Fertility and Urban Context: A case study from West Africa using remotely sensed imagery and GIS

Extended abstract

1. Background

In the coming decades most of the world's land cover and land use change is predicted to take place in the tropics, where population is growing the fastest (DeFries, Asner and Foley 2006). United Nations projections estimate that virtually all of the world's population between now and the middle of this century will emerge in cities of the developing world (United Nations Population Division 2011), driven by natural increase along with continued migration from rural to urban areas as people search for economic opportunity (Lee 2007). Literature on urbanization of the developing world is mostly focused on large cities and their prevailing slums, while largely ignoring the magnitude of urban growth that is taking place in small and mid-size cities (Montgomery 2008). However, most urban dwellers in Asia, Africa and Latin America live in urban settlements with less than one million people (Satterthwaite 2000), and it is in those intermediate cities and market towns that we can expect the most rapid rates of population growth (Cohen 2006). The expansion of social networks that is brought by urban growth is not only changing landscapes it is also reshaping traditional ways of thinking in areas such as family strategies (Newson and Richerson 2009). Studies in Sub Saharan Africa have found that urbanization is linked to decreasing fertility levels (Brockerhoff and Yang 1994, White et al. 2005). However as places are urbanizing rapidly, the rate of assimilation to the urban lifestyle varies and little is known about how the association between urbanization and fertility changes with heterogeneous urban contexts.

In sub-Saharan Africa total fertility rates (TFR) are amongst the highest in West Africa, a region that remains largely rural and where fertility is declining at a very slow pace. Within the region, Ghana is leading the fertility transition. With an average TFR of 4 children, it is ahead of neighbors such as Côte D'Ivoire with a TFR of 5 or Burkina Faso with a TFR of 6 (Measure 2008). Ghana is at the same time leading the urbanization trend spreading throughout the region, having become one of three countries with over 50% of their populations residing in urban areas as of 2010 (United Nations Population Division 2011). Understanding the demographic changes taking place in Ghana will help anticipate the demographic changes that will take place in the rest of the region as West Africa becomes increasingly urban.

This study investigates how landscape characteristics associated with urbanization in southern Ghana provide clues to changes taking place in the social context that are associated with fertility decline. An alternative definition of urban places is proposed, expanding on the classic classification of places as

either rural or urban. Using a gradient approach an urban context definition is proposed based on measures of landscape fragmentation generated by remote sensing and geographic information system (GIS) techniques. The overall objective is to test the hypothesis that the characteristics of the urban context in a region are associated with fertility outcomes.

Study area

In Ghana urban growth is spreading at fast pace, in 2010 the UN estimated that more than half of the country's population resided in urban areas, a figure that is projected to reach three quarters by 2050. Ghana Statistical Service estimates that population in Greater Accra increased from under 1.5 million in 1984 to almost 3 million in 2000. This rapid growth in urban population translates into dramatic changes in land use land cover. The study area for this research is located in southern Ghana, composed of 17 districts covering Greater Accra and 13 adjacent districts in the Central, Eastern and Volta regions. The coastal region of Ghana has seen a steady increase in population growth and urbanization because of the predominance of Accra's metropolitan area, but also because of growing intermediate cities such as Cape Coast, Takoradi, and Tema. The study site includes Greater Accra, the metropolitan fringe, periphery and hinterland. The districts selected for this study stretch over Accra's neighboring regions defined here as the capital's extended area of influence composed by a diverse urban landscape.

2. Methodology

The physical characteristics of urban places generate spatial and spectral signatures that are readily identified with remotely sensed data (Elvidge et al. 2004) and, as a result, detection and monitoring of urban growth at global, regional and local scales is increasingly relying on the use of such data (Potere et al. 2009, Small 2005, Ward and Phinn 2000, Lu and Weng 2006). In developing countries, where urbanization is taking place at the fastest rate (Miller and Small 2003), the geographic comprehensiveness of satellite imagery has turned it into a useful tool for quantifying and monitoring the distribution of human settlements (Harris and Longley 2002, Small 2003, Weeks 2004). While different urban land uses are composed of different combinations of land cover, a common denominator of cities throughout the world is the predominance of the built environment. This is why in remote sensing research urban landscapes are generally defined as impervious surfaces or built environments (Arnold and Gibbons 1996). The built environment corresponds to artificial structures such as buildings, paved roads, parking lots and sidewalks where cement or asphalt prevail (Weeks 2003, Lu and Weng 2008).

In this study degree of urbanization is estimated for a uniform grid cell unit of analysis using satellite imagery and a combination of remote sensing and GIS techniques. Moderate resolution optical and radar

imagery from Southern Ghana for 2000 are used to estimate vegetation and built land covers. Landscape metrics are calculated for vegetation and built land covers in order to examine landscape fragmentation. Proportions of land cover are combined with measures of landscape fragmentation to generate a definition of the urban context that is based in landscape patterns. This approach incorporates morphology into the urban classification scheme and proposes a nuanced definition of urban spaces allowing for differentiation of sparsely populated areas, small settlements, fragmented satellite cities, suburban fringe, sprawl and compact urban core.

Variables describing population, housing and fertility characteristics are created using the 2000 population and housing census. Enumeration area level variables are aggregated to the uniform grid cell level in order to model the association between fertility and urban context. Fertility levels are modeled through ordinary least squares (OLS) regression using urban context as the independent variable of interest while controlling for characteristics of the women, head of household and housing. The resulting residuals are then analyzed for spatial autocorrelation in order to identify whether there is a spatial component unaccounted for in the regression analysis. A spatial filter is used to decompose independent variables into spatial and non-spatial components which are then used as explanatory variables in the OLS regression. A spatial autoregressive (SAR) model is finally used to specify the remaining spatial autocorrelation within the error term and identify the magnitude of spatial effects found in unaccounted variables.

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