improvements have been made, the country remains in a state where half of the existing rural roads are not in good condition, becoming impassable during the rainy season each year. As access to roads has been linked to improved nutritional status, continued improvement of rural roads could have a significant impact on a mainly rural population that contains approximately 25% of the children under five years of age suffering from underweight (weight-for-age z-score <-2, or too thin for their age) in 2014.[4]

The purpose of this analysis is to determine if a decrease in access to markets in the rainy season is correlated with underweight. This analysis identifies areas that essentially lose access to markets during the rainy season due to the condition of the roads, which can be used to inform the ERA of roads that, if improved, would have a large impact on the health of households in those areas.

Results

The underlying context for this analysis is shown in Figure 3, including locations of markets, road type, and land cover type. Households were clustered in small areas, therefore a single symbol is used in the maps to represent a "village" of households. Each "village" represent 12 to 83 households, for a total of 830 households analyzed.

As demonstrated in the maps to the right, significant difference in travel time to the nearest market was observed between seasons. Figure 4 displays the travel time to the nearest market during the dry season, while Figure 5 displays rainy season travel time, taking into account the decrease in speed and road availability as discussed in the methods section. Travel time was categorized into groups and displayed in Table 2, showing the number and the percent of households in each time category, for each season. According to this analysis, the mean travel time during the dry season is 2.3 hours and the majority of households need less than 1 hour to travel to the closest market. The rainy season analysis resulted in a mean travel time of 8.9 hours, with the majority of households requiring over 12 hours to travel to the closest market.

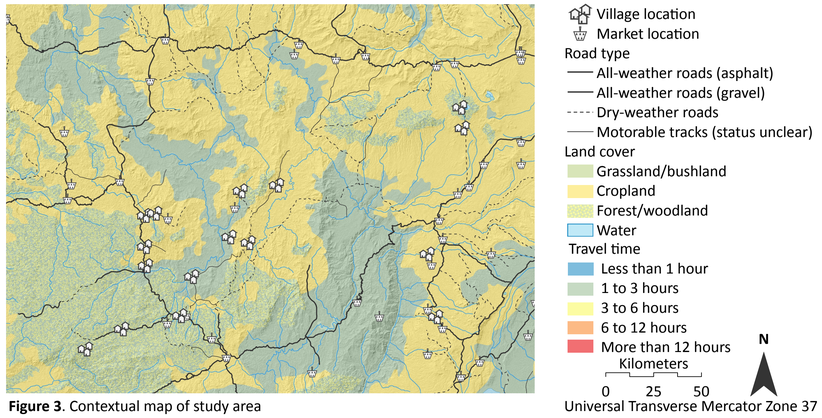

Figure 3. Contextual map of study area

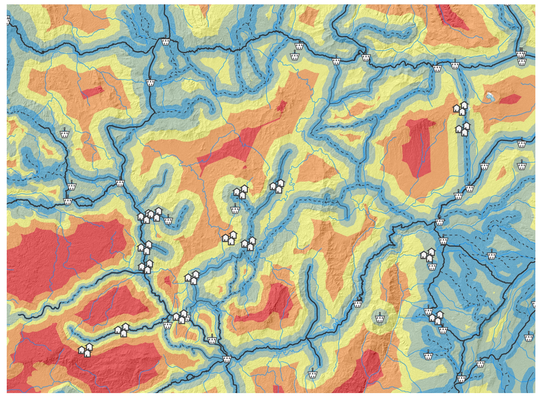

Figure 4. Map of travel time to markets in the dry season

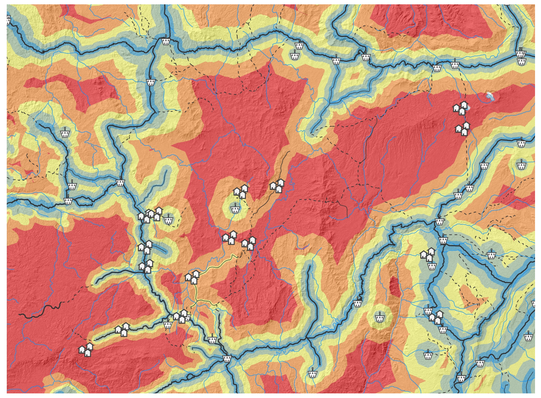

Figure 5. Map of travel time to markets in the rainy season

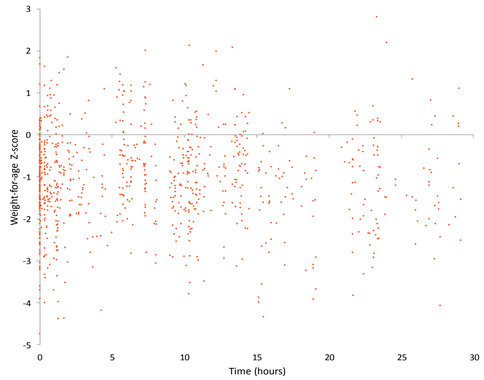

Figure 6. Scatterplot of underweight and travel time in the dry season

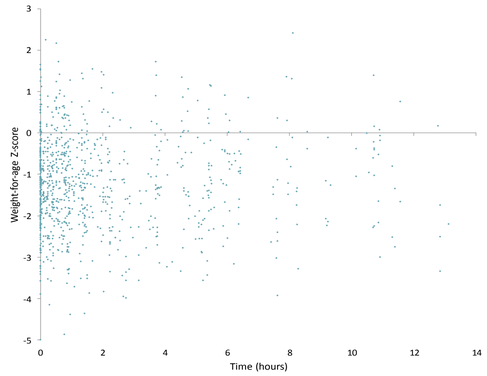

Figure 7. Scatterplot of underweight and travel time in the rainy season

Travel times in both seasons were extracted and plotted with underweight data for children under five in these households. Figure 6 shows the relationship between dry season travel time and underweight z-scores, while Figure 7 shows the relationship between rainy season travel time and underweight z-scores. Paired t-tests were conducted using Stata, and were used to determine the statistical significance of seasonal variation. This resulted in statistically significant p-values for travel time and underweight z-score at the 95% confidence level, indicating significantly higher travel time and lower underweight z-score during the rainy season.

	Dry season		Rainy season		Difference	
	No.	%	No.	%	No.	%
Less than 1 hour	499	48.9	181	17.8	380	37.3
1 to 3 hours	275	27.0	183	17.9	45	4.4
3 to 6 hours	147	14.4	106	10.4	201	19.7
6 to 12 hours	92	9.0	274	26.9	204	20.0
More than 12 hours	7	0.7	276	27.1	190	18.6

Table 2. Number and percent of households by travel time category

A map displaying the difference in travel time was created using the raster calculator tool; reference Figure 8. The mean difference in travel time between seasons is 6.7 hours, however the majority of households only need less than 1 additional hour to travel to the closest market during the rainy season, compared to the dry season.

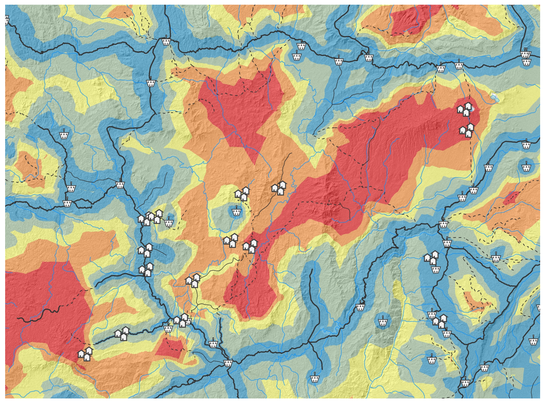

Figure 8. Map of travel time difference between dry and rainy seasons

Methods

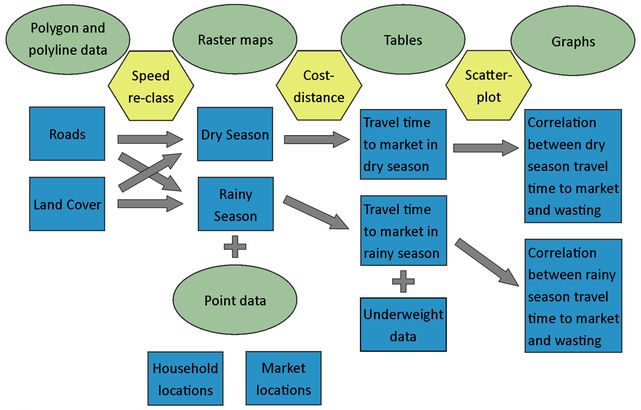

Figure 2. Methodology

Four components were used to estimate the amount of time it takes to travel from each household to the nearest market: roads, land cover, market locations, and household locations. The data for roads and land cover included distinct categories of road and land cover type, and are listed in Table 1 with the estimated average travel speed during the dry and rainy seasons. A cost-distance analysis was then performed, calculating the travel time to the nearest market. Travel time during the dry and rainy seasons were extracted from this analysis and plotted with underweight data collected in the corresponding season. The dataset of households used in this analysis was obtained from the ENGINE study, which provided anthropometric measurements of children and geographic location for each household.

	Traveling speed (km/h)	
Road type	**Dry season**	**Rainy season**
All-weather (asphalt)	70	70
All-weather (gravel)	45	40
Dry-weather roads	35	NA
Motorable tracks (status unknown)	35	30
Land cover	**Dry season**	**Rainy season**
Open or sparse grasslands, >50% croplands, mosaic of forest/croplands or forest/savannah	3	2.25
Deciduous shrubland or woodland, closed grasslands, desert and dunes, bare rock	1.5	1.125
Lowland forest, swamp bushland and grassland	1	0.75
Submontane and montane forest	0.6	0.45
Dense forest, swamp forest, mangrove	0.3	0.225
Water	NA	NA

Table 1. Road type and land cover speed assignments in dry and rainy seasons

Limitations

The locations of markets were one noteworthy limitation of this analysis. Market locations are not well documented and informal markets that were not included in this analysis undoubtedly exist. However, because not all market locations are known, this analysis combined two reputable datasets of known markets, supplemented with locations of settlements. Previous work used locations of settlements over 5,000 people as a proxy for markets, as a settlement of this size would create high enough demand for agricultural and livestock products to generate informal markets in the absence of a more formal market location.

Another limitation is how speeds were assigned to roads and land cover. This model assumed that households used to a motorized vehicle for road travel and were walking over land, however a more comprehensive model would consider other means of travel, including motorcycle, horse or horse-drawn cart, bicycle, etc. Though defining road and land cover speeds would be difficult, the vast majority of Ethiopians do not own a car thus including alternative travel methods would provide a more accurate analysis.

Finally, the results of this analysis are not generalizable to the overall population in Ethiopia since only ENGINE households were included in the analysis. However, the same analysis could be done using fine-grain population density in place of ENGINE household locations. An analysis using population density would help determine which areas would be most impacted by construction of new and restoration of existing roads, making this a valuable decision-making aid and an effective tool for resource allocation.

References and Data Sources

References

[1] Gebriel, Zaid Wolde. "RSDP Performance: Twelve Years Later." Addis Ababa: Ethiopian Roads Authority, November 2009. http://www.era.gov.et/Portals/0/RSDP%20III_Second%20Year%20Ass%20_Nov_2009.pdf.

[2] "Statistics." *UNICEF*. Accessed May 5, 2016. http://www.unicef.org/infobycountry/ethiopia_statistics.html.

[3] Shiferaw, Admasu, Mans Soderbom, Eyerusalem Siba, and Getnet Alemu. "Road Infrastructure and Enterprise Development in Ethiopia." International Growth Centre, September 2012. http://www.theigc.org/wp-content/uploads/2015/02/Shiferaw-Et-Al-2012-Working-Paper.pdf.

[4] "Nutrition Landscape Information System: Nutrition Landscape Information System (NLIS) Country Profile." Accessed May 4, 2016. http://apps.who.int/nutrition/landscape/report.aspx?iso=eth.

Data Sources

Household locations and child anthropometry: ENGINE dataset (rounds 3 and 4), March 2016
Hydrography: International Livestock Research Institute, 2007
Land cover: International Livestock Research Institute, 2007
Market locations: Famine Early Warning Systems Network (FEWSNET) and World Food Programme
Settlement locations: CIESIN, 2001
Roads: Ethiopian Road Authority, November 2015

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May 2016, NUTR231 Fundamentals of GIS

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