The Urban Transition in Ghana and Its Relation to Land Cover and Land Use Change Through Analysis of Multi-scale and Multi-temporal Satellite Image Data

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Objectives

1. Identify, map, and quantify land cover and land use (LCLU) and change (LCLUC) within an extensive study area in Ghana, particularly for the period 2000 through 2010.
2. Understand the regional impacts of LCLUC associated with rural-to-urban migration in driving these changes.
3. Assess LCULC and its effect on demographic and quality of life factors for four major urban centers during this time period.

Research Approach

- Map and quantify LCLUC at two spatial scales: (1) inter-regional scale for the Greater Accra, Central, Ashanti and Eastern regions of southern and central Ghana, and (2) intra-urban scale for Accra, Kumasi, Cape Coast and Obuasi, the four major cities within the study area
- Inter-regional identification of LCLU and LCLUC based on moderate spatial resolution, multi-temporal image data largely from Landsat ETM+/OLI and ERS-2/Envisat synthetic aperture radar (SAR)
- Intra-urban identification of LCLU and LCLUC based on high spatial resolution image data from QuickBird, WorldView, IKONOS and Geoeye commercial satellites
- c.2000 through c.2010 study period coincides with a period of demographic and health survey data for Ghana
- Utilize quantitative spatial analysis techniques to examine relationships between LCLU/LCLUC and magnitudes and changes of demographic, socioeconomic, and health variables using generalized linear and multi-level regression models, multinomial logit models, regression tree analysis, and agent-based models
- Emphasize the effects of LCLUC on quality of life indicators such as child mortality, slum indices, and food security, within four of the major cities of Ghana

Project Web Page

http://geography.sdsu.edu/NASA_IDS/research/ids.html

Study Area, Classification Scheme and Methodology

Inter-regional	Intra-urban
• Urban	• Residential
• Agriculture	• Non-residential
• Agriculture/natural vegetation mix	• Undeveloped, vegetated (including agriculture)
• Forest	• Undeveloped, non-vegetated
• Non-forest natural vegetation	• Water
• Water	
• Barren	

Figure 1. Map of regional study area (yellow) and study cities (red) in Ghana.

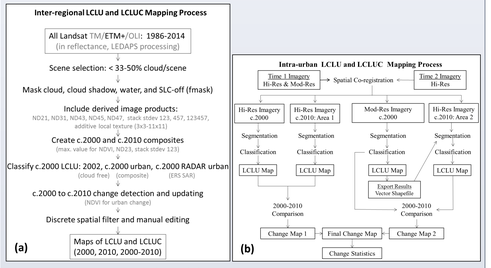

Figure 2. Processing flow: (a) inter-regional scale LCLU and LCLUC mapping; (b) intra-urban LCLU and LCLUC mapping.

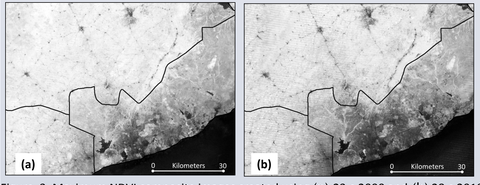

Figure 3. Maximum NDVI composite images created using (a) 23 c.2000 and (b) 28 c.2010 Landsat 7 ETM+ images with extensive cloud cover and SLC-off data gaps (Accra area).

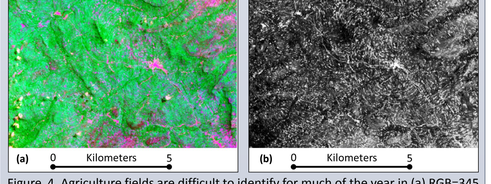

Figure 4. Agriculture fields are difficult to identify for much of the year in (a) RGB=345 image, but are evident in (b) S.D. transform of May/June Landsat 7 ETM+ data.

Inter-regional Land Cover and Land Use Classification

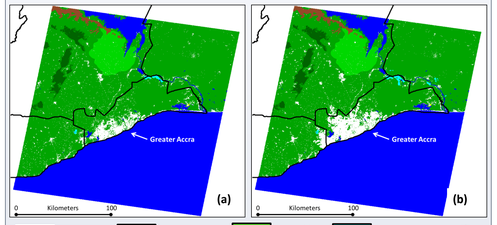

Figure 5. Example LCLU maps for (a) c.2000 and (b) c.2010.

Figure 6. Discr
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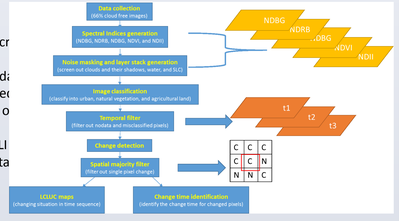
classification o
Landsat
TM/ETM+/OLI
dense time sta



Intra-urban Land Cover and Land Use Classification I

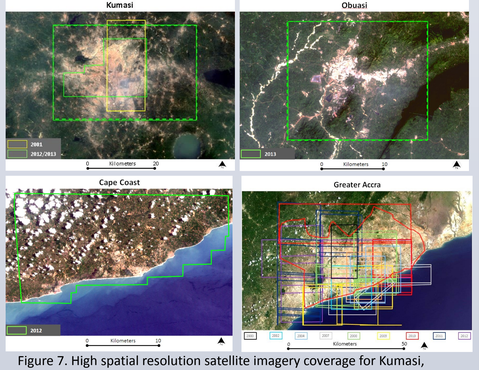


Figure 7. High spatial resolution satellite imagery coverage for Kumasi, Obuasi, Cape Coast, and Greater Accra. No c.2000 coverage for some cities.

Intra-urban Land Cover and Land Use Classification II

Figure 8. LCLU classification map for c.2000 based on QuickBird multispectral data (2.4 m) (right). Upper rectangular based imagery captured in 2000 and lower area a composite from 2002. An object-based image analysis approach was utilized.

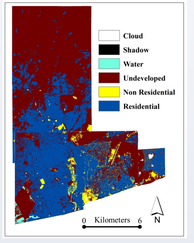
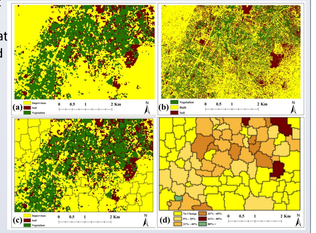
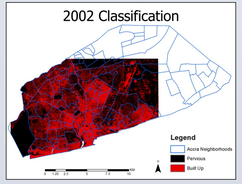


Figure 9. Initial approach to mapping LCLUC based on multiple spatial resolution data sets (below). Portions of all four cities for c.2000 are not covered by high spatial resolution imagery. An integration of Landsat 7 ETM+ and QuickBird imagery based on Vegetation-Impervious-Soil classification is demonstrated. Figure 9 includes: a) Landsat 2002 classified at 30 m, b) QuickBird 2010 classified at 2.4 m, c) Landsat segmented to create mapping units, d) change in impervious amount between 2002 and 2010 (infill and expansion).



Impervious
Soil
Vegetation



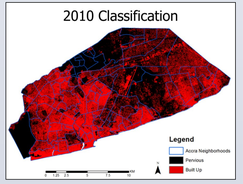
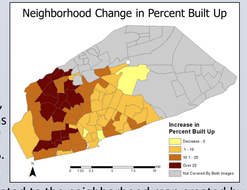


Figure 10. Maps of binary built-up and pervious surfaces were created using decision trees on Quickbird images for 2002 and 2010 (aggregated to 4.8 m spatial resolution). Approximately 200 combinations of individual bands, ratios, texture measures, and spatial resolutions were evaluated. The overall accuracy of the best products were found to be 83%.

The built-up area derived from the 2002 and 2010 Quickbird images were aggregated to the neighborhood map created by Engstrom et al. (2013). Once aggregated, the percent change in built-up area was calculated for the neighborhoods that were covered by both images.

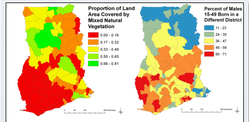


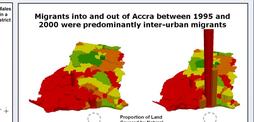
Engstrom, R., Ofiesh, C., Rain, D., Jewell, H., and Weeks, J. (2013) Defining Neighborhood Boundaries for Urban Health Research in Developing Countries: A Case Study of Accra, Ghana Journal of Maps DOI:10.1080/17445647.2013.765366

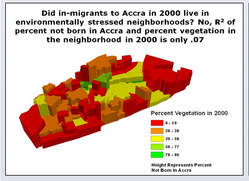
Demographic and Health Analyses

Central Hypothesis: Demographic and health outcomes in Ghana are strongly influenced by land cover and land use change (LCLUC)

Specific Hypotheses: (1) Districts with greater environmental stress will experience net-outmigration *(environmental stress measured initially by the type of land cover/land use as derived from satellite imagery)*, (2) migration is largely from rural to urban areas *(measured by migration data from the census) and* (3) within urban areas, migrants will be in the most environmentally stressed parts of the city *(measured by a combination of land cover and housing quality variables)*







More information about our research is online at; https://geography.sdsu.edu/Research/Projects/IPC/research/research.html

Benefits of Studying Ghana

- Abundant demographic and health data relative to rest of Sub-Saharan Africa
- Stable and democratic government and reasonably safe environment
- Leader in science and technology for Western Africa
- Research team has almost 10 years of experience working there
- Reasonable imagery availability relative to other Western Africa countries

Challenges Studying Ghana

- Prevalent cloud cover and winter Harmattan wind and dust storms
- Limited high spatial resolution satellite coverage for early 2000s
- Limited Landsat-5 TM receiving capability; Landsat 7 ETM+ SLC-off
- Census boundary files require georeferencing and substantial editing by SDSU team and delayed delivery of 2010 census data

Acknowledgements

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