Mapping the Eco-Social Construct of Santa Rosa

An Emerging City in a Watershed of Opportunities for Development

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Abstract

The years 1946 to 2020 saw the gradual dwindling of Santa Rosa City, Laguna's agricultural land, from 96% to 15.4%. Meanwhile, the city's urbanization catapulted to 84.5% by 2013 from just below 4% in 1946. Under the regional development plan of the Aquino Administration designating Region IV-A, Cavite, Laguna, Batangas, Rizal, and Quezon (CALABARZON) as the industrial hub of the country, and driven by the increased access with the construction of the expressway in the 1980s, Santa Rosa City's manufacturing industry rose from 746 in 1980 to 5,201 in 2013, a near 700% increase. Today, Santa Rosa City is at the heart of the urbanization and industrialization, topping Metro Manila's economic growth. The highest population density is concentrated at the shore areas of Laguna Lake, the largest freshwater lake in the Philippines. From an environmental perspective, this is an economic bubble waiting to burst, but the effect to the city's environmental sustainability is dire: water abstraction at its highest may lead to land subsidence, not to mention water scarcity, which the environmental effects lead to the increased pollution of its catchments, waterways, and the shoreline, and continuous land conversion particularly for housing are imperiling its array of ecosystem services.

This paper will give a historical perspective and present the current state of the Santa Rosa City land use by employing remote sensing and Geographic Information System (GIS). Map overlays of natural boundaries of catchments and waterways will be analyzed in terms of barangay's governance boundaries to show its effect on the populace's in health, and physical, material, economic, social well-being, and the quality of life in general. Results of participatory mapping with local communities that capture indigenous expert knowledge will be shown as social and cultural representations of the local landscape.

Keywords

watershed; land use/land cover change; remote sensing, Geographic Information System (GIS), participatory mapping

Introduction

This study tracks the urbanization sprawl southward of Mega Manila along a major spine of South Luzon Expressway (SLEX) towards the City of Santa Rosa and extending to the City of Calamba. Population growth and land-use change between the years 2000 to 2015 are analyzed. Historically, this spine that extended the Osmeña Highway into the South Luzon Expressway (SLEX) was constructed in the late 1970s. At the southern edge of Mega Manila, where Muntinlupa City meets Laguna province, one starts to see and feel the difference. Cool air meets the motorist and the view is filled with vast expanses of rice fields that extend to at least 20 kilometers until one reaches the foot of the majestic Mount Makiling in the City of Calamba. Famous for its rich water reserves, Santa Rosa is home to two big companies of soda and beer. The vital ecosystem services of fresh air and abundant water are rapidly disappearing with the massive replacement of agriculture with housing and industry.

This study aims to produce a governance proposal that follows the natural boundaries of a watershed ecosystem. Further, a watershed vulnerability index is presented that allows a governance manager, i.e. Mayor of a City of Municipality, to be guided on the mix of land uses in his/her area of jurisdiction that ensures a sustainable flow of benefits without sacrificing the provision of watershed ecosystem services.

Materials and Methods

Study Area

The study area is focused on the significant spine of Mega Manila that extends to the South Luzon Expressway (SLEX) traversing the area of interest, i.e. City of Santa Rosa. Figure 1 shows the cities and municipalities (black) and the watersheds (pink) along the spine with the City of Sta Rosa (highlighted).

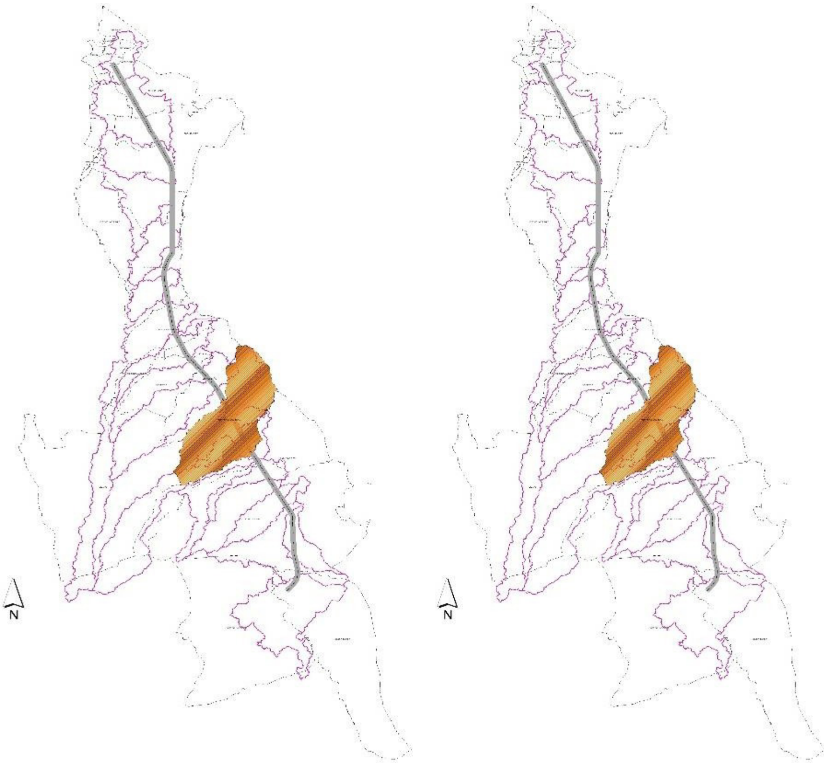

Fig. 1. Cities and municipalities and the watersheds along the spine. Nathaniel Bantayan.

Mapping Process

The mapping process follows the phases of GIS implementation as described in Bantayan, et al., namely: Geographic Information System (GIS), Geographic Encoding and Processing (GEP), GIS Analysis and Modelling (GAM), and GIS Geographic Output and Display (GOD) (*GIS in the Philippines* 44). The first phase involves the transformation of the gathered data and information into one uniform framework. As in the case of the city of Santa Rosa, the inputs include various sources: maps, reports, satellite images, GPS notes, tables, databases, and others. As noted by Bantayan et al., "the input sources derive from remote sensing (i.e. aerial photography and satellite images) and global navigation systems (e.g. GPS)" (*GIS in the Philippines*, 44). More recently, the use of Unmanned Aerial Systems (UAS) is becoming prevalent.

GIS Analysis and Modelling (GAM) is considered the real power behind GIS because it is where GIS analytical operations are performed, resulting in several scenarios and new insights and information. The third and final phase is putting the output into a format that will reach the greatest number of users and in the most understandable, i.e. readable way. In GIS output and display (GOD), the common results of GIS analysis are maps and statistical reports. These can be printed on paper or sent to other users (i.e. as digital files) for further analysis.

Ridge-to-Reef (R2R) Model of Sustainability

The R2R model raises the success potential of a poverty alleviation project as communities may be easily asked to participate in development activities. The activities may be a community organization, nursery establishment, fishpond development, tree planting, or farming.

Under the R2R concept, local government unit-partners are tapped when these are around a "watershed or micro-watershed, lake ecosystem, including its tributaries." The model also defines the choices of recipients grounded on land ecologies of highland, low-lying areas, coastal and marine ecosystems, including ecotones (*Business Mirror*, "Leyte town adopts"). The concept also promotes the following: (1) zoning enhancement to avoid and alleviate climate impact and to sequestrate carbon dioxide; (2) mandatory development controls for high risk flood-prone areas; (3) stricter building code standards implement a relocation plan for informal settlers residing in "no build zones"; (4) mitigation measures such as use of permeable surfaces, reforestation, etc.; and (5) coordinated land-use planning among local governments in managing the watershed eco-system.

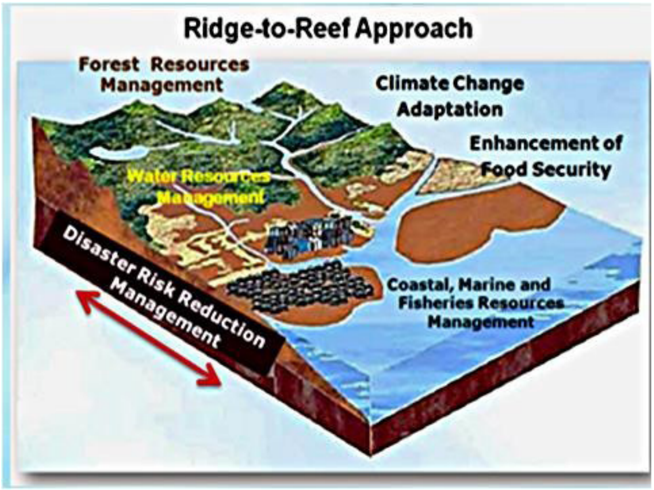

Fig. 2. Ridge-to-Reef Approach. From Housing and Land Regulatory Board (HLURB), 2014.

The Ecosystem-Based Management (EBM) is parallel to the ideologies of the ridge to reef or R2R approach. It can mostly be appreciated as a strategy that fares the ecosystems, but relatively due to the organizational undertaking of anthropological activities, environmental and ecological effects have been detrimental to the ecosystems from ridge to reef. These effects can be taken into account while creating organizational and management decisions (Gavaris 6-14).

EBM will likewise hasten the understanding of material transfers from watersheds and reducing "downstream" agriculture and forestry effects on coastal aquatic ecosystems. Preservation of existing vegetation and development with runoff mitigation measures reduce rainfall-runoff, leading to less intense and frequent flooding. Exposure of people to floodwater could be further reduced by strict action and through reinforcement of building standards in flooded areas.

The most important degradation process in the upland areas is deforestation, which leads to increased erosion, soil depletion, and, eventually, water pollution, and irregular streamflow.

Typical causes of deforestation include shifting farmlands to building industrial parks, commercial areas, and residential areas. It can be observed that most of these hazards are experienced at the 3rd level of hazard exposure to which there are four barangays are vulnerable, these barangays are Don Jose, Malitlit, Pulong Santa Cruz and Santo Domingo.

The most prominent degradation processes in the lowland areas are derived from agricultural activities resulting in soil and water pollution with fertilizers and pesticides, and depletion of fresh water used for irrigation. Additionally, settlements and the related release of solid and liquid wastes and loss of vegetative cover from infrastructure development contribute to these processes. These barangay settlements lead to a degradation of water quality in the surface, ground, and coastal waters and air and soil pollution.

The matrix on Table 1 shows the exposure and vulnerability of Santa Rosa City to four types of environmental hazards: flood, liquefaction, landslide, and erosion. Flood, landslide, and erosion are natural phenomena influenced by the climatic element of rainfall, resulting from typhoons, extended rain, strong thunderstorms, and La Niña episodes. These could be aggravated by climate change. These hazards induced by rainfall are experienced yearly by the city. The most vulnerable barangays are considered to be at the 1st level hazard exposure.

Table 1. Disaster/Hazard Inventory Matrix Based on the Possible Levels of Hazard Exposure for Project Research Implementation

Barangay	Flood	Liquefaction	Landslide	Erosion
1st Level				
Aplaya	/	/		
Caingin	/	/		
Sinalhan	/	/		
2nd Level				
Market Area	/	/		
Ibaba	/	/		
Kaunlaran	/	/		

Malusak	/	/		
Labas	/	/		
Tagapo		/		
Pooc	/	/		
Dila		/		
3rd Level				
Balibago		/		
Dita		/		
Don Jose			/	/
Macabling		/		
Malitlit				/
Pulong Santa Cruz				/
Santo Domingo			/	/

Of the three hazards of flooding, landslide, and erosion, it is flooding that presents a high risk to the population, urban use areas, natural resource-based production areas, critical point facilities, and lifeline utilities—especially those located in the northern flat areas with low slopes and elevation (Santa Rosa City Comprehensive Land Use Plan).

Soil erosion is an imperceptible and slow process, but it accumulates over the years. It is the cause of the siltation of rivers, consequently exacerbating flooding in the northern lowland section of the city. Additionally, the three hazards mentioned above are exacerbated by anthropogenic activities in the uplands of Silang within the Silang-Santa Rosa sub-watershed. It can be observed that most of these hazards are experienced at the 3rd level of hazard exposure to which there four barangays are vulnerable, these barangays are Don Jose, Malitlit, Pulong Santa Cruz, and Santo Domingo.

These activities pertain to the denudation of secondary forest, commercial tree plantations, and grasslands in Silang brought about by urban development that allows rainwater to flow quickly to the lowlands of Santa Rosa City and Cabuyao City without being caught by vegetation or absorbed by the soil. The watershed must be managed well, especially in terms of maintaining the ground cover in the higher elevations and steeper slopes of Silang to minimize the occurrence of the three hazards in the cities of Santa Rosa and Cabuyao.

The identification of levels through city's hazards is important because these levels would help the impact areas based on multi-sectoral approaches operating at a multiple geographical scale. It would integrate flexible management structures of the city and barangays that will allow adaptive management.

The use of R2R management allows the use of biodiversity and ecosystem services from each sub-watershed to help people adapt to the hazards the city experiences. Each ecosystem layer has specific methods and environmental impact assessment that has positive and negative effects in the environment. The public depends on healthy ecosystems, such as purifying the atmosphere for clean air, sequester carbon for climate regulation, proper nutrient cycling for to clean drinking water without costly infrastructure, and pollinating crops so that there would be no food scarcity. As the world's population continues to grow, so too does our dependence on healthy ecosystems to provide the necessities essential to our survival. Valuing nature and the ecosystem in a way may help promote conservation efforts in the future. It brings nature back into the cost-benefit discussion in a way that can be easily understood through ecosystem service mapping.

Another important information transformed usable forms such as two-dimensional maps for the upland, midland, and lowland/coastal portions of the watershed, three-dimensional maps for the upland and midland barangays, as well as decision-maps using a GIS program. These forms can be used for planning purposes by the community, environmental planners, local government, decision-makers, and other stakeholders.

In summary, the key aspects of most R2R approach include: (a) interconnectivity of ecosystems; (b) protection and restoration of ecosystem functions; (c) integration of socio-economic and institutional aspects; and (d) harmonized management of human and natural resources (Andrade et al., "Principles and Guidelines").

The basis for sustainable natural resource management is a harmonized and systematic land use and development planning. This means that R2R looks at the physical interconnectedness and at the institutional and sectoral synergies as well as overlapping of mandates and tenurial instruments.

Sustainability Analysis: Watershed Perspective

The sustainability of the provisioning and regulating services depend on the maintenance of the health of these watersheds. A healthy watershed can provide sufficient water and productive soils which are essential to the populace and agriculture and fisheries. As watersheds reflect the intricate connections among land, water, and other resources, an integrated assessment of the watershed's health should include, at least, the following: water quality, hydrology, geomorphology, connectivity, and biological condition. Our study assessed these factors using Geographic Information System (GIS) and remote sensing. Research results reveal that portions of the study watersheds are prone to drought between January to July. The drought covers an area of up to 950 ha. in thirteen (13) and six (6) barangays in Los Baños and Laguna de Bay, respectively (Bantayan 12).

Results and Discussion

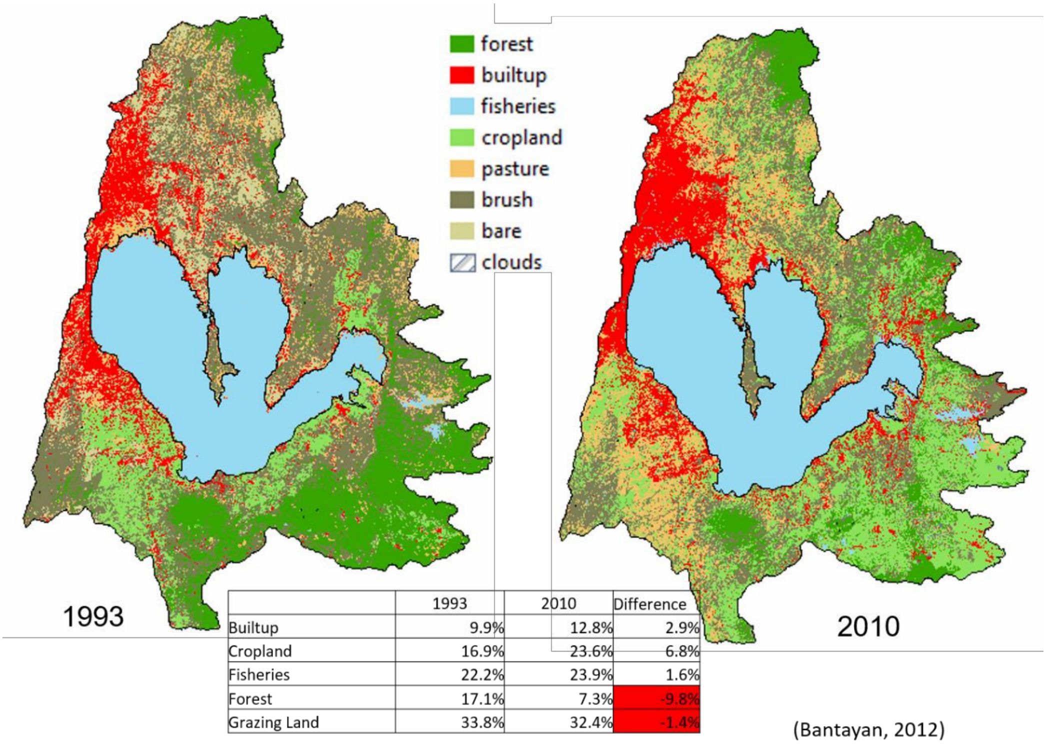

Fig. 2. Ecological footprint of Laguna Lake Basin. From Bantayan, "Estimating the Impact of Natural Disasters on the Laguna Lake Basin Using Ecological Footprinting Analysis."

Table 2. Ecological footprint of Laguna Lake Basin

	Biocapacity		Ecological Footprint		Surplus (Deficit)	
	Total No. of Species	**Per Capita**	**Total Earth Area per Person**	**Per Capita**	**Total**	**Per Capita**
1993	561,130	0.0326	362,449	0.0155	198,680	(0.0155)
2010	512,560	0.0220	479,678	0.0206	32,883	(0.0206)
Surplus (Deficit)	(48,569)	(0.0106)	117,228	0.0050		

Ecological footprinting is a mature and robust way of capturing human demand on nature. The global footprint network has catalogued humanity's ecological footprint and biocapacity from 1961 to the present and shows that there is a deficit of more than one earth due to human activities. While ecological footprint appraises the biologically productive land and sea or bodies of water that is needed to provide the renewable resources that a population consumes and to absorb the wastes it generates. The use of prevailing technology and resource-management practices is to determine how many people a given land area or the entire planet can support. It measures the requirements for productive areas (croplands, grazing lands for animal products, forested areas to produce wood products, marine areas for fisheries, built-up land for housing and infrastructure, and forested land needed to absorb carbon dioxide emissions from energy consumption)This scaling makes it possible to compare ecosystems with differing bioproductivity and in different areas of the world in the same unit, a global hectare. A global hectare represents a hectare with average world productivity.

In Bantayan's paper titled "Estimating the Impact of Natural Disasters on the Laguna Lake Basin Using Ecological Footprinting Analysis," five categories of biologically productive (bioproductive) area were similarly examined in this present paper. These categoriesare cropland, grazing land, forest, built-up areas, and fisheries. The ability of these areas to supply ecological goods and services depends on a host of environmental and socio-economic factors, such as soil, climate, management practices, and technological inputs (Fischer et al.,1999). These characteristics collectively determine a given area's productivity. Conventional Ecological Footprint accounts for weight productivity through equivalence and yield factors. Figure 2 and Table 1 both show that the Laguna Lake Basin is in deficit.

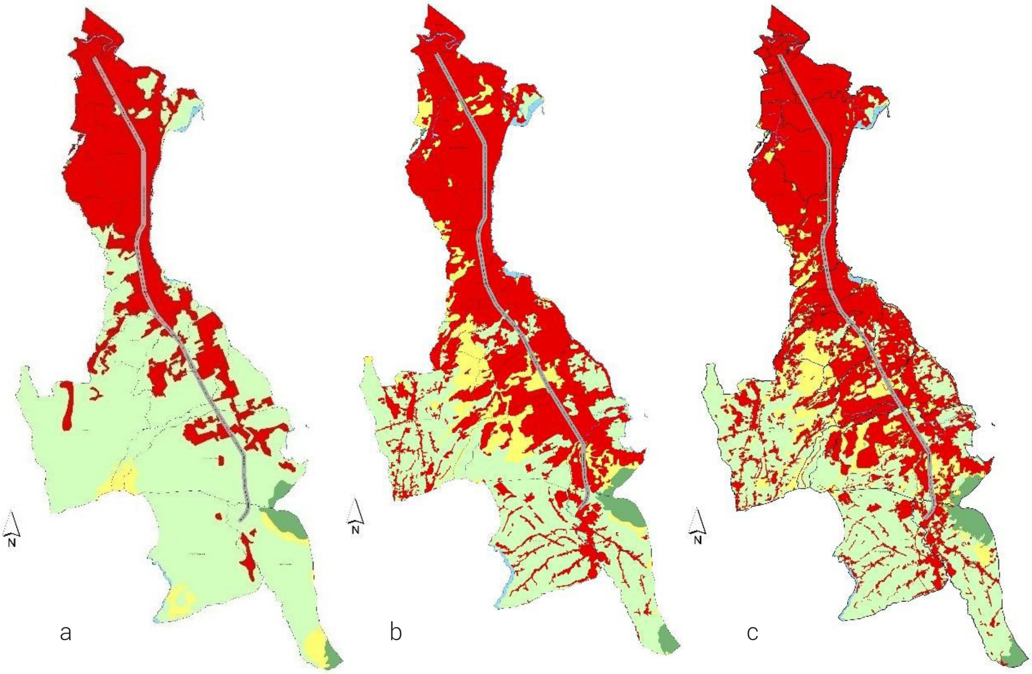

Fig. 3. **Population and Land Use Dynamics in the Santa Rosa City. Land-use change in the study area (a. 2003; b. 2010; c. 2015). Nathaniel Bantayan.**

During the study period, built-up areas increased by 31% while agriculture decreased by 46% (Figures 3 and 4). This transformation is most apparent between 2003 and 2010 where most of the changes occur. In the City of Santa Rosa, agriculture decreased by about 79% while built-up areas increased by more than 104%.

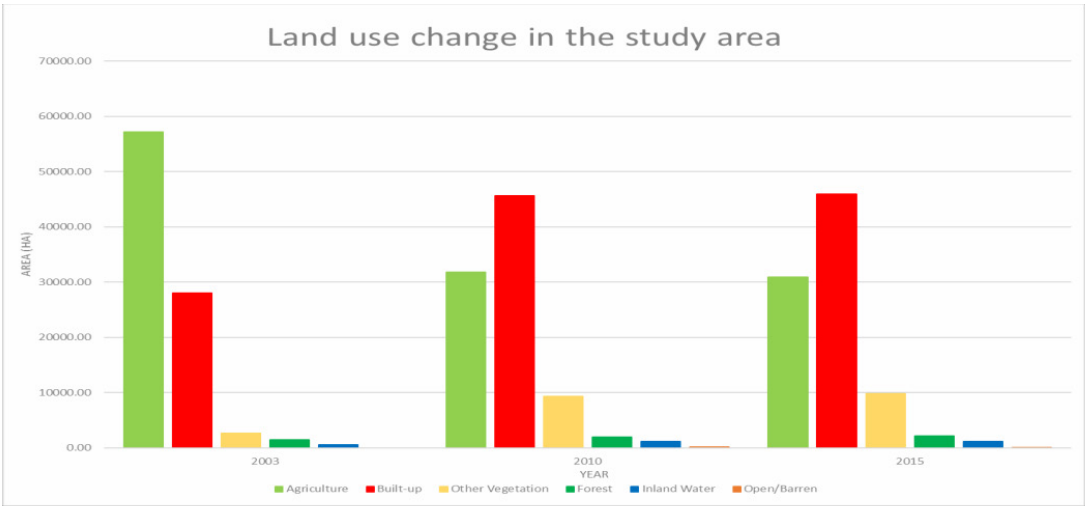

Fig. 4. Land cover change along the spine.

In terms of population growth, the City of Santa Rosa ranked 11th, 10th, and 9th among the 23 cities and municipalities along the spine, for 2000, 2010, and 2015, respectively. In terms of population density, it ranked 16th, 17th, and 18th (table 2) on 2000, 2010, and 2015 respectively.

Table 3. Population Growth and Density (2000-2015)

	Population along the spine (HouseHold)						Population density along the spine (HH)					
City/Municipality	2000		2010		2015		2000		2010		2015	
Cabuyao City	106630	16	248436	12	308745	12	22.5	18	52.4	16	65.2	16
Carmona	47706	21	74986	19	97557	18	19.8	20	31.1	18	40.4	19
City Of Biñan	201186	10	283396	11	333028	10	53.5	15	75.4	15	88.6	15
City Of Calamba	281146	8	389377	7	454486	6	20.2	19	27.9	20	32.6	20
City Of Las Piñas	472780	1	552573	3	588894	3	144.3	9	168.7	10	179.8	10
City Of Makati	471379	2	529039	4	582602	4	188.8	7	211.9	7	233.3	6
City Of Muntinlupa	379310	5	459941	5	504509	5	96.8	13	117.4	14	128.8	14
City Of Parañaque	449811	4	588126	2	665822	2	100.3	12	131.2	12	148.5	12
City Of San Pedro	231403	9	294310	9	325809	11	96.2	14	122.3	13	135.4	13
City Of Santa Rosa	185633	11	284670	10	353767	9	33.0	16	50.7	17	63.0	17
City Of Tanauan	117539	14	152393	15	173366	16	10.5	22	13.6	23	15.5	23
Ermita	5969	23	7143	23	10523	23	23.9	17	28.6	19	42.2	18
Gen. Mariano Alvarez	112446	15	138540	16	155143	17	128.9	11	158.8	11	177.8	11
Malate	77398	19	77513	18	86196	20	279.0	4	279.4	4	310.7	4
Paco	64184	20	70978	21	82466	21	226.6	5	250.6	5	291.2	5
Pandacan	79003	18	73895	20	87405	19	480.9	2	449.8	2	532.1	2
Pasay City	354908	6	392869	6	416522	7	198.4	6	219.6	6	232.8	7
Sampaloc	352329	7	341461	8	375119	8	454.3	3	440.3	3	483.7	3
San Miguel	16798	22	15992	22	17464	22	185.6	8	176.7	9	192.9	9
Santa Ana	177480	12	176894	14	195155	14	524.5	1	522.8	1	576.8	1
Santo Tomas	80393	17	124740	17	179844	15	9.0	23	14.0	22	20.2	21
Silang	156137	13	213490	13	248085	13	10.9	21	14.9	21	17.3	22
Taguig City	467375	3	644473	1	804915	1	131.1	10	180.8	8	225.8	8

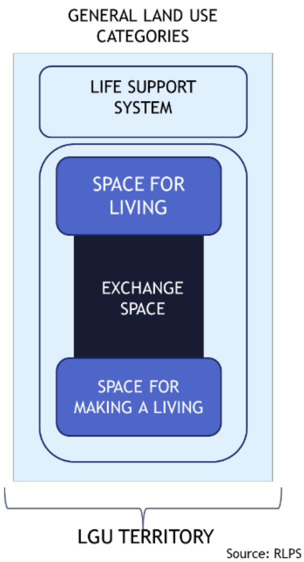

Fig. 5. **General Land Use Categories. Department of Interior and Local Government (DILG), 2007.**

Conclusion

The ability of the City of Santa Rosa to provide a quality way of life for its citizens will continue to be diminished unless it slows down, expanding the built-up areas at the expense of its natural environment. As shown in the previous section, built-up areas increased by an estimated 31% at the expense mostly of its agriculture and other open areas. Correspondingly, population growth continues to rise among its neighbors. While there is still some space for expansion given that it currently ranks 5th in population density with about 63 persons per hectare, the City should consider embracing the watershed approach, which is provided for in the first place by the Department of Interior and Local Government (Figure 5). The premise of the rationalized local planning system (RLPS) is that every square meter of the territorial jurisdiction of the local government should be placed under a policy. The four policy areas correspond to the four generalized land use areas within any given political/administrative unit or territory, i.e. areas for living (SETTLEMENTS), areas for making a living (PRODUCTION), the areas taken up by infrastructures to connect and support the two areas (INFRASTRUCTURE), and the life support systems (PROTECTED AREAS). The life support system ensures the provision of ecosystem services like water and air. These areas are usually located at the upstream of the watershed. Ultimately, as shown in Figure 1, Santa Rosa City should collaborate with local governments that share boundaries of the watersheds encompassing it, particularly Silang, Biñan, and Cabuyao.

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