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URBAN SPRAWL: EXTENT AND ENVIRONMENTAL IMPACT IN BAGUIO CITY, PHILIPPINES

Lord Byron F. Gonzales[1], Saint Louis University, School of Engineering and Architecture, Environment and Habitat Planning, Baguio City, Philippines

Urban sprawl has emerged as a striking characteristic of recent global urban development. Land use policies advocating urban expansion for residential use to the detriment of a critical environment as in the case of Baguio City, Philippines, have shaped and reinforced the urban sprawl phenomenon. Urban sprawl is characterized by discontinuous, fragmented/leapfrog development, with random population densities. There are generally few studies regarding the environmental impact of urban sprawl and it is along this vein that this study was undertaken. The purpose of the study is to gauge how extensive urban sprawl has grown in Baguio City via Shannon's entropy model and to explore its impact on the city's environment. The result of the study revealed that urban sprawl prevails over the city's physical development. The proximity of the entropy value to the maximum reference value, indicate a highly dispersed urban development attributed to the continuous increase in population, coupled with the physical constraint of topography and its limited land area. The most critical issue challenging the local government of Baguio City and its people is the creation of a Long Term Development Plan that should strike a balance between local ambitions, demographic facts, and the environmental sustainability.

***Key words*: urban sprawl, urban growth, shannon entropy, environmental impact.**

INTRODUCTION

In the last few decades, there has been a wide and growing global interest in the field of urban sprawl as an elemental characteristic defining urban growth and development. The world population has been largely concentrating in urban areas. Since the 1950s, global urban population has nearly doubled twice, from 732 million to 2.8 billion. Urban populations already totalled more than 3.2 billion in 2006 (United Nations, 2006). Although alarms and challenges have already been raised in Europe (European Environment Agency, 2006), according to the United Nations, virtually all this growth has and will continue to take place in developing countries. Runaway urban growth and development have resulted in unbridled environmental degradation in the urban domain. Urban sprawl or the free-developing and non-coordinated growth of cities beyond their peripheries is not limited to any particular social, economic group, culture, or any place. It is primarily the consequence of population growth which is neither planned nor managed. This urban growth is propelled from the bottom and is influenced by a gestalt of forces mainly, but not exclusively, economic, but nonetheless having impacts that are difficult to explain (Besussi, 2003).

[1] Bonifacio Street Baguio City 2600, Baguio City, Philippines
arch_lbfgonzales@yahoo.com

The need for large scale and intermittent urban expansion will definitely result in the encroachment of the surrounding natural environment or open land parcels such as agricultural fields, forest lands and even wet lands. The transformation of these areas into non-reversible built-up areas may have important negative costs on the urban ecosystem, including the city's water system, biodiversity, and climate (Xu *et al.*, 2000).

Baguio City in the Cordillera Administrative Region in northern Philippines dramatically reflects the urban sprawl phenomenon. Complexity defines the management of Baguio's environmental and natural resources, mainly because of considerable issues, including its current designation as a town site reservation (a status which had its origins in the American colonial period), the plethora of various and often antagonistic ancestral land claims over large areas of the city, and the city's undulating to moderately steep topography. However, in spite of the presence of rigorous data painstakingly gathered through remote sensing and GIS in exploring the trends and patterns of urban growth and development, there are generally few studies in terms of the environmental impacts of urban sprawl.

It is along this vein that this study was undertaken. It aims to gauge the limits of urban sprawl using Shannon's entropy

model and integrating remote sensing and GIS in the analysis. This paper discusses the concept of urban sprawl and how this phenomenon occurred in Baguio City. Qualitative evaluation of data was also conducted to determine the environmental impact of urban sprawl in the city.

CONCEPTUAL OVERVIEW OF URBAN SPRAWL

Urban sprawl is a development observed after World War II. It was largely a consequence of the demand for improved housing conditions, a demand that arose out of the Great Depression, low family formation and low home construction rates. Urban sprawl was pushed strongly by leaps in technology as well as by business and marketing strategies that led to changes in demography from consumption rates to personal choices. There was also an increased importance of privacy and control over private affairs. Transportation preferences factored flexibility exemplified in the private automobile and the subsequent establishment of interstates and freeways (Schultink *et al*., 2005).

The term "urban sprawl" does not possess a standard definition. Ewing (1994) defines it in terms of "accessibility between related uses." He writes that poor accessibility arises from an inability to focus development or to functionally combine land uses. Urban sprawl has also been employed to refer to various urban forms, including contiguous growth in the suburbia, linear patterns of strip development, and leapfrog or scattered development. These forms have normally been related to patterns of modern centers where agglomeration grows out from malls, peripheral cities, and new towns and communities.

Burchell and Mukhjerji (2005) link sprawl to low density occupation as well as to leapfrog development characterized by unlimited expanses. In this wise, expansion occurs importantly in residential or non-residential forms in relatively idle environments. Everywhere, this development is of low density, leapfrogging, as it were, over the development of another area. While urban sprawl is a phenomenon common to both developed and developing countries, particular causes and specific attributes vary significantly. In developed countries, for instance, urban sprawl may arise from consumer tastes and preferences to innovative techniques of capital accumulation through real estate development. The European Environmental Agency, acknowledging this lack of consensual definition, simply defines sprawl as "'the physical pattern of low-density expansion of large urban areas, under market conditions, mainly into the surrounding agricultural areas" (European Environment Agency – Swiss Federal Office for the Environment, 2016).

Research on urban sprawl has been concentrated largely on mega cities and highly advanced metropolises (Hamidi and Ewing, 2014; Hennig *et al*., 2015). However, middle sized and smaller urban areas may experience the highest rates of urban sprawl. A case in point is Ajmer, a medium sized city located in the state of Rajasthan in India, where population growth has tripled, together with an increase of the urban zone from 1997 to 2002 (Jat *et al*., 2003).

Sudhira *et al.* (2003) elsewhere in India reported an expansion of the population by 54% in the last three decades of the 20th century, with a corresponding expansion of urban areas by a remarkable 146%, that is, slightly less than thrice the population growth rate. More recently, similar and parallel trends have been studied and analyzed in China (Su *et al*., 2010; Liu *et al.,* 2014) and Malaysia (Boori, *et al.* 2015) in Asia and Ghana in Africa (Cobbinah and Amoako, 2012).

The relationship between green areas in the urban fringe and the consequent reduction of agricultural land in China was also discussed by Su *et al*. (2010) who further emphasized the importance of government programs to ecological conservations and controlled urban expansion. Research on urban sprawl, however, remains relatively sparse in developing countries.

Thus, more studies on the emergence and unfolding of this process in particular areas, particularly in the South East Asian region, are necessary to understand trends, causes and consequences that should widen our perspectives of urban growth in areas where urban sprawl is more intense (Muniz *et al.,* 2007). In the Philippines, for example, while planners are concerned with the rational allocation of land uses within fast-growing municipalities and cities, scant attention or none at all is given to the phenomenon of urban sprawl in official planning documents such as the Municipal Comprehensive Land Use Plan.

The impact of sprawl-induced land use conversions is an increasingly significant concern both in urban and rural places. People do not really fully understand these impacts which may range from exhaustion of ground water resources by private deep wells, nitrate and phosphate contamination of ground water by private septic systems and contaminated runoff caused by pesticides and fertilizers to contamination sourced from industrial and commercial establishments and toxic substances from poorly designed landfills (Mohammadi *et al*., 2012).

URBAN SPRAWL PHENOMENON IN BAGUIO CITY

The Locus of the Study

The study finds ground in Baguio City, which is located in Benguet, the southernmost province of the Cordillera Administrative Region in the Philippines. It is bounded by the following municipalities, namely, La Trinidad in the north, Itogon in the east and Tuba in the southwest. Baguio City is the Philippine's "Summer Capital" with an average temperature of 19.7°C, generally lower by 8-10°C than those of the low land areas. The city is a plateau with an altitude of 1,417 meters above sea level. Its total land area of 5,749 hectares is characterized mainly by undulating to moderately steep slopes with grades of 19-50 percent (see Figure 1).

Baguio's transformation from "Kafagway" (the city's pre-colonial appellation) into the country's "summer capital" started in the late 19th century, when the Americans penetrated the Cordillera and established Baguio City as a Colonial Hill Station (Reed, 1999). The American colonial regime would eventually lead to the dispossession of the pre-colonial indigenous landowners of their lands for the purpose of requisitioning a military reservation (Cleto, 2012). Under the commission of then the United States Secretary of War William H. Taft on October 3rd, 1905,

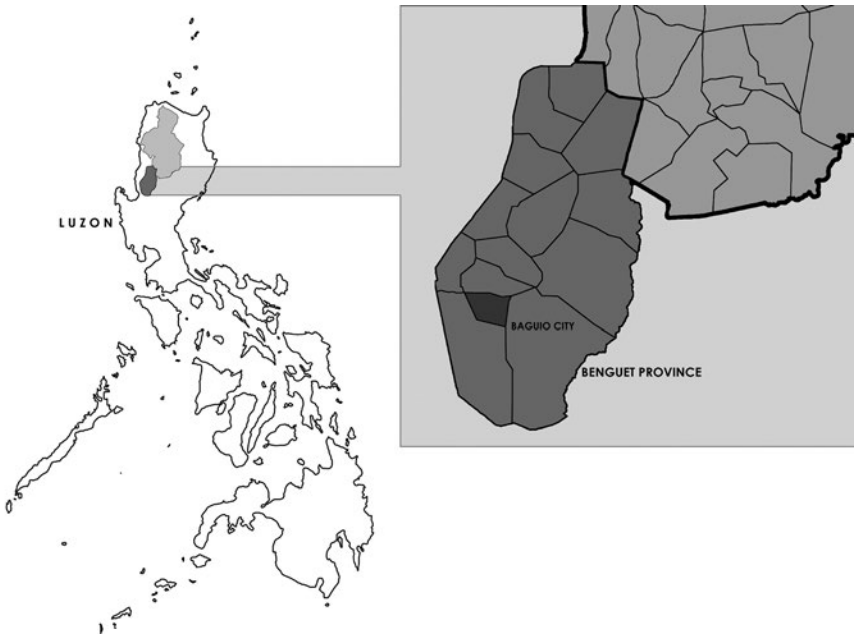

Figure 1. Location of the Study Area in the Province of Benguet, Philippines (Source: CLUP 2014-2023)

the American planner and architect Daniel H. Burnham formulated the comprehensive urban design of the future city (Boquiren, 1994).

It is interesting to note that Burnham strongly opposed to a dense settlement in Baguio, pushed for the regulation of the city's expansion, and promoted stringent laws for the purpose of preserving the natural environment. Burnham initially envisioned Baguio as a city of just 25,000 people. Unfortunately, Burnham's initial design, meant as the blueprint for the city's main thrust of development, was formulated without a formal survey (ibid.). At the brink of World War II, Baguio had grown into a centre of transportation, a medical and educational hub, and the administrative headquarters of highland industrial and commercial activities (such as mining, lumbering, tourism and vegetable production).

From the early 1900s onwards, Baguio City's urban population grew rapidly. In 2010, the City had an estimated population of 318,676 with a high population growth rate of 2.36% from 2007 to 2010. The city's population is expected to reach 344,070 by 2020 and may double in thirty (30) years (CLUP 2014-2023).

Methods and Procedures

The environmental and policy challenges posed by urban sprawl necessitate effective and integrated plans to be able to solve them. To be able to address the challenges however, there is a need for accurate and integrated tools to measure the phenomenon of urban sprawl. This research will therefore utilize qualitative and quantitative measures for a robust understanding of urban sprawl in Baguio City.

The quantitative tools used were the remote sensing, specifically the Geographic Resources Analysis Support System Geographic Information System (GRASS GIS) and the Quantum Geographic Information System (QGIS), as these two can be interfaced allowing morphological (physical and locational) classification of space. The second quantitative tool is the Shannon Entropy, also known as Shannon's diversity index, Shannon-Weaver or Shannon-Wiener Index. The qualitative tool used is the Galster *et al.* (2001) which uses configuration and density as criteria in classifying the sprawl typology.

Data-gathering proceeded on several levels. First, data on land uses in the City of Baguio at three points in historical time, i.e. 2002, 2010, and 2013 were primarily sourced from the City Comprehensive Development Plan (2014-2023). These were then independently validated by land use data from the Environmental Urban Planning Research Laboratory of Saint Louis University, School of Engineering and Architecture in Baguio City. Land uses were initially dichotomized into built-up and un-built areas. The built-up area was then re-classified into four policy areas (i.e. production, protection, settlement, and infrastructure), resulting in a cumulative and simplified categorization of land uses to which the Shannon's entropy model was applied. Shannon's entropy was thereafter computed for the years 2002, 2010 and 2013 and the results were analyzed as measures of urban sprawl at these particular points in historical time and for their cumulative impact on the city.

These measures of urban sprawl were complemented by imagery analysis. We utilized satellite images from Digital Globe 8 – band, taken in 2012. Grass GIS was used for remote sensing, while QGIS software was used for data display and analysis. Furthermore, available thematic maps prepared by the local government in reference to their Comprehensive Land Use Plan (CLUP) were employed in the analysis of the morphology of urban sprawl and its impact on the city's physical environment. The Galster Physical Patterns Defining Sprawl – a common tool used to provide a better apprehension of the physical attributes and typology of the prevailing urban morphology related to the urban sprawl phenomenon – provided the parameters in the characterization and classification of the urban form of the city.

RESULTS AND DISCUSSIONS

Measuring urban sprawl by Shannon's Entropy Model

As mentioned earlier, the quantitative data for the study was based from the total built up and un-built areas from years 2002 to 2013, which correspond to the four policy areas within any given political/administrative unit or territory. For the purpose of this study, the various land uses in the city have been classified in these policy areas. Areas for living included settlements or the residential land use; areas for making a living covered production areas, which included commercial, industrial, private and public institutions and the special economic zone; the areas to connect and support the settlements and production areas meant the physical infrastructure of the city, including utilities, airports, roads and bridges and the life support systems encompassed protected areas, including agricultural lands, forest and water reserves, creeks and rivers and others (Serote, 2004).

Protected areas are those that are not built over, but are left in their pristine conditions as they accomplish their purposes maximally, i.e. as a source of food, clean air, safe water and also as receptor of wastes generated in the settlements, infrastructure and production areas. The first three policy areas comprise the overall built up area. This re-categorization, thus, further reduces the territory into two broad policy areas: the built form and the un-built environment. The major focus of this study is on the measurement of urban sprawl. It employed Shannon's Entropy Model to gauge the extent of spatial concentration or dispersion of a geographical variable (xi) among n zones. The general structure of this model is reproduced as follows:

$$H = -\sum_{i=1}^{n}$$

Where H represents the value of Shannon's entropy, Pi represents the proportion of the variable in the ith zone and n is the total number of zones. Entropy value ranges from 0 to Ln (n) = maximum entropy and shows the urban sprawl physical growth. Here, if the value approaches zero, the distribution is very compact and if the value approaches Ln (n), the distribution is dispersed. The classified land use for both periods was divided into two categories; built-up and non-built up areas.

The result shows that for the years 2002, 2010, and 2013 the entropy values were registered at 1.7874, 1.4639, and 1.6577 respectively. This is indicative of a highly dispersed urban development which may be attributed to the continued increase in population, coupled with the physical constraints of the topography and limited land area. Shannon Equitability during the year 2013 indicates a more evenly dispersed rate of urban sprawl as compared to the year 2010 where it was closer to 1 (See Table 1).

This is due to the reduction of construction activities, especially in infrastructure sector, caused by the economic inflation problems experienced by the country in the year 2010.The actual magnitude of increase in development from 2002 to 2010 is 11.28% which is considered extensive, considering the limited land area compounded with topographical constraints of the city.

Table 1. Calculating Shannon's Entropy for Baguio City, years 2002, 2010 and 2013

LAND USE	EXISTING AREA (Has.)		
	2002	**2010**	**2013**
Residential	1,760.96	3,405.01	3,239.92
Commercial	201.35	282.77	317.13
Institutional	410.02	416.27	213.05
Park	48.83	70.68	81.32
Forest/Water Reserves	521.23	521.23	240.37
Special Economic Zone	288.1	288.1	301.86
Open/Vacant Forested Areas	1,951.80	566.21	591.84
Industrial	130.39	42.86	57.89
Airport	1.72	27.89	32.16
Cemetery	20.13	12.79	13.87
Abattoir	5.6	4.43	2.7
Utilities	0	15.74	8.54
Bureau of Animal Industry	0	95.02	104.35
Bureau of Plant Industry	0	0	8.98
Creeks/Roads	309.71	0	210.16
Reservation Area	0	0	323.55
Sewerage Treatment Plant	0	0	1.31
Agrarian Reserves	96.57	0	0
Dumping Site	2.59	0	0
TOTAL	**5,749**	**5,749**	**5,749**
Shannon's Entropy (H)	1.7874	1.4639	1.6577
LN(N)	2.6391	2.5649	2.8332
Shannon's Equitability (EH)	0.6773	0.5707	0.5851
Numbers Equivalent (Nq)	5.9739	4.3228	5.2472

From the geocoded data, it may be inferred that the urban area grew in all directions with more built-up developments towards the northern and north eastern part of the city; this is mainly due to the expansion of commercial areas originating from the centre of the city, coupled with real estate developments in all directions of the city.

Classification and influencing factors of urban sprawl in Baguio City

Different urban morphologies may be described with the use of a typology based on two continuous dimensions, which are made discrete here for explanatory purposes: settlement density (high and low) and physical configuration, ranging from contiguous and compact to scattered. Adopting the physical patterns defining sprawl (Muniz *et al.,* 2007), the general urban form of Baguio City is classified into two types: scattered and leapfrogging development which can be gleaned from the irregular settlement density and physical arrangements, extending from contiguous and compact to scattered and discontinuous developments. It can be posited that sprawl as a pattern or a process can be differentiated from the causes that lead to the emergence of such a pattern or from the effects of such patterns (see Figure 2).

This proposition undoubtedly states that the analysis of patterns and processes should be distinctively separated from the analysis of causes and consequences. Nonetheless, some studies (Schultink *et al.,* 2005) submit that the consequences of development bring forth a specific urban

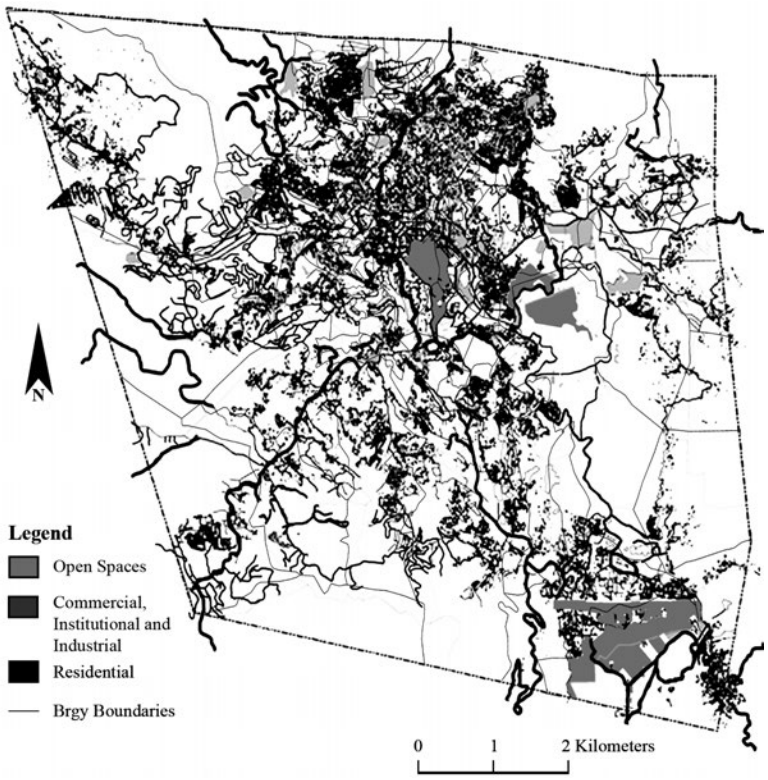

Figure 2. Baguio City Built-up Map, 2015
(Source: CLUP 2014-2023)

pattern as undesirable, not the patterns themselves (Galster *et al.,* 2001). Therefore, whether a pattern is positive or negative should be analyzed based on the factors that bring about such a pattern. Anent to this, the author deems it necessary to enumerate the influencing factors that cause urban sprawl in Baguio City. These factors are enumerated as follows: Rapid Population Growth, Slow Economic Productivity, Land Speculation, Land Use Conversion, Legal Disputes, Physical Geography, Lack of Affordable Housing, Transportation System and Failure to Enforce Planning Policies.

Cumulative environmental impact of urban sprawl in Baguio City

Although the problems associated with urban sprawl are far from being conclusive, the preponderance of evidence is nonetheless compelling. In the case of Baguio City, the decreasing area of prime open lands has long been identified as a negative consequence of urban sprawl even as the 2014-2023 Comprehensive Land Use Plan (CLUP) recommended increasing residential land usage to correspond to the shrinkage in the city's open areas. An assessment of the space covered by urban green spaces and even forest reservations in the city is difficult due to the variations in land use categories used in the said CLUP, which lists "Forest/Water Reserves" and "Open Areas" as land use categories (see Figure 3).

This is highly an evidence of a speculative and arbitrary nature on how open areas are reserved for urban expansion rather than for environmental protection. Currently, the city is mostly composed of residential lands, which take up 61% of its total land area. The second largest land use is for "Vacant Forested Area" at 12.38 %, followed by Commercial Land Use at 2.57 %. Meanwhile Forest/Watershed Reserves comprise 2.54 % of the city's lands.

Aside from the negative collaterals on open spaces and forest areas, urban sprawl and the pressure of continued population increase have moreover exerted a severe strain on the City's water resources (Su *et al.,* 2010). Several watershed reservations and four major waterways are situated in or pass through Baguio City. Although the Cordillera Region generally has a relatively high ground water storage capacity , the water requirements of the highly-urbanized Baguio coupled by its shrinking forest cover have apparently outstripped its water resources leading to water shortages in the city (CEPMO, 2010). To date, the dwindling water supply is at the top of the environmental problem of the city.

The pollution of the City's tributaries continues to be significant and waste generated by the city passes through the northern flanks of La Trinidad municipality where the highly polluted Balili River also passes through. Sources of pollution for the city's water ways include informal settlements along the water ways considering that most of the overflow from septic tanks and other waste products go directly to this river without a treatment system in place.

Currently, waste management easily qualifies as the biggest environmental problem in the city. The local government has been reported to collect 284 tons of garbage per day. The top source of waste is coming from residential areas at 43%, followed by food establishments at 22%. RA 9003, however, requires a certain level of segregation at source in spite of the fact that CEPMO (2010) admits that garbage

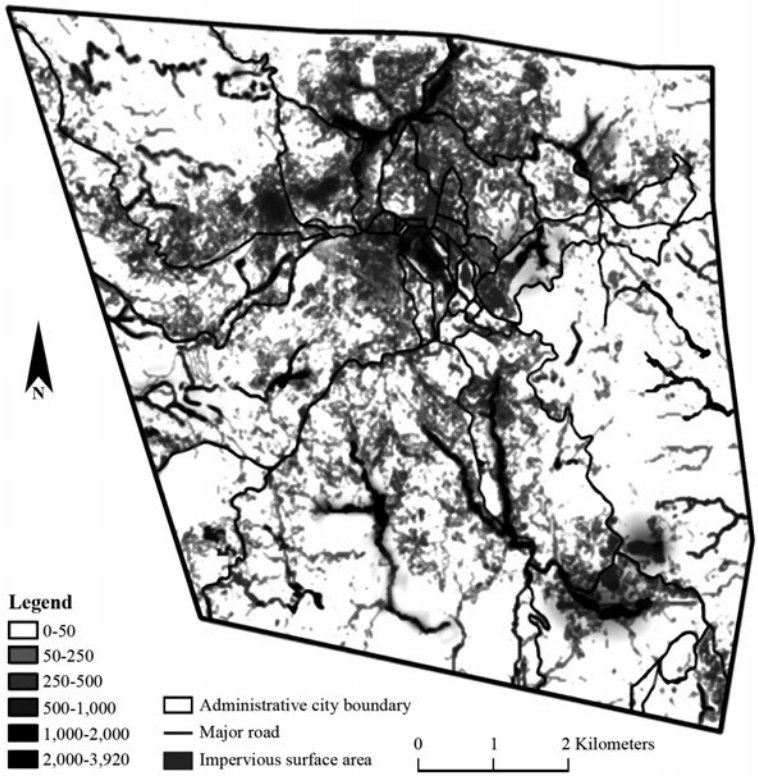

Figure 3. Flow Accumulation Model
(Source: CEPMO, 2010)

collection remains mixed. There is no existing sanitary land fill for Baguio City, most of the city's wastes are transported to Capas, Tarlac sanitary landfill, which is about 3 hours away from Baguio City. The management of the city's liquid waste is given to the Baguio City Sewage Treatment Plant (BSTP) which serves only 66 barangays or districts; the rest of the 63 barangays depend on individual septic tanks and natural canals contributing to a large degree on the aspect of water pollution.

In terms of transportation issues, the radial road network of Baguio City results in all traffic converging at the Central Business District of the city. The increasing dependence on private rather than public utility vehicles has promoted traffic congestion both in and around the city. As of 2007, the total of registered private and public transportation vehicles were recorded at 31,472. This is undesirably high, considering the small land area of Baguio City. With the high dependence on motorized form of transportation, the air quality in the city is deteriorating. According to the Community Environment, Parks and Management Office (CEPMO, 2010), the transportation sector remains the primary contributor to the carbon dioxide emissions problem, contributing 62% to total emissions. This is followed by residential areas at 22%, commercial areas at 10% and industrial areas at 6%.

In general terms, Baguio's fragile environment, as disadvantaged by the urban sprawl phenomenon, increases the population's vulnerability to the deleterious effects of climate change. CEPMO recently declared that Baguio City was now among the World Bank's Top Seven Risk-Prone Cities in Asia. The existing physical configurations of Baguio City in terms of its impervious surface ratio with its total land area are obviously beyond the expected dimension of a sustainable environmental quality.

CONCLUSION

The result of the study reveals that urban sprawl prevailed over the city's growth and development scenario. In quantitative terms, the proximity of the entropy value to the maximum reference value indicates a highly dispersed urban development attributed to the continued increase in population, coupled with the physical constraints of its topography and limited land area.

The planning pattern, where more and more lands are projected for residential use as reflected in both 2010-2020 and the 2014-2023 Comprehensive Land Use Plans (CLUPs) of Baguio City, is an evidence of an apparent paradoxical planned-uncontrolled urban growth caused mainly by the increasing population and the complexity of land management issues, chief of which includes the city's legal mandate as a town site reservation, the unresolved conflicts in ancestral land claims, squatting activities and real estate developments. Land use conversion by legal circumventions predominate the land use and environmental management aspects of the city, reinforcing the urban sprawl phenomenon to the detriment of the city's environmental sustainability.

Aggravated by the human foot print, Baguio City is currently stripped of a significant portion of the pine forest that had since served to resupply and replenish Baguio's aquifers. As a consequence, inadequacy now characterizes the city's groundwater supply, while excessive surface run off has annually flooded the lowest places of the city. Extensive development and construction in the city have also led to

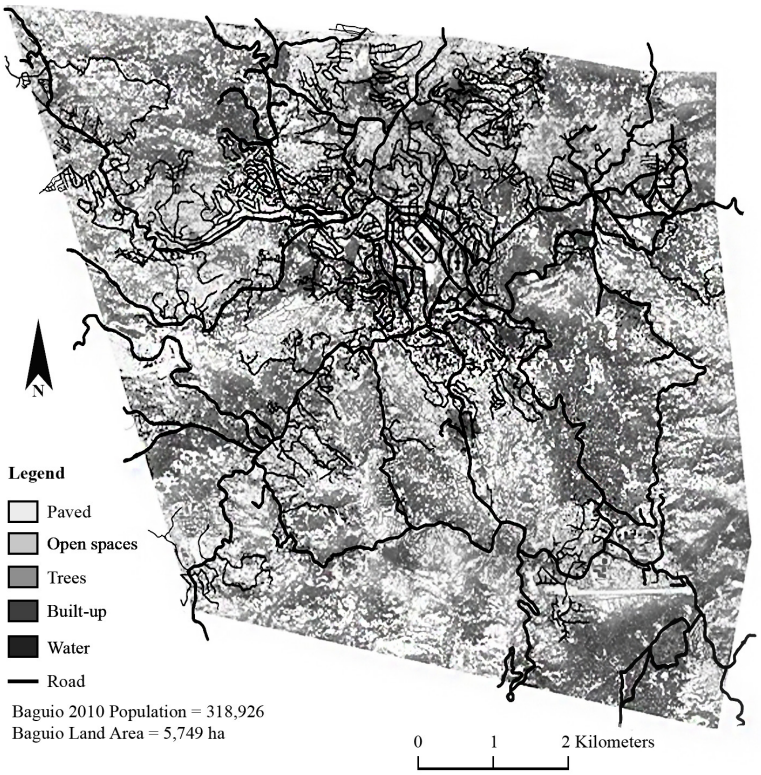

Figure 4. Baguio Environmental Footprint 2013
(Source: EUPRL, Saint Louis University, School of Engineering and Architecture)

the conversion of once thickly-forested slopes and hitherto highly absorptive substrates to impervious surfaces that define a poorly planned urbanization, resulting to a polluted environment (see Figure 4).

In relation to these findings, it is evident that the most critical issue challenging the local government of Baguio City and its people is the identification of the city's unique competences by designing a "climate smart" long term development plan which clearly specifies its regional role. If planning is to remove the city from the precipice of this environment and climate recipes, all efforts should be coordinated in the pursuit of a multi-year plan through a transparent participatory process. If Baguio City envisions itself to maintain environmentally competitive and sustainable, it must concentrate on striking a balance among local ambitions, demographic realities and the emergent challenges of the environmental impact of urban sprawl as well as climate change.

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