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Landscape Transformation in an Urbanizing Area in Laguna, Philippines: Assessing Trends and Policy Implications on the ASEAN Integration

ABSTRACT

Landscape transformation (LT) is increasingly shaping the earth's surfaces. Despite the importance of LT analysis in land use planning and environmental management, there is paucity of informationon LT especially in developing countries such as the Philippines. The paper seeks to analyze the trend and policy implications of LT in one of the country's urbanizing landscapes in Luzon by using landscape dynamics as its framework and geographic information system as the analytical tool. Land use-land cover (LULC) maps for the periods 2003, 2005, and 2010 were sourced from NAMRIA and digitized, geoprocessed, and recoded to determine the transformation. Nine LULC classes were identified and subjected to patch analysis to quantify their changes in number, size, and class area proportion within the period of analysis. The landscape was predominantly agriculturein 2003-2005 periods but is highly dominated bybuilt-up area in 2010, potentially reducing agricultural production and increasing inundation. Patch analysis also indicates changes in landscape configuration with reduced mean patch size and increased patch number from 2003 to 2010. These trends necessitate the implementation of a policy that ensures sustainable security of life, food, and property of the local communities to make them competitive during ASEAN integration.

Key words: *landscape transformation, geographic information system, Philippines, urbanization, ASEAN integration*

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INTRODUCTION

Landscape transformation (LT) is increasingly shaping the earth's surfaces. According to *Pacheco et al.* (*2011*), changes in landscape are driven by several factors including national policies and markets, as well as global market dynamics associated with an increased role for transnational traders and investors. Increasing economies drive urbanization, which requires extensive spatial expansion. People tend to migrate to an area with an active economy. The result would be a net rural-urban migration where the level of urbanization is the share itself and the rate of urbanization is the rate at which those shares are changing (*Satterthwaite, McGranahan, and Tacoli 2010*). The growing urban population and economic activities then allow the shift in settlement patterns from a dispersed to a more dense. More spaces would be opened for the increasing demand for land for housing, commerce, and industry. In the process, landscape changes from a natural to man-made, which is mainly composed of cement, asphalt, chemical materials and metals (*Al-Manni, et al. 2007*). And such changes could be measured as the changes of patch shape, area, quality, and spatial combination (*Li et al. 2010*). According to *Zhou and Zhao* (*2013*), rapid urbanization has been accompanied by more drastic changes in land use types, disorderly landscape layout, and fragile ecological environment.

Huang, Zhang, and Wu (*2009*) indicated that urbanization is rapidly increasing worldwide, creating extensive land use changes and urban spatial expansion. The United Nations Population Division reported that in 2005 almost 50% of the world population is urban dwellers, and the figure is increasing especially in developing countries (*Huang, Zhang, and Wu 2009*) such as the Philippines. Rural landscapes in the Philippines especially near urban fringes are invariably transforming into active economic hubs. The increasing economic activities on these areas induced the massive conversion of large tracts of productive agricultural lands into various urban uses. In recent years, however, land conversion has resulted in massive transformation of landscape including the country's natural forests. This is critical for ecologically important biological systems where diverse endemic species reside. Land conversion may reduce their habitat, and consequently, reduce the spaces necessary for their survival, reproduction, and other physiological activities.

In addition, landscape transformation due to urbanization may affect hydrological processes such as water, nutrients, and materials flow through the riparian corridor, and the movement of organisms across the landscape (*Leitão et al. 2006*). As impervious surfaces increase, surface run off increases, and consequently,the likelihood for flooding increases because either water has not been absorbed into the ground or streams have overflowed (*Uttara, Bhuvandas, and Aggarwal 2012*).This is critical for developing countries especially those in Asia such as the Philippines, which experienced regular weather-related disasters. High precipitation from monsoons, typhoons, or cyclones would lead to flash floods that may cause lossof lives and damages to properties and consequently, losses in the economy. According to *EnviroNews* (*2014*), Asian countries including the Philippines experienced the highest number of weather- and climate-related disasters in the world during the period 2000-2008 and suffered huge economic losses, accounting for the second highest proportion of the total global economic loss.

Given these impacts on the environment and economy, it is important to analyze the trends in landscape transformation in the country and identify their policy implications especially when ASEAN integration is being fully implemented by the end of 2015 (*Rappler.com 2014*). Member states of the Association of Southeast Asian Nations (ASEAN) agreed to establish the ASEAN Economic Community (AEC) in 2015. AEC has been seen as a way to enhance or promote economic as well as political, social, and cultural cooperation across the region (*Lehmacher 2016*). It is envisioned to move the region towards a globally competitive single market and production base where goods, services, labor, investments, and capital flow freely across the 10 member states. Expectedly, this integration will increase trade and investments in the country, and possibly lead to more spatial expansion to accommodate the additional demand for spaces for commercial, residential, industrial, and road network development and improvement. As *Johnson* (*n.d.*) in *Rappler.com* (*2014*) has indicated, the ASEAN Economic Integration has the potential to ensure sustained economic growth centered on decent and productive work in the Philippines. This will help the country achieve its goal of inclusive growth that creates jobs and reduces poverty (*Rappler. com 2014*).

Using the framework of landscape dynamics and the tool of patch analyst in geographic information system (GIS), the study was conducted to assess the trends of landscape transformation and its policy implications. Landscape dynamics as a framework asserts that landscape varies through space and time. No landscape remains static albeit the time scales of changes may range from month to millennia (*Baudry 2000*). The spatial variations of landscapes are often related to change in the driving forces shaping them (*Baudry 2000*). The driving forces could be classified into natural and man-made where the latter involve economics, socio-cultural, and political decisions among stakeholders. As *Bürgi et al.* (*2004*) had indicated, landscape change could be driven by mobility, industrialization, urbanization, and globalization, all of which are economically and politically driven. On the other hand, however, uncontrolled factor of calamities and other unexpected disasters need to be added as they have increasingly transformed global landscapes (*Antrop 2005*). The transformation effects of these driving forces could be described quantitatively through the use of a set of metrics. In the study, three landscape metrics were used namely class area proportion, mean patch size, and patch number to describe the changes that took place in the studied landscape.

The integration of spatial analyst tools in GIS has made landscape transformation analysis a lot easier. Automation in the computation of landscape metrics allows easy and fast processing of categorical data. Landscape analysis tool such as patch analyst in GIS environment facilitates immediate spatial analysis of landscape patches and modeling of attributes associated with patches (*Center for Northern Forest Ecosystem Research n.d.*).With its ability to assign patch values, it makes easier the visualization and analysis of landscape transformation trajectories across time and space. This capability was utilized in the study in characterizing patch pattern of the landscape being investigated in the study throughout the period of analysis.

Generally, the study was done to analyze the trends in landscape transformation in an urbanizing section of the CALABARZON region in Southern Tagalog, Philippines. Landscape transformation was measured through the use of three landscape metrics, namely: class area proportion, mean patch size, and patch number of the land class types. Specifically, the study was conducted to measure the changes in these metrics from 2003 to 2010. In addition, the study identified policy implications of the transformation especially with the implementation of ASEAN integration in the country in 2015. However, no attempt has been done to forecast the future characteristics of the landscape under investigation as a result of the implementation of ASEAN integration due to limitations of data and the lack of modeling capacity of the software being used.

MATERIALS AND METHODS

Study Site and Design

The study was conducted in an urbanizing section of the CALABARZON region in Southern Tagalog, Philippines (**Figure 1**). The site was chosen purposively based on an observed occurrence of landscape transformation and availability of time series GIS-enabled maps. It is geographically located between 14° 0′ 0″ N, 121° 30′ 0″ E with a total land area of 13,023.34 has. The site is within the Sta. Rosa-Calamba economic hub, which has undergone a massive land conversion in recent years. For instance, the economic activity in Calamba City has increased rapidly in just a decade. Such increase in investments has reduced its agricultural land by 67% while its urban areas had increased by 212% between 2003 and 2010 (*Bagarinao 2013*). The reduction was due primarily to the conversion of agricultural land to urban uses. On the other hand, Sta. Rosa has been dubbed as the Makati City of the South in terms of economic activity. It houses several residential, commercial, and industrial estates and establishments (http://www.santarosacity.gov.ph). Its growing economy has increased the demand for land for commercial, industrial, and residential uses, and therefore significantly transformed its suburban landscape. The various economic developments in these cities have led to a dramatic transformation of the landscape being investigated in the study. The increasing investments are also due to its nearness to Metro Manila, which serves as the seat of the economic system and processes of the country.

Data Sources and Data Processing

All the data used in the assessment of transformation were extracted from GIS-enabled thematic maps (2003, 2005, and 2010) of the study site. Land cover-land use maps in 2003 and 2010 of the study were obtained from the National Mapping and Resource Information Authority (NAMRIA). The maps were formatted as shapefile and were based on satellite images. The 2003 land cover map was based on 2000-2002 LANDSAT ETM with 30 meters resolution while the 2010 land cover map was based on ALOS-AVNIR2 satellite images with 10 meters resolution. The 2005 land cover map was obtained from the City of Calamba and was extracted from a topographic map (*Urbis Philippines 2000*). This makes data validity dependent on the precision of data extraction from the base materials. Nonetheless, data validation was done on 2 July 2013 and 4 December 2013 with the support of the City Planning and Development Office (CPDO).

Figure 1. Study site (source: Google map; Wikipedia).

The thematic maps were processed in GIS software, the ArcView 3.2 (ESRI). Changes in land cover were analyzed using the geoprocessing extension of the software. The resulting map shows the transformation of a land class type. The land cover of the resulting map was re-coded to reflect the changes in the land class type between two time scales. Nine land class types were identified, namely: closed forest, inland water, open forest, built-up area, annual cropland, perennial cropland, grassland, shrubland, and wooded grassland. The area for each land class type was computed by using the sample script for calculating area and perimeter of the software.

Landscape Metrics Calculation and Transformation Assessment

Three landscape metrics were used for the assessment of the transformation trends of the study site, namely, class area proportion, patch number, and mean patch size.

Class Area Proportion. Class Area Proportion or CAP is a measure of landscape composition, without considering the spatial character, placement, or location of patches within the mosaic (*Leitão et al. 2006, p.68*). According to *Leitão, et al.* (*2006*), CAP is the single most important landscape descriptor, which represents a fundamental aspect of landscape structure. It was calculated by computing the area (in ha) occupied by a particular land class type (LCT), expressed as a proportion of the total landscape area, as follows (*Leitão et al. 2006*):

$$CAPi = \sum_{j=1}^{n} aij \ / A \qquad (1)$$

where CAP_i equals the Class Area Proportion for the *i*th LCT, a_{ij} equals the area (ha) of patch *j* for the ith LCT, and A equals the total landscape area (ha). In this case, CAP_i is the sum of the areas of all patches of the corresponding patch type, divided by the total landscape area (*Leitão et al. 2006*). Since the metric is a proportion, it has no unit and can range from zero to one. "CAP approaches zero when the corresponding LCT becomes increasingly rare in the landscape, and equals one when the entire landscape consists of a single patch of the corresponding LCT" (*Leitão et al. 2006*).

Patch Number. Patch Number (PN) is the sum of the number of patches of a land class type. In contrast to CAP, PN is a measure of landscape configuration, which deals with the spatial character of the landscape, especially the degree of subdivision of the class or landscape (*Leitão et al. 2006*). Hence, combining this metric with CAP is recommended to have a complete picture of the landscape transformation. In the study, PN was computed following *Leitão et al.* (*2006*), as follows:

$$PNi = \sum_{i=1}^{n} Pi \qquad (2)$$

where: PN_i equals patch number of *i*th LCT and P_i equals patch of *i*th LCT.

Since PN is simply a count of all the patches within the landscape, it does not have any unit and could take values starting from 1.

Mean Patch Size (MPS). Mean Patch Size (MPS) was computed as the average size of patches of a particular LCT (*Leitão et al. 2006*). This metric measures the subdivision of the class or landscape, and has critical relevance to landscape function for people as well as for natural processes (*Leitão et al. 2006*). MPS was computed as follows:

$$MPSi = \sum_{j=1}^{n} aij \ / \ ni \qquad (3)$$

where: MPS_i (in ha) equals mean patch size of *i*th LCT, a_{ij} equals the area (in ha) of patch *j* in *i*th LCT, and ni equals the total number of patches in the landscape of *i*th LCT (*Leitão et al., 2006*). MPS takes values that are greater than zero and has no limit.

Using these landscape metrics, the transformation of the landscape being investigated was assessed for three periods, namely: 2003, 2005, and 2010. The assessment looked at the changes of the nine land class types within the three periods. Trends were analyzed and policy implications were identified and discussed in the context of the ASEAN integration.

Other sources of information such as comprehensive land use plan, reports, peer-reviewed journal articles, unpublished theses and conference papers, and the like were also consulted. Key informant interviews involving staff in Calamba City CPDO, DENR-Region IV-A, and NEDA-Region IV-A were also done on 22-30 July 2013.

Data Analysis and Visualization

The patch analyst extension of the software was used to calculate all metrics at the landscape level. Descriptive statistics such as means, percentages, minimum, and maximum values of the metrics for each land class type were computed and used in the analysis. Changes in land class type from 2003 to 2010 were visualized as maps and figures.

RESULTS AND DISCUSSION

Landscape Transformation: Visual Analysis

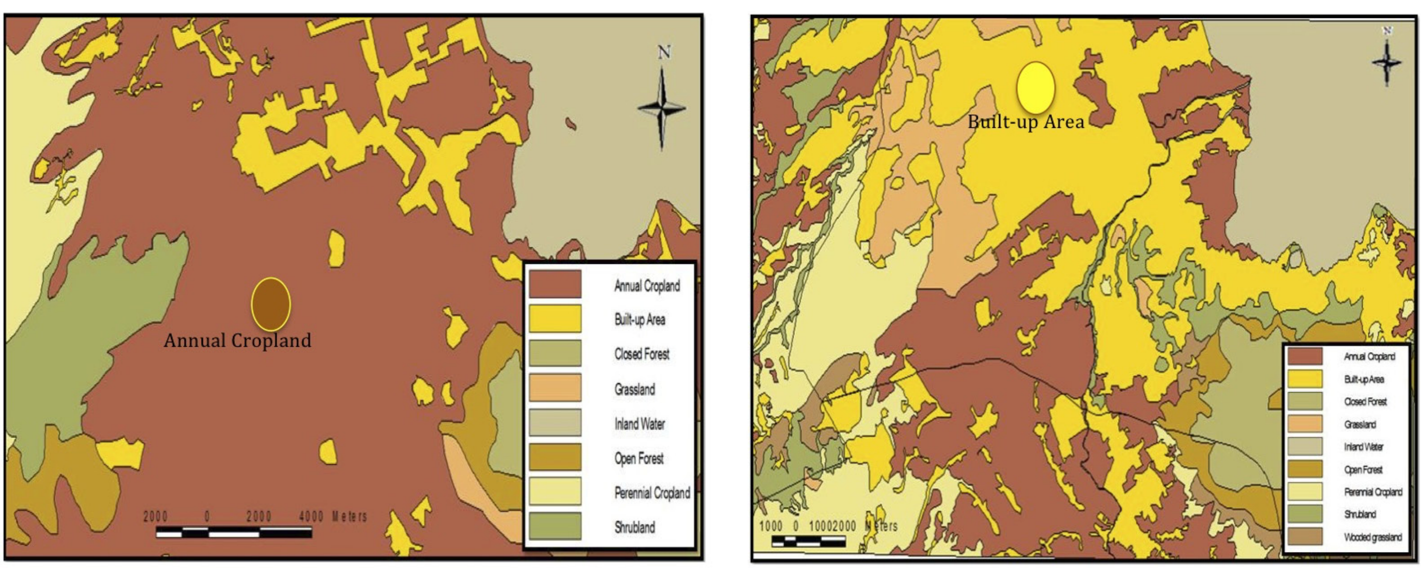
Visual analysis of the thematic maps indicates that annual cropland has been replaced with built-up area in 2010 (**Figure 2**).

The land class type also has been fragmented due to the formation of new built-up area patches in later years. Some of the shrubland land class type has been replaced with perennial cropland though the former has gained areas on the south-eastern side of the landscape.

Trends of the LandscapeMetrics

Class Area Proportion. Based on the investigation, the landscape of the study site underwent transformation (**Figure 3**). The transformation started with the annual cropland constituting the matrix in 2003 ($CAP_{annual\ cropland}$ = 0.78) while the built-up area occupied only 15% of the landscape (**Figure 4**). Similar trend was observed for the next two years without having any significant changes among the land class types (i.e. 2005). Significant transformation took place shortly before 2010 where annual cropland no longer constitutes the matrix but was replaced with built-up area. In 2010, annual cropland constitutes less than 25% ($CAP_{annual\ cropland}$ = 0.23) while built-up area has expanded to almost 50% of the landscape ($CAP_{built\text{-}up\ area}$ = 0.48) to support the increasing human population, commercial, and industrial space needs of the area. According to *NSO* (*2010*), population size in the area has increased by as much as 38% during the 2000-2010 period while the number of investors has increased by 20% in 2007-2008 period (*CPDO 2010*).The shift of patch dominance in the landscape, i.e. from annual cropland to built-up area has increased the percentage of the landscape covered by impervious surface. To cite, about 48% of the 2010 landscape is covered with impervious surface, which exceeds the widely accepted threshold of 10% (*Center for Watershed Protection 1998 in Leitão et al. 2006*).

There are several environmental implications of such transformation. annual cropland has been transformed into impervious surfaces (**Figure 3**). These surfaces have less capacity to store rainfall, and thereby, have higher likelihoods of producing flash floods. Flash floods occur because there is a rapid onset of flood caused by very rapid surface runoff during heavy rainfall (*University Corporation for Atmospheric Research 2010*). In addition, with less storage capacity for water in urban basins, and more rapid runoff, urban streams rise more quickly during storms and have higher peak discharge rates (*Konrad n.d.*). Moreover, replacing the annual cropland with built-up areas would lead to pollution of surface water, formation of stagnate water puddles, and heat island effect (*Pineo and Barton 2009*).Though overflows from annual cropland may also contain chemicals from pesticides or fertilizers, surface runoff from built up areas picks up pollutants as it flows into storm drains, which then flows directly into the river and lake ecosystems in the area. This is critical in the study site because stormwater drains into Laguna Lake, which is currently experiencing significant ecological problems and poor water quality. In addition, the lake has been used for fishery production, and thus, contaminated runoff from impervious surfaces in the study site may generate more



a. 2003 Landscape

b. 2010 Landscape

Figure 2. 2003 (a) and 2010 (b) landscape showing changes in annual cropland ang buildup area land class types.

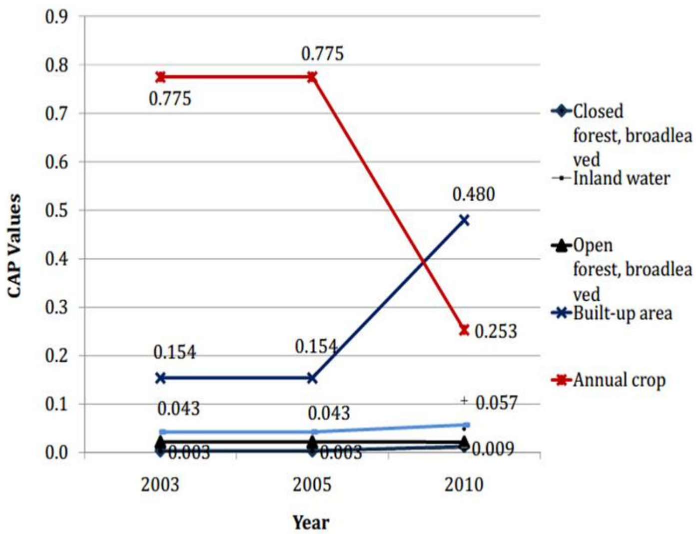


Figure 3. Class area proportion by land class type by year.

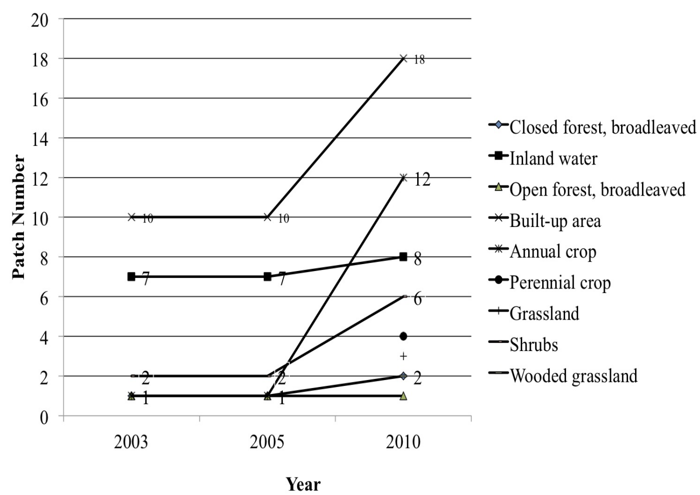


Figure 4. Computed patch number by land class type by year.

problems for biodiversity as well as public health (*Pineo and Barton 2009*). On the other hand, runoff in impervious surfaces may puddle for long periods of time and become breeding places for undesirable insects such as mosquitoes (*Pineo and Barton 2009*). The heat-absorbing quality of asphalt and other paving materials could also increase ambient air temperatures, which will require more energy for cooling (*Pineo and Barton 2009*).

Patch Number. The transformation of the landscape is also apparent with the trend of the computed patch number for each land class type. The landscape consists of patches of built-up area, inland water, and shrubland dispersed in an intact matrix of annual cropland during the 2003-2005 period (**Figure 3**). However, in the 2005-2010 period, the landscape has been subdivided into the nine LCTs. As development proceeds, new patches of built-up area ($PN_{built-up\ area}$ = 18) were created and the annual cropland LCT has become fragmented ($PN_{annual\ cropland}$ = 12).Shrubland also appeared to be fragmented in 2010. Computed PN has increased from two in 2003 to six in 2010.Also an interesting transformation of the landscape in terms of PN is the slight increase of this metric for inland water LCT in 2010 ($PN_{inland\ water}$ = 8) from the 2003 value ($PNi_{nland\ water}$ = 7). This could probably be an indication of some surfaces being inundated due to runoff puddling in impervious areas.

This landscape transformation process is fairly common in many parts of the world where people subdivide the landscape in order to use land resources to carry on commerce and industry (*Leitão et al. 2006*). According to *Leitão et al.* (*2006*), "these subdivisions of use result in different patches of LCTs being created via conversion of one LCT to another or by isolating a patch from its neighbors." Though this may be significant for forest LCTs where movement of organisms would be affected by fragmentation, the creation of more patches of built-up area may affect water flow, quantity and quality, and air ambient temperatures as explained above.

Mean Patch Size. There is a general reduction of the computed mean patch size throughout the study period in almost all LCTs, except the built-up area. To cite, computed MPS for the annual cropland has reduced significantly from more than 1,000 ha in 2003-2005 period to less than 30 ha in 2005-2010. Similar trend was observed for closed forest (broadleaved) whose computed MPS of 49.96 ha in 2003-2005 was reduced significantly to 8.50 ha in 2005-2010; shrubland computed MPS has reduced from 27.68 ha in 2003-2005 to 12.39 ha in 2005-2010 period. Such decreasing trend of the computed MPS of these LCTs indicates that the process of fragmentation is advancing, and may have some critical implications on the socio-ecological systems of the area. For instance, though there is a differential response of organisms to forest fragmentation, it may negatively affect the interior species that are dependent on the size of the forest core (*Leitão et al., 2006*). Consequently, this may result in biodiversity loss or reduction in species number. According to *Leitão et al.* (*2006*), the genetic diversity of these communities will likewise decline as a consequence of reduced population size.

Moreover, the internal food security of the communities within the study site may be threatened with the reduction in the mean patch size of the agricultural LCTs (i.e. annual and perennial cropland). The reduction of patch size of the agricultural LCT would lead to decreasing yield. According to *FAO* (*2011*), the reduction in urban agricultural production would negatively affect the nutrition and food security especially of those highly vulnerable individuals such as the poor families, persons who are physically challenged, senior citizens, and the sick. The area would be more dependent on external supply of food than becoming more self-sufficient. Any movement in food prices would affect the consumers, most especially the urban poor households since they are net food buyers. *FAO* (*2011*) reported that the recent price spikes in food commodities are believed to have pushed over one hundred million more people into extreme poverty.

On the other hand, the computed MPS for the built-up area has increased from 20 hain 2003-2005 period to 34.69 ha in 2005-2010, indicating an expansion of the patches of this LCT or increasing conversion of other neighboring LCTs to this land class type as the process of urbanization progresses. The imminent impact of expanding patches of built-up area is the reduction in groundwater availability and flooding due to increased amount of surface runoff. *Freeborn* (*2011*) indicated that the combined effects of development are increased stormwater runoff into surface waters and decreased infiltration for groundwater recharge. Both effects would have tremendous impacts either directly and/or indirectly on development and people. For instance, about five villages in Sta. Rosa City and an entire barangay in Calamba City were submerged in water in 2012 due to a sudden increase of floodwater during the tropical storm Ofel (*Cinco 2012*). Both citieswere again declared in a state of calamity in 2013 due to flood caused by persistent rain (*Legaspi 2013*). These had caused tens to hundreds of families to be evacuated, and loss of millions of pesos due to damages in properties and infrastructures. These impacts require some policies that could regulate the transformation of landscapes in the area.

Policy Implications

The primary driver of landscape transformation in the study site is urbanization. With increasing investments in the area, more patches of built-up area LCT would be created to support an increasing human population and commercial and industrial establishments. The recent favorable economic state of the study site is expected to make a leap with the implementation of ASEAN integration in 2015. According to former Philippine Budget Secretary Florencio Abad as cited by *Valente* (*2013*), "The free entry of goods and services across economic borders can only mean more economic opportunities for countries in the region and therefore more opportunities for employment and livelihood." Since currently the study site has already been converted into a haven of industrial and commercial centers, its economic activities are predicted to grow significantly with ASEAN integration primarily because of its closeness to Metro Manila.

However, more patches of built-up area will be created to accommodate such economic growth. This expected landscape transformation trajectory necessitates the strong implementation of the policies that would regulate or manage land conversion and its environmental externalities. It also requires the formulation of a strategic, sustainable, and holistic development plan to consider the synergistic effects of making more built-up areas to its environment. The increasing MPS and PN values of built-up areas and the increasing intensity of flooding in the study site imply the formulation of a policy that would support the establishment of a good and efficient flood regulation system. In addition, it may also require a policy that would require the inclusion of a rainwater-harvesting facility as part of the building design. In addition, a policy that would promote environment-friendly and resource-saving design of and construction process for buildings, industrial centers, commercial centers, road networks, and/or residential estates is deemed necessary to reduce or manage the impacts of urbanization on its environment. According to *Uttara et al.* (*2012*), urbanization would lead to the creation of heat island, pollution, flooding, degraded water quality, habitat modification, and resource use intensification. Therefore, a policy that would encourage stakeholders to use green design in their development projects in the area is wanting.

Moreover, localizing the implementation of ecological solid waste management law (Republic Act 9003) in the study site is deemed necessary as urbanization in the area progresses. According to *Pai et al.* (*2014*), increasing population and rapid development are posing challenges on solid waste management. Unmanaged disposal of solid wastes would likely lead to flooding and/or inundation of low-lying areas during heavy rain as they clog drainage systems and watercourses (*Muñoz-Cadena et al. 2009 in Lamond et al. 2012*). In addition, wastes and debris collected by floodwaters during a flood can cause increased damage to property and lead to higher flood losses, or can block access, become a source of toxins, and/or serve as breeding ground for disease-carrying organisms (*Lamond et al. 2012*).

The significant drop of computed MPS of the annual cropland LCT necessitates the implementation of measures that could enhance nutrition and food security in the area. Though the reduction may probably reduce community's exposure to agricultural-related hazardous chemicals such as pesticides, insecticides, and the like, it may have a significant implication when it comes to food security. The study site would become more dependent on externally sourced food supplies, which in turn are dependent and easily affected by price movement. Any slight price movement in food and other basic commodities would significantly affect the highly vulnerable members of the community such as the children, elderly, poor households, and the physically-challenged individuals. According to *FAO* (*2011*), poor households are net food buyers and thus, any increase in food prices would push them further to extreme poverty. Unless an effective and efficient measure for securing food and nutrition requirements of the people in the study site would be put in place, the sectors that are vulnerable to price movement would likely to suffer from the rapidly losing areas of annual crops.

SUMMARY AND CONCLUSION

The use of GIS has facilitated the analysis of the landscape transformation of the study site. It was observed that the study site has been transformed from a landscape covered with an annual cropland matrix to a landscape that is highly fragmented for the period 2003-2010. The dominant fragment, however, belongs to the built-up area LCT due to urbanization and increasing economic activities in the study site. This is due to the increasing creation of built-up area patches from annual cropland and other land class types.

The trend may intensify with ASEAN integration because of the proximity of the study site to Metro Manila. It is expected that the economic activities in the area would increase with ASEAN integration. This highlights the need to intensify the implementation of policies that are formulated to reduce, abate, or manage the impacts of urbanization such as flooding, solid waste disposal, and food insecurity. Further, there should be a systematic land use plan of the area to properly accommodate any economic expansion brought about by the integration process.

It should be noted however that such observation was based on the data extracted from the GIS-based land use-land cover maps of the site. Thus, references and utility of the analysis and implications of the trend presented and discussed in the paper should consider this context. Likewise, it is recommended that setting current baseline condition of the landscape is important to monitor changes and impacts directly influenced by the Philippines' integration to the ASEAN Economic Framework. Measuring the economic costs of the environmental as well as socio-physical damages due to its transformation is also recommended. The valuation could justify the implementation of any policies that could regulate or reduce the impacts of the transformation on the environment. Unless these measures would be done, the transformation of the study site from mostly agricultural landscape to built-up area would continue to create environmental risks and hazards that could jeopardize the safety of the people, and the sustainability of the development in the area.

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