Johnson KB, Jacob A, Brown ME. Forest cover associated with improved child health and nutrition: evidence from the Malawi Demographic and Health Survey and satellite data. Glob Health Sci Pract. 2013;1(2).

APPENDIX. Technical Description of the Satellite Remote Sensing Data Used to Analyze the Relationship Between Forest Cover and Child Health and Nutrition Outcomes

Earth scientists use satellite remote sensors to measure and map the density of green vegetation on Earth. They use these data to monitor major fluctuations in vegetation and to understand how those fluctuations affect the environment. The data are also used by programs such as the Famine Early Warning Systems Network (FEWS NET) funded by the U.S. Agency for International Development (USAID),[1] which helps food security analysts determine and predict household risk of food insecurity, and provides decision-makers with timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. (For more information about FEWS NET, see www.fews.net.)

One type of satellite data used in our analysis of the relationship between forest cover and child health and nutrition outcomes are results of land vegetation assessments from July 1981 through December 2008, known as Normalized Difference Vegetation Index (NDVI) composites.[2] These data come from the NASA Global Inventory Monitoring and Modeling Systems (GIMMS) group at NASA's Biospheric Sciences Branch, and they are obtained from a satellite instrument known as the maximum value Advanced Very High Resolution Radiometer (AVHRR).

The NDVI data set is global and has a spatial resolution of 8,000 m. Spatial resolution is the ability of a sensor to identify the smallest size detail of a pattern on an image. For the NDVI measure, a resolution of 8,000 m means that there is 1 measure of the health of the plant canopy across an 8 km x 8 km area. The information combines multiple observations across an 8,000 m x 8,000 m region to provide 1 integrated number. A post-processing satellite drift correction has been applied to this data set to further remove artifacts due to orbital drift and changes in the sun-target-sensor geometry.[3]

The GIMMS operational data set incorporates data from sensors aboard several satellites operated by the National Oceanic and Atmospheric Agency (NOAA) (specifically, satellites NOAA-7 through 14). The data from the AVHRR on NOAA-16 and 17 uses data from the French satellite sensor, called SPOT Vegetation, as a bridge for a by-pixel inter-calibration.[4] Despite its coarse resolution, the AVHRR data are well-correlated with vegetation data from other sensors.[5-6]

The AVHRR sensor collects images of the Earth's surface and measures the wavelengths and intensity of visible and near-infrared light reflected by the land surface back up into space, capturing the activity of chlorophyll in a given area at a given time. These data are used with the NDVI algorithm to quantify the concentrations of green leaf vegetation around the globe. NDVI provides an integrated estimate of vegetation health and a means of monitoring changes in

vegetation over time, because when plants are not healthy their photosynthesizing activity shuts down and the NDVI value plummets. The possible range of values is between -1 and 1, but the typical range is between about 0.1, referring to areas of bare soil, and 0.8, which is the upper boundary typical for the African continent. The values are multiplied by 1,000 to remove rounding errors.

The formula for calculating NDVI is: NDVI = (NIR – Red)/(NIR + Red), where the Near Infrared (NIR) information is obtained from AVHRR Band 2, and Red is given in AVHRR Band 1.

NDVI data are available from 1981 through 2012, resulting in a 30-year continuous time series.[2] In our analysis of the relationship between forest cover and child health and nutrition, we used an annual NDVI variable (to control for the interannual variability of rainfall) that is the average NDVI for December, January, and February (the growing season) of the given year of the survey.

Another type of satellite data that we used in our analysis is called the Vegetation Continuous Fields (VCF) collection, which contains proportional estimates for vegetative cover types: woody vegetation, herbaceous vegetation, and bare ground. The data are derived from all 7 bands of the MODerate-resolution Imaging Spectroradiometer (MODIS) sensor onboard NASA's Terra satellite. The continuous classification scheme of the VCF product may depict areas of heterogeneous land cover better than traditional discrete classification schemes. Traditional classification schemes indicate where land cover types are concentrated, but the VCF product excels in showing how much of a land cover such as "forest" or "grassland" exists anywhere on a land surface.[7] The resolution of the MODIS data is 250 m, which we averaged to 5 km to accommodate the spatial displacement of the DHS cluster. For the VCF measure, a resolution of 250 m means a forest clearance on the ground must be at least 250 m^2 in size for it to be distinguished from the forest surrounding it.

REFERENCES

1. Brown ME. Famine early warning systems and remote sensing data. Heidelberg, Germany: Springer Verlag; 2008.

2. Tucker CJ, Pinzon JE, Brown ME, Slayback DA, Pak EW, Mahoney R, et al. An extended AVHRR 8-km NDVI dataset compatible with MODIS and SPOT vegetation NDVI data. Int J Remote Sens. 2005;26(20):4485-4498. CrossRef

3. Pinzon J, Brown ME, Tucker CJ. Satellite time series correction of orbital drift artifacts using empirical mode decomposition. In: Huang N, Shen SSP, editors. Hilbert-Huang Transform: introduction and applications. Hackensack, NJ: World Scientific; 2005. p. 167-186.

4. Achard F, Malingreau J-P, Phulpin T, Saint B, Saugier B, Segun D, et al. A mission for global monitoring of the continental biosphere: the "Vegetation" Instrument on board SPOT 4. Toulouse, France: LERTS; 1992.

5. Brown ME, Pinzon JE, Didan K, Morisette JT, Tucker CJ. Evaluation of the consistency of long-term NDVI time series derived from AVHRR,SPOT-vegetation, SeaWiFS, MODIS, and Landsat ETM+ sensors. IEEE Trans Geosci Rem Sens. 2006;44(7):1787-1793. CrossRef

6. Fensholt R. Earth observation of vegetation status in the Sahelian and Sudanian West Africa: comparison of Terra MODIS and NOAA AVHRR satellite data. Int J Remote Sens. 2004;25(9):1641-1659. CrossRef

7. Hansen MC, DeFries RS, Townshend JRG, Carroll M, Dimiceli C, Sohlberg RA. Global percent tree cover at a spatial resolution of 500 meters: first results of the MODIS Vegetation Continuous Fields algorithm. Earth Interact. 2003;7(10):1-15. CrossRef