Detecting and analyzing land use/cover changes in a hill station:
The case of Baguio City, Philippines

Ronald C. Estoque
Division of Spatial Information Science, Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan
Email address: purplebee80@yahoo.co.uk

1. Introduction

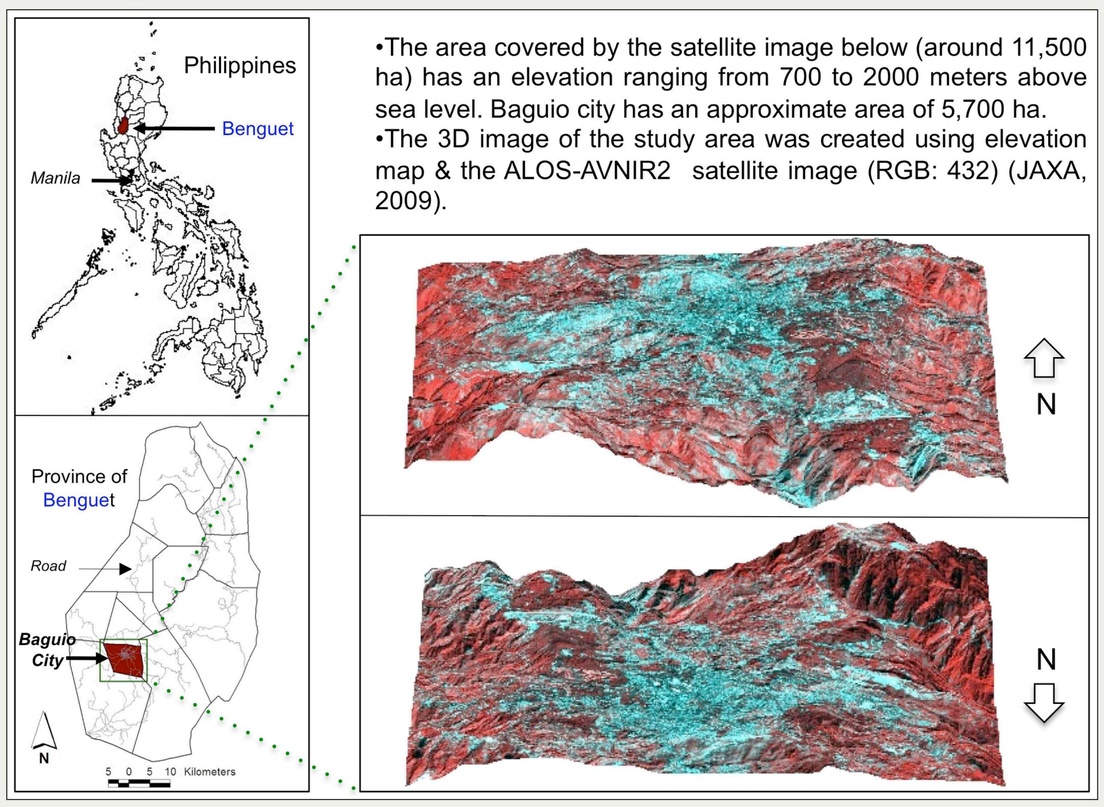
Baguio city, the summer capital of the Philippines, is one of the hill stations in Southeast Asia and the only one in the country. The city has enjoyed economic, political and social prominence for more than a century. The development and availability of basic and essential urban services and facilities have helped transform the city into a major educational and tourist hub in the region. In recent years, Baguio city has emerged not only as a leading industrial centre, but also as a health services centre north of Metro Manila. However, rapid urbanization and population growth are straining the city's resources. Such developments are beginning to take a toll on the people's well-being and on the environment.

In order to mitigate this current problem and to effectively plan for the future development of the city, studying the land use/cover (LUC) change patterns might be of great help, hence, this study.

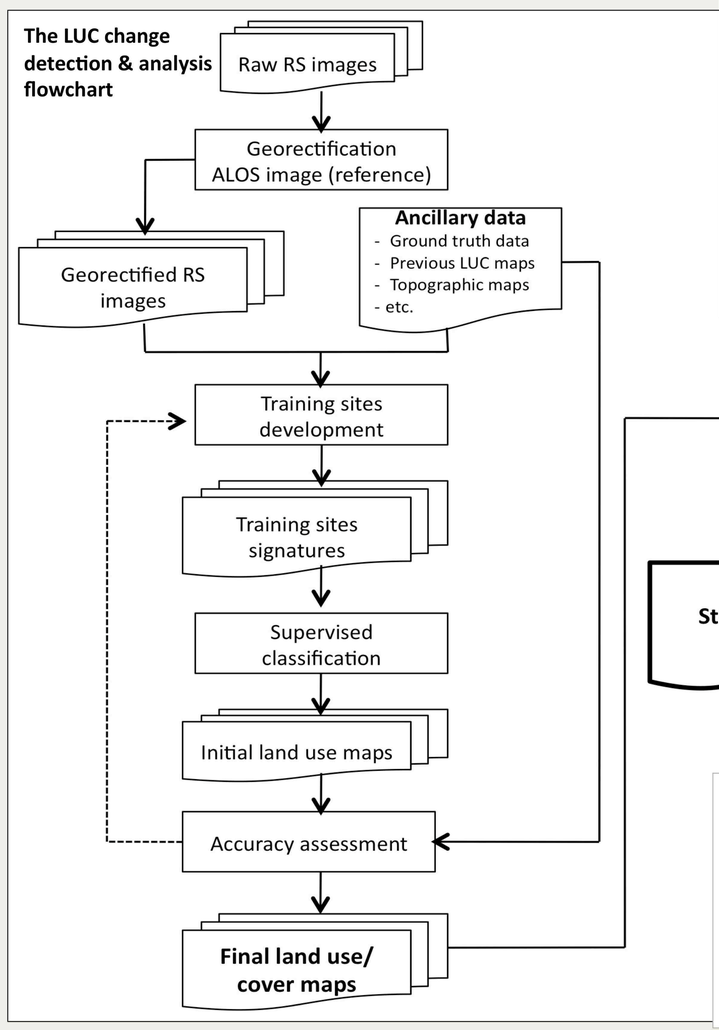
1.1. Objectives

The primary aims of this study are to detect LUC changes and analyze the possible driving factors of urban growth in Baguio City, Philippines, using Remote Sensing (RS), Geographic Information Systems (GIS) and socio-economic data.

1.2. Study site

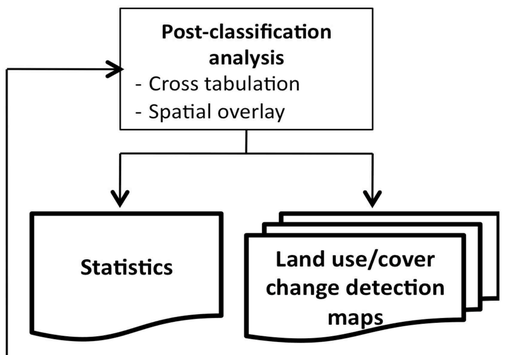


2. Methodology



Data used

Data	Date	Scale/ Resolution	Source
1. RS images			
ALOS-AVNIR2	2009	10 m	JAXA
Landsat TM	1998	30 m	USGS
Landsat TM	1988	30 m	USGS
2. Topographic maps	1977	1:50,000	NAMRIA-DENR
	1995	1:10,000	NAMRIA-DENR
3. Land use maps	1991	1:50,000	MGS-DENR
	2000	1:250,000	FMS-DENR
	2006	1:225,000	FMS-DENR
	2008	1:50,000	OCPDC-Baguio City
4. Ground truth and socio-economic data	2010	N/A	Field survey

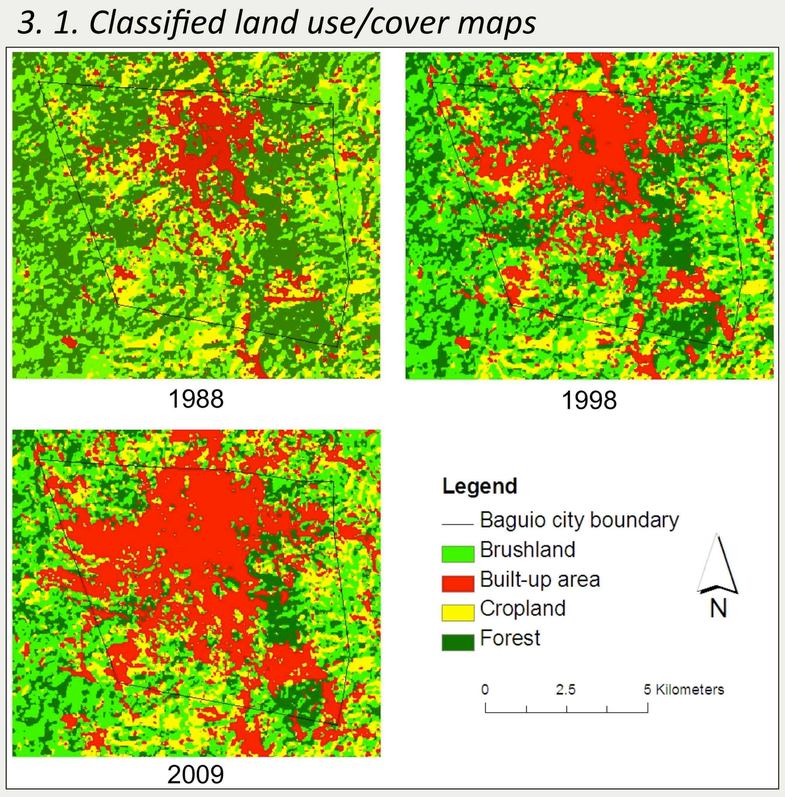


Analysis of the possible driving factors of urbanization

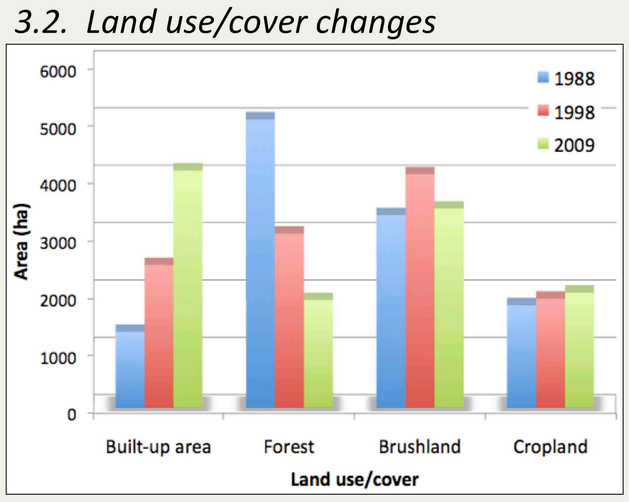
- Data used
  - Barangay (village administrative boundary) map
  - Elevation and slope maps
  - Road map
  - Tourism sites map
  - Census of population (1990-2007)
- Method
  - Correlation analysis

3. Results

3. 1. Classified land use/cover maps



3.2. Land use/cover changes



3.3.a. Major land use/cover conversions

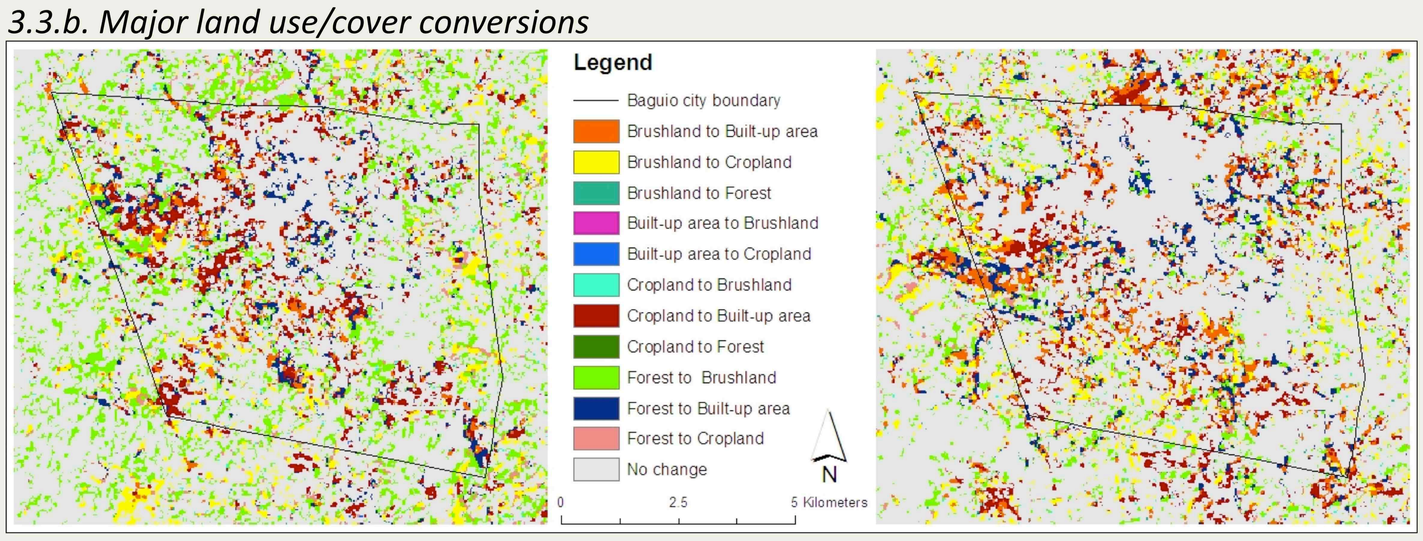
	1988-1998			1998-2009	
From class	To class	Area (ha)	From class	To class	Area (ha)
Forest	Built-up area	354.24	Forest	Built-up area	453.6
	Brushland	1410.75		Brushland	586.35
	Cropland	244.71		Cropland	151.02
Brushland	Built-up area	285.12	Brushland	Built-up area	677.52
	Cropland	462.15		Cropland	522.54
Cropland	Built-up area	545.49	Cropland	Built-up area	539.64
	Brushland	56.52		Brushland	38.79
Other conversions		36.63	Other conversions		51.12

3.4. Correlation matrix of the possible driving factors of urban expansion

Variables		Annual urban growth (%)	Mean slope (degrees)	Mean elevation (m asl)	Proximity to major road (m)	Proximity to tourist site (m)	Proximity to urban center (m)	Non-built-up area in 1988 (%)	Annual population growth (%)
Annual urban growth (%)	Pearson Correlation	1.000							
Mean slope (degrees)	Pearson Correlation	.218**	1.000						
	P – value	.006							
Mean elevation (m asl)	Pearson Correlation	.087	-.265**	1.000					
	P – value	.164	.001						
Proximity to major road (m)	Pearson Correlation	.106	.023	-.212**	1.000				
	P – value	.115	.396	.008					
Proximity to tourist site (m)	Pearson Correlation	.095	-.065	-.056	.714**	1.000			
	P – value	.142	.232	.264	.000				
Proximity to urban center (m)	Pearson Correlation	.188*	.051	-.227**	.533**	.493**	1.000		
	P – value	.016	.282	.005	.000	.000			
Non-built-up area in 1988 (%)	Pearson Correlation	.613**	.447**	-.267**	.176*	.041	.234**	1.000	
	P – value	.000	.000	.001	.023	.323	.004		
Annual population growth (%)	Pearson Correlation	.207**	.272**	-.278**	.028	-.068	.077	.346**	1.000
	P – value	.009	.001	.001	.377	.221	.193	.000	

**. Correlation is significant at the 0.01 level.
*. Correlation is significant at the 0.05 level.
N = 129 (Number of barangays (villages)
Formulae used: Annual urban growth (%) = ((2009built-up area of each barangay – 1988built-up area of each barangay) / (Area of each barangay * No. of years within the calculating period)) * 100 (Adopted from Xiao, et al., 2006).
Annual population growth (%) = (((2007population – 1990population)/1990population)*100)/17

3.3.b. Major land use/cover conversions



4. Discussions & conclusions

This study has assessed the LUC changes and the possible driving factors of urbanization in Baguio City, Philippines, using RS, GIS and socio-economic data. Results revealed that the study area has experienced great LUC changes. A great decrease in forest resources and a rapid expansion of urban/built-up areas have been observed. Analysis further revealed that slope, % non-built-up area, population growth and proximity to the urban center have better relationship associated with urban growth than the other variables. This study has contributed to the understanding of the spatial and temporal dynamics of LUC changes in Baguio city, which is a vital input in the succeeding steps to be undertaken in this research project such as predicting future LUC changes and assessing the environmental impact of such changes.

Future plans for this research:
Continue the analysis of the driving factors of urban expansion & LUC changes; predict future LUC changes; & assess the environmental impact of such changes.

Cited Reference:
Xiao, J., Shen, Y., Ge, J., Tateishi, R., Tang, C., Liang, Y., & Huang, Z. 2006. Evaluating urban expansion and land use change in Shijiazhuang, China, by using GIS and remote sensing. *Landscape and Urban Planning*. 75, 69 – 80.

Acknowledgment
The ALOS data used in this research from the JAXA collaborative project "Monitoring spatiotemporal patterns of urbanization using satellite remote sensing data" lead by Dr. Rajesh Bahadur Thapa (PI#536), University of Tsukuba is gratefully acknowledged.

(Poster presented during the CSIS Days 2010, University of Tokyo, Japan)