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Making Visible the Invisible: Nighttime Lights Data and the Closing of the Human Rights Information Gap

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Abstract

War, poverty, geographical remoteness and political isolation all contribute to unreliable or non-existent data for developing regions of the world. As a consequence, research within these areas has been hampered by an abject lack of data in underdeveloped regions. The satellite-based nighttime lights data introduced here may hold the potential to overcome this problem by providing a proxy measure for large numbers of variables dealing with second and third generation human rights issues. The images presented here represent some of the newest forms of data available to social science investigations and those interested in human rights studies, and are already being used to estimate national and sub-national socioeconomic variables, such as gross domestic product (GDP), income and wealth per capita, population density, urban development, and even CO2 emissions. Beyond its usefulness in these areas, nighttime lights images may also yet reveal embedded information about population growth, mortality rates, migration, subnational poverty rates and infant mortality. The following "Notes from the Field" is a photo-essay geared toward a general audience of practitioners and academics, and is meant to introduce to these audiences a new form of proxy data in the hopes that it will be more widely used by the human rights community in such a way that it can begin to fill-in what has been called an "information gap" on human rights data for some regions of the world.

Key Words

Satellite-Based Nighttime Lights Data, Human Rights, Information Gap, and Underdeveloped Regions

"It is indeed a human right to be counted in population statistics in an accurate and timely manner and [no one] should be 'invisible' in national and international statistics." (Freemantle, 2010)

Satellite-based nighttime lights data depicted here, represent a possibility for a border-breaching, interdisciplinary approach that may hold the promise to allow social scientist and human rights organizations to gather information to better formulate policy on second and third generation human rights, in regions of the world where such information is currently lacking or highly unreliable.

A distinction first proposed by Karel Vasak, second and third generation rights demark the turn toward social justice in human rights movements, and often refer to social, economic, cultural and

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environmental rights. These are separated from first generation human rights, which have typically designated traditional political and civic rights (Vasak, 1977). Thus second and third generation human rights expand notions of universal rights to include (but are not limited to) issues such as infant mortality, clean air, water and land, opportunities for economic development, and social and economic equality. While conceptual expansion of what constitutes human rights has progressed over the last several generations, it has also exposed a serious information gap on human rights issues for some regions.

While statistical and data infrastructure within private industry, governmental organizations and academia have produced a surplus in recent decades in usable data on and about developed regions, there are large swaths of the world outside of the borders of developed nations, where information, and especially statistical information, is greatly lacking or unreliable due to war, poverty, geographical remoteness and political isolation (Chen and Nordhaus, 2011). As a consequence of the dearth of reliable data for some regions of the world, and the great expense at collecting data in these locations, tracking and combatting human rights abuses in these regions has been hampered by an abject lack of information in poor regions. And this has had profound consequences for those working in the human rights arena

Of late, Jane Freemantle has been perhaps the most vocal in bringing attention to the harm to human rights efforts propagated by disparities in the availability of data between segments of the world community. In her *UN Chronicle* piece, "Indigenous Children- Their Human Rights, Mortality, and the Millennium Development Goals" (2010), speaking to the exclusion of readily accessible data to understand, much less combat human rights issues such as infant mortality and childhood poverty for indigenous children, Freemantle argues "All too often in the past we have seen the effect of policies that reflect the principle of 'no data, no problem, no change'" (2010: 1). A "gap" exists between the desire and mandate to promote human rights for people across the globe, and the ability to accurately and empirically assess human rights shortfalls, much less formulate good policy and law to address these.

The satellite-based nighttime lights data presented here, however, hold the potential to begin to overcome this gap by providing a proxy measure for large numbers of relevant social scientific variables on second and third generation human rights issue- especially poverty and infant mortality- that heretofore have been unavailable. Since the early 1990s, nighttime lights data have been used to estimate national and sub-national socioeconomic variables, such as gross domestic product (GDP), income and wealth per capita, population density, urban development, and even CO2 emissions (Henderson, Storeygard, and Weil 2012; Nordhaus and Chen, 2013; Chen and Nordhaus 2011; Sutton, Elvidge,

and Ghosh 2007; Ebener, et al. 2005; Doll, Muller and Elvidge 2000; Sanderson 2000; Elvidge et al. 1997). While most early efforts in utilizing nighttime lights data have been conducted by geography and remote sensing scientists, social scientists and human rights proponents have lagged behind in leveraging this proxy data.

Beyond its usefulness in providing valuable information on economic development, urbanization, and human impact on the environment, nighttime lights images may also yet reveal embedded proxy information about population growth, mortality rates, migration and childhood nutrition, just to list a few. While more work still needs to be done to test the data's ability to help predict these particular second and third generation human-rights related variables, initial work is already underway.

Nighttime lights data were initially gathered by US Department of Defense satellites starting in the 1960s to determine the extent of worldwide cloud coverage. These light images were later made publicly available as the Defense Meteorological Satellite Program Operational Linescan System (DMSP-OLS, 2012). The pixel, or the data unit, stored in a light image is extremely small, about 5X5 census blocks, and each pixel is assigned a certain value that reflects the brightness of the pixel as shown in Image 1 and Image 2. Pixel values can be aggregated to any level of political administrative or geospatially coded areas. For example, the values of pixels in Image 4 can be aggregated to the administrative II level in Image 3 using administrative boundary maps and the raster summation function in ArcMap program. The values of pixels can also be summed according to any geographic area to generate total luminosity of the area regardless the rigid national or state border. For example, the digital numbers of nighttime lights have been summed at the 1-degree by 1-degree grid cell over the entire globe in the studies by Chen and Nordhaus (2011) and Nordhaus and Chen (2014).

This is particularly important in gathering human rights data in a localized context- especially for regions with large indigenous populations. Lights from high-resolution images provide real-time and accurate information on brightness of small neighborhoods, city blocks and even isolated villages. Not only has it been found useful in predicting state-level estimates of variables such as infant mortality rates at the macro-level, but it also thus holds great potential in providing information for much smaller and isolated areas, and does so without subsuming isolated populations into national aggregate data- a process which often times hides substantial regional and ethnic differences in country and region-wide measures. This is especially important for indigenous populations that may otherwise be subsumed within larger national-level data. Put simply, not only does nighttime lights data provide information for regions of the world where no data is available, it provides more precise measures for those areas with pre-existing data.

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Nighttime lights, therefore, can be used in designing effective and precise localized policy- especially when combined with ethnographic and qualitative data on the given population- to address pertinent human rights issues.

The Defense Meteorological Satellite Program (DMSP) at the NOAA National Geophysical Data Center (NGDC) publishes multiple versions of nighttime lights data, including the “raw,” the “stable,” the “calibrated”, and the VIIRS nighttime lights (DMSP-OLS, 2012). The radiance calibrated lights data has better quality than the raw and stable lights data, but it is only available for 2006 (DMSP-OLS, 2012). The VIIRS lights data is the most recent lights product and is of the highest resolution (15-arc second) compared to other lights products. Among these lights products, the stable lights data is most often used in research because of its higher quality compared to raw light data, and the fact that it has been available for almost two decades.

Recent work in the social sciences is now focusing on the possibility of using nighttime lights to predict poverty and infant mortality in developing countries, both identified as human rights issues in the UN’s *Convention on the Rights of the Child* and the UN’s *International Covenant on Economic, Social and Cultural Rights*. Given very little standard statistical data available on poverty rates or infant mortality for developing countries, previous research in these regions has been limited and speculative due to the lack of reliable data. Initial results from ongoing research using lights data as a proxy for these human rights indicators, is revealing that lights data may be able to significantly predict poverty rates and infant mortality rates for developing regions (Chen, 2014). For instance, for every 1% increase in light intensity, it appears local poverty rate decreases by .001 for Vietnam, and by .0015 for Guatemala. For subnational areas in low-GDP and low energy-consumption regions, for every 1% increase in log lights the infant mortality rate (IMR) in the area decreases by .17% (Chen, 2013). Although further investigation and refined tests are still in the works, early investigation is pointing toward the immediate usefulness of nighttime lights data in investigating poverty and infant mortality issues in these underdeveloped world regions.

National and international governmental agencies and non-profits all stand to benefit from advancements in using luminosity data as a proxy measurement, as it provides more reliable, real-time, and cheaper data than what is currently available, if available at all, for underdeveloped regions of the world as the cost of obtaining luminosity-generated information on relevant variables, is much less than conducting a standard census or survey. It is estimated that the cost of the 2000 US Census was 4.5 billion, and the cost for the 2010 US Census was 14.5 billion, approximately 15 dollars per person in 2000 and 47 dollars per person in 2010 (Gauthier, 2002). Such costly, time-

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consuming surveys are unobtainable for poor countries. In comparison, the lights data as a by-product from DMSP is freely accessible to the public. Further, such data collection is not hindered by war, restricted access, or politically corrupt regimes that attempt to hide or refuse to document human rights abuses occurring within their borders.

Beyond its usefulness in providing data for geographical regions for which we have historically had none (or unreliable data at best), nighttime lights data as a predictor for unattainable sociological and human rights variables also holds practical and moral implications in the area of human rights policy. Satellite-based nighttime lights data undoubtedly provide an unprecedented ability to finally gather human-rights-related data that thus far, has been unavailable. In doing so, such data holds the possibility to make visible that which has been invisible, and in doing so, holds the promise to provide needed empirical data to help formulate and assess policy. As Freemantle has argued, "It is indeed a human right to be counted in population statistics in an accurate and timely manner and [no one] should be 'invisible' in national and international statistics."

The fact that satellite nighttime-lights data now holds the possibility to make visible that which some borders have previously made invisible to those working in the human rights field, is an important social scientific advancement, especially given the historical trajectory of the human sciences. Starting with the publication of Emile Durkheim's study on suicide, credited with being the first sociological use of statistical data in analyzing social phenomenon, the social sciences have progressively evolved from largely theoretical speculations, to data-driven, theoretical testing, empirical-based work. With the advent of modern technology in the form of satellite images with small pixels, coupled with sophistication of statistical modeling, there stands the possibility for the social sciences, governmental agencies and human rights organizations to expand beyond conventional survey data collection and testing. This provides the social sciences and those interested in the advancement of human rights the ability to finally begin to close the information gap between developed and underdeveloped regions of the world, and in doing so, provides the promise of generating more reliable data to inform policy on and about second and third generation human rights, and to do so in a highly localized context.

Image Credits

The lights data are credited to NOAA's National Geophysical Data Center. DMSP data collected by US Air Force Weather Agency. (<http://www.ngdc.noaa.gov/dmsp/downloadV4composites.html>). The data was retrieved June 10th, 2012.

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The poverty rate data are credited to the Poverty Mapping Project, the Center for International Earth Science Information Network (CIESIN), Columbia University; Global Subnational Infant Mortality Rates and SAE Poverty and Inequality [map]; CIESIN, Palisades, NY, USA. (<http://sedac.ciesin.columbia.edu/>). The data was retrieved March 15, 2012.

The infant mortality data are credited to Center for International Earth Science Information Network (CIESIN)/Columbia University. 2005. Poverty Mapping Project: Global Subnational Infant Mortality Rates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). <http://sedac.ciesin.columbia.edu/data/set/povmap-global-subnational-infant-mortality-rates>. Accessed August 1st 2013.

All data was processed and configured by the named author in ArcMap to produce the images as depicted here.

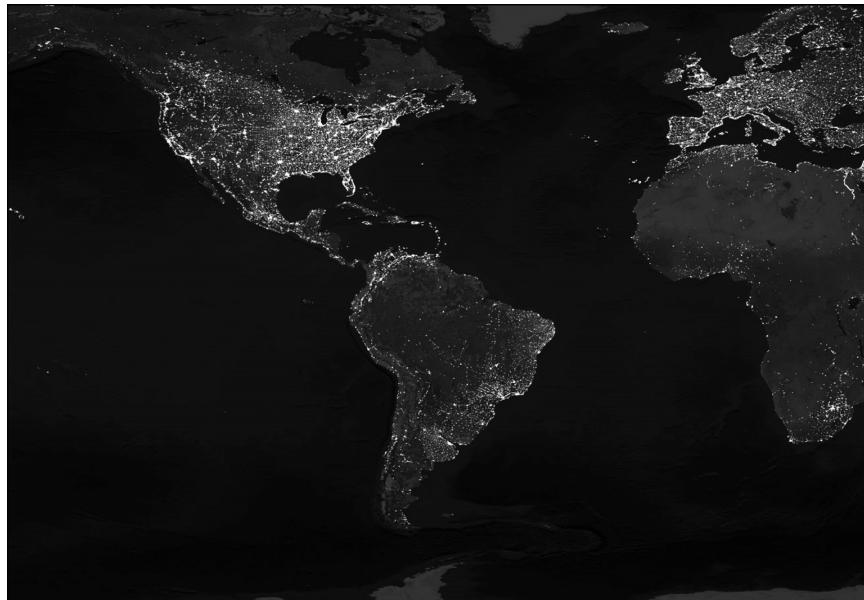


Image 1. Global image of nighttime lights (Stable lights 2006).

While visually appealing, beyond its aesthetic value, nighttime lights images such as the one above, contain embedded, real-time statistical data about numerous social scientific and human rights related variables.

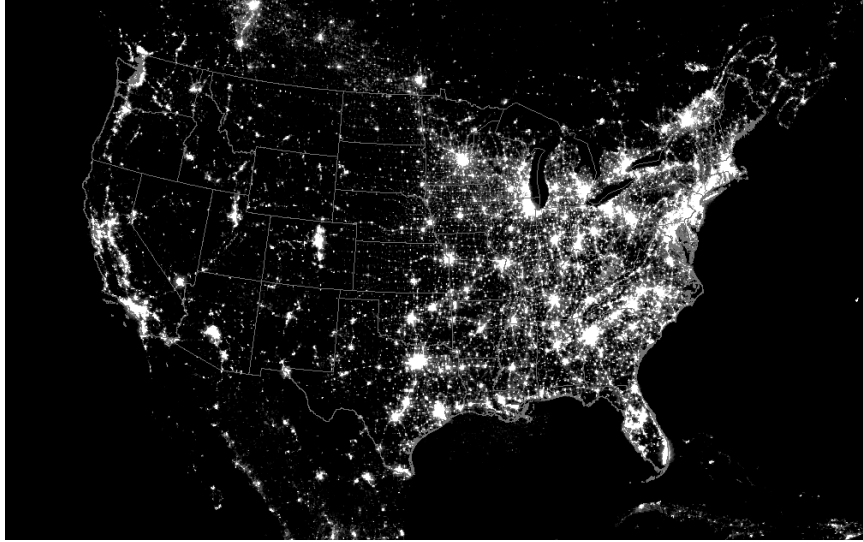
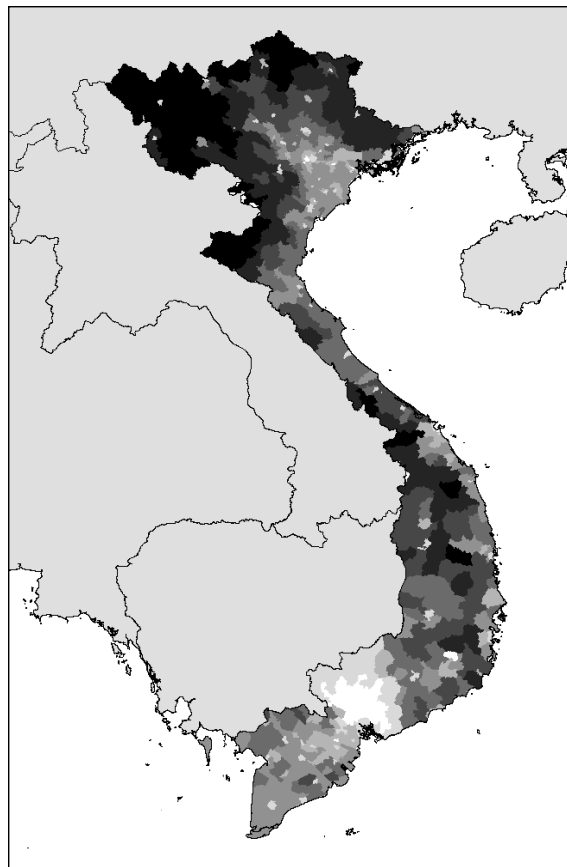


Image 2. Nighttime lights in North America (Stable lights 2006).

The satellite-based nighttime lights data depicted here, while a direct measure of nighttime brightness, also stands as an accepted proxy measure for GDP, income and wealth per capita, population density, urban development, and CO2 emissions. Beyond its known usefulness in providing data about these variables, it also holds the potential to reveal information on population growth, mortality rates, migration, subnational poverty rates and infant mortality- though more work needs to be done in these areas.

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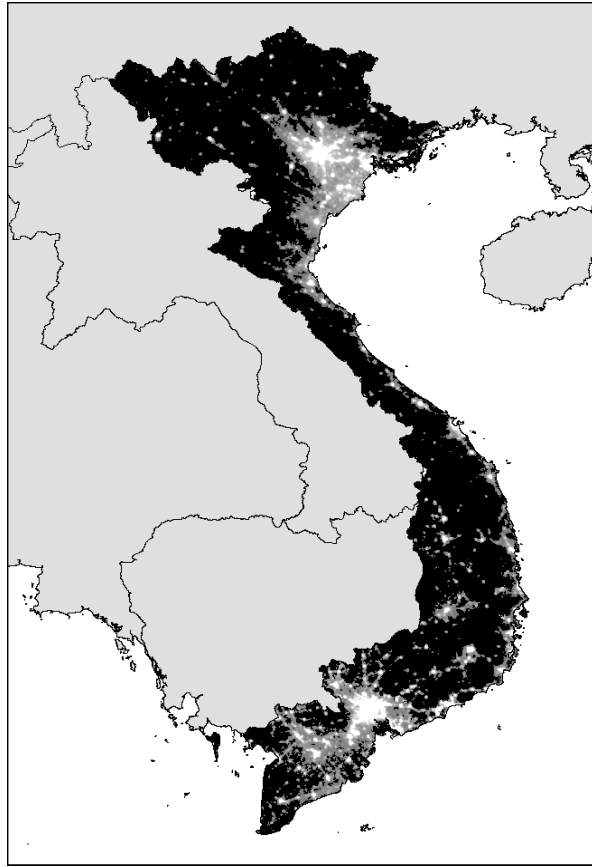


Image 3 and Image 4

These two images compare the poverty rates and nighttime lights for Vietnam. The image on the left is the Small Area Estimates (SAE) of poverty rate measured at the administrative II level. The image on the right is calibrated lights for the year 2006. While a cursory visual comparison of the two images indicate possible correlations between lights and poverty, more rigorous statistical testing is now bearing this out. Early statistical testing is indicating that in lieu of standard survey measurements of poverty, measurements that are often unavailable for many developing parts of the globe, nighttime lights data can provide supplemental, cheap and real-time data on variables such as poverty.

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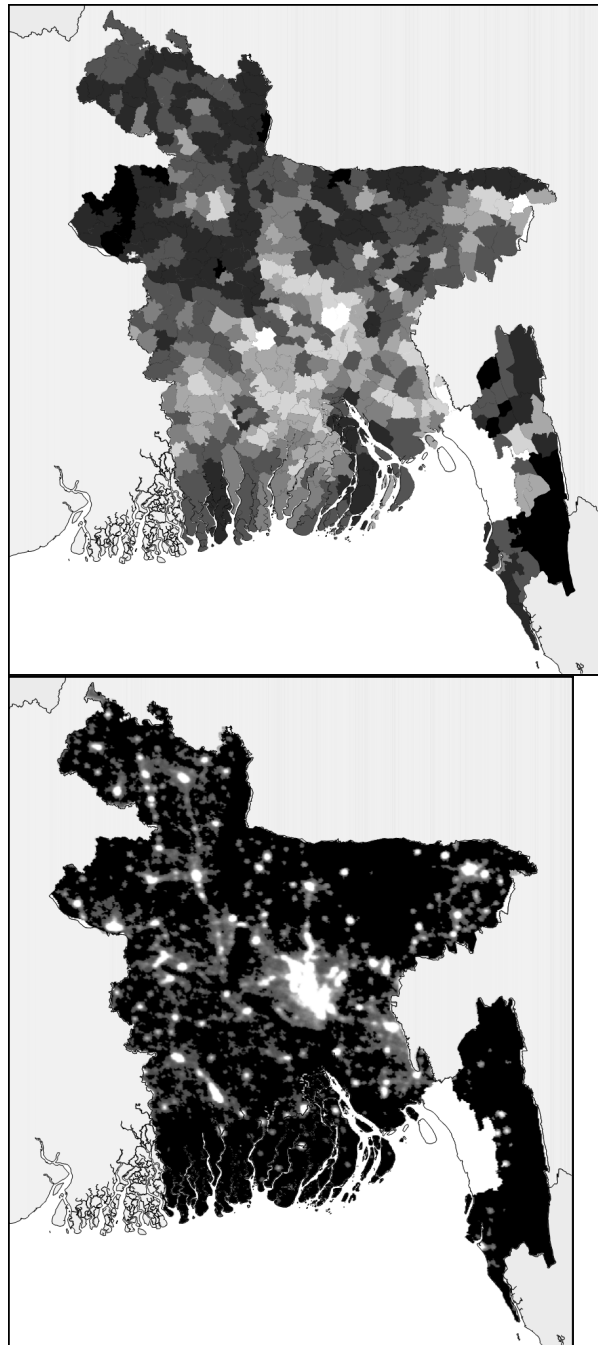


Image 5 and Image 6

These two images compare the poverty rates and nighttime lights for Bangladesh. The image on the left is the Small Area Estimates (SAE) of poverty rate measured at the administrative II level. The image on the

right is calibrated lights for the year 2006. Published studies have found nighttime lights data best utilized for those countries with low energy consumption and low per capita GDP (Chen and Nordhaus, 2011 and Chen, 2014)- making such data highly valuable for tracking many second and third generation human rights variables in underdeveloped regions of the world.

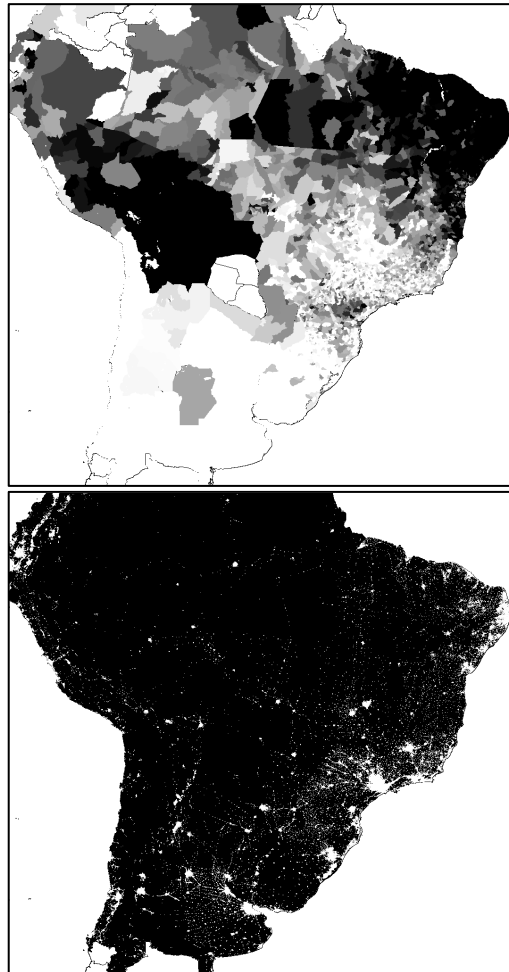


Image 7 and Image 8

These two images compare the infant mortality rate and nighttime lights for central South American countries. The image on the left is of the year 2000 infant mortality rate measured at the subnational administrative

level. The image on the right is of calibrated lights for the year 2006. The image on the left demonstrates the crude estimates of infant mortality rates that we currently have at the subnational level. The observed large areas of either black or white, the estimated state level rates, are the result of averaging urban and rural infant mortality rates, even including rates in remote regions and rainforest areas. However, the lights data on the right, derived from high-resolution images, provides information on brightness of small neighborhoods, blocks and isolated rural villages. Not only has lights data been found useful to predict state-level estimates of infant mortality, but it also holds a great potential in predicting infant mortality rates in much smaller areas and therefore holds substantial promise in designing effective localized policy- something currently not possible with the crude statistical (or non-existent) infrastructure in some regions of the globe.

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Xi Chen is an assistant professor in Sociology at Quinnipiac University. Her main research areas include quantitative research methods, spatial demography, income inequality, and Chinese Muslims. Her recent work investigating utilization of remote sensing nighttime lights information as proxy data and in social science research has appeared in the Proceedings of the National Academy of Sciences, *Journal of Economic Geography* and *Spatial Demography*. She also helps manage the GEcon data project at Yale University, (gecon.yale.edu), which produces a geophysically based data set on economic activity for the world.