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Spatial Land Use and Land Cover (LULC) Changes for A Sustainable Biodiversity Conservation: Factors for Potential Implementation of Buffer Zone for FRIM Natural Heritage Site, Malaysia

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Abstract. There will be nearly 2 billion new residents by 2030 due to human migration and population growth, yet the consequences of both current and future urbanization on biodiversity conservation are poorly known. However, an increase in the awareness of the consequences on the role of biodiversity in sustaining livelihoods and human wellbeing has been translated into the various movements, in line with the Sustainable Development Goals (SDG), especially SDG15 and SDG3. Conservation areas (CAs) have become one of the solutions to uphold ecosystem sustainability for biodiversity conservation. Thus, the study aimed to analyze the changes in land use and land cover (LULC) surrounding the CA - Forest Research Institute Malaysia (FRIM) Natural Heritage Site, Malaysia. The objectives were: 1) to quantify the changes of LULC, 2) to construct the Digital Elevation Model (DEM), of FRIM and the surroundings, thus representing the Malaysian terrestrial CAs and, 3) to suggest LULC changes- based criteria for CA buffer zone (CABAs). The data used were spatial data and satellite images and, ERDAS Imagine and ArcGIS software to execute the analysis. The study revealed a reduction in forest areas and addition in built-up (housing) and water bodies. There was an encroachment of built-up area (housing) into the FRIM. Therefore, the study suggested buffer zones for FRIM, a shield to prevent the stresses caused by urbanization and encroachment activities that may jeopardize the intactness of the conservation areas. The study also provided an effort to formulate a more effective strategy for enhancing sustainable development to the policymakers.

Keywords: *land use and land cover (LULC); conservation areas (CAs); biodiversity conservation; conservation area buffer zone (CABZs); FRIM Natural Heritage Site Malaysia; SDG 3; SDG 15*

1. Introduction

Globally, 1.2 billion people were forecasted in urban areas by 2030. Direct impacts were cumulatively substantial, with an estimated 290,000 km2 of natural habitat forecast to be converted to urban land uses between 2000 and 2030. Studies of direct urban impacts on biodiversity, such as food consumption affect a greater area, but few studies have quantified urban indirect impacts on biodiversity [1]. Land use change in the surroundings of protected areas (conservation areas) is rampant worldwide [2]. Land use and land cover (LULC) change was fragmenting natural ecosystems, with major consequences for biodiversity [3. In order to uphold the ecosystem sustainability for biodiversity conservation, CAs were set aside. The term "conservation areas" has been described as an area of notable environmental or historical interest or importance (natural or built-up) [4] which was protected by laws, legislation, and policies against undesirable changes. CAs existed for example, in the form of forest reserves, protected areas, national parks, wetlands, Man and Biosphere reserves, geological parks, heritage sites, and urban reserves. The terms and definitions varied based on individual countries worldwide. They are sometimes overlapping in terms of areas designated or names given, based on different jurisdictions worldwide andnationally [5].

The need for CAs must be clarified – to both decision-makers and to the general public alike as the demand for efficient and pressing utilization of natural resources has increased. This, however, created some difficulties. For example, in the Malaysian context, different types of CAs were managed by different authorities such as the Department of Wildlife and National Parks and Forestry Department and areas having double gazettement such as permanent forest estates and national botanical garden. Furthermore, some CAs were categorized under the jurisdiction of the federal government or state government, and in particular cases under parties as well as private land/parties and 'no man's land'.

The sustainability of biodiversity depends on the balanced ecosystem of the CAs and the landscape as a whole. It covered a wide range of areas with the main purpose is to achieve sustainable development by protecting biodiversity and providing a wide range of benefits to human well-being. Thus, CAs must not be viewed in isolation but interconnected and, in a broader context of the landscape.In order for CAs to survive the pressures of those conflicts, it must be justifiable in both regional development, biological and, socio-economic terms. This study aimed to analyze the changes of LULC surrounding the FRIM Natural Heritage Site, Malaysia. The objectives were: 1) to quantify the changes of LULC, and 2) to construct the Digital Elevation Model (DEM), of FRIM and the surroundings, thus representing the Malaysian terrestrial CAs 3) to suggest LULC changes-based criteria for CA bufferzone (CABAs).

2. Materials and Methods

2.1. Study Area

FRIM Natural Heritage site is located in Kepong, Selangor, Malaysia. It is surrounded by BukitLagong Forest Reserve on one side, and developments, on the other (Figure 1). Considered as one ofthe largest man-made forests in the world, FRIM has become a model for forest management, reforestation, forest protection and, forest conservation agenda.

Figure 1. Study area: FRIM Natural Heritage Site, Malaysia (Source: https://www.google.com/maps)

FRIM Natural Heritage Sites enjoyed secure protection through the National Forestry Act 1984 and Heritage Act 2013. The status in recognition of its conservation efforts, historical significance, and legacy, and is the largest and oldest man-made tropical forest in the world established since the 1920sas well as the one and only tropical forest research institute in Malaysia. Since FRIM is categorizedunder the Environmental Sensitive Area (ESA) Rank 1, of National Physical Plan II (NPP II) referring specifically to biodiversity and heritage conservation and climate mitigation [6], only certain activities are allowed in this area which is ecotourism, research, and rehabilitation.

The site is extremely important from an environmental conservation point of view because of its unique biodiversity. The area is considered an outstanding representative of the tropical terrestrial ecosystems due to its species richness, endemism, high taxonomic uniqueness, and variability of habitats. Besides this ecological uniqueness, there is also an inhabitant inside the FRIM [7]. However, while the area is relatively large in local terms, it is relatively narrow in width and thus is vulnerable to disturbance and nonconforming physical development in the peripheries. The need for the study arises out of increasing pressure for various forms of development in these peripheries, which has the potentialto negatively affect the integrity of the CAs and the unique resources, especially their biodiversity, water production, and scenic values. It is indeed a need for the area 'to hold to the part' due to significantchanges of land uses around it.

2.2. LULC Dataset and acquisition

The study took a quantitative approach whereby the spatio-temporal data; topographic maps and satellite images of the years 2013, 2016, and 2019 were used. ERDAS Imagine and ArcGIS softwarewere used for the analysis. The data were divided into two components: first, remotely sensed imagedata in which to determine the LULC changes, and DEM in which to generate elevations of the area.The second data component was topographic maps obtained from PLANMalaysia [8]. This study explored, the role of remotely sensed images towards LULC changes and forest reserved management. The process of identifying changes using the remote sensing technique was the preferred choice as itwas a relatively fast and effective way of detecting changes of LULC at the regional scale. The process covers three main stages; pre-processing, subset, and image processing.

LANDSAT Thematic Mapper (TM) optical images with 30m pixel size were obtained from the Malaysian Space Agency (MYSA) and were captured in 2013, 2016 and 2019 with the areas of 5.5kmX 11km covering approximately 60.5 km square. All the data have been registered into local coordinate projection. The study area covers from 3º 50'N, 101º 55'E (Upper Left) to 3º 35'N, 102º 25'E (LowerRight). LULC patterns were classified by grouping its pattern. Some items are similar to each other, and a simplification is to be reduced the pattern to three (3) types namely; vegetation (forest), water body and built-up area (development mainly housing area). The three (3) classes of classification (Table 1) were enough for the purpose of this study, which was mainly to identify the area and direction of theLULC changes especially vegetation and built-up area [9]. Supervised classification was used and accuracy assessment was done to determine the accuracy of the classification process.

The study area is located partly in the districts of Sungai Buloh and Jinjang, Selangor, Malaysia. The topographic maps of Sungai Buloh (Series DNMM 6101: edition 2-PPNM: 1:10,000) and Jinjang (Series DNMM6101; edition 3-PPNM; 1: 10,000) were acquired from the Department of Survey andMapping Malaysia (JUPEM). Two maps were joined together and the areas were clipped based on the boundary mark established on allotments certified maps. Based on the topographic map, the study area covered approximately 60.5 km square. Contours depicted on the topographic maps for the study area were digitized to sustain x,y,z (position and height) points. 3D model - DEM was generated using ArcGIS software. The topographical map was on a scale of 1:50,000 and the contour interval was 100 meters. The scanning process was done to change the topographic map in digital form. The contour lineswere then digitized and the vector contour lines were then converted into points using ‘polytwopoints.ave’ in ArcView. The contour points theme was converted into a raster format beforeinterpolation took place.

2.3. Data Analysis

Digital classification was carried out through a supervised classification approach using training areas and Maximum Likelihood. The Maximum Likelihood classifier assumed that the statistics for eachclass in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless a probability threshold was selected, all pixels were classified. If the highest probability was smaller than a threshold, the pixel remains unclassified. The identity and location of feature classes or cover types (vegetation, agriculture, and built-up) were known beforehand through theavailable topographic map.

Specific areas were typically identified on the multispectral imagery that represents the desired known feature types and uses the spectral characteristics of these known areas to ‘train’ the classification program to assign each pixel in the image to one of these classes. An accuracy assessment was done to determine how correct the classification was. Accuracy assessment is critical for a map generated from any remote sensing data. Error matrix is the most common way to present the accuracy of the classification results. Overall accuracy and Kappa statistics were then derived from the error matrices.

2.4. Accuracy assessment

Accuracy assessment is the procedure used to quantify the reliability of classified multispectral images. This process was carried out to conform to the accuracy of the data used. The assessment for the corresponding results from the software was analyzed on each of the classified images of processing.Table 1 summarized the accuracy assessment made for each of the processing satellite images.

Table 1. Result for Accuracy Assessment of multispectral images

Year	Accuracy (%)	Kappa Statistics
2013	94	0.8720
2016	94	0.8938
2019	93	0.8856

All processing images (Table 1) obtained accuracy above 90% indicating the accuracy of the data computed in the software with the multispectral images only recorded an acute error upon computationof the result between years. A Triangulation Irregular Networks (TIN) is a widely recognized approach to develop elevation modelling with relative benefits. It was done using ARC/INFO and ArcView GIS13 software.

TIN represents results in flat surfaces for areas where only contour data was used; a set of triangles represents the terrain surface. Consider a set of coordinates marked on a map, these coordinates were 'triangulated' and their verticals represent the spatial point. Each triangulation covers its area without overlapping each other. The map used to generate DEM is derived from TIN which represents the terrain surface. The DEM provides a digital description of the terrain surface, giving continuous elevation values over the entire study area. The study area can later be seen in 3D views.

3. Results

3.1. LULC changes between the years

Table 2 showed an increase in the built-up area from 36.9% in 2013 to 37.1% in 2016 and further increases to 37.4% in 2019. Similar to a waterbody, and increased from 15.6% in 2013 to 16.3% in 2015 and further increased to 17.1% in 2019 were noted. Nonetheless, a decreased in forest areas from 46.3% in 2013 to 45.4% in 2016 and further decreased to 44.3% in 2019. These proven that forest areas have been replaced by the built-up area, in this case, housing area. It is maybe due to the urbanization activities that have taken place. The increase in water bodies may be due to additional drainage systems to supportthe increase in population within that area.

Table 2. LULC and its area percentage for the year 2013, 2016 and 2019

Row	Class name	Histogram	Area (%)	Histogram	Area (%)	Histogram	Area (%)
			2013		2016		2019
	Unclassified	1730	1.2%	1730	1.2%	1730	1.2%
1	Built up	51352	36.9%	51852	37.1%	52198	37.4%
2	Water body	21791	15.9%	22692	16.3%	23233	17.1%
3	Forest	64623	46.3%	63529	45.4%	62341	44.3%

3.2. Digital Elevation Model (DEM)

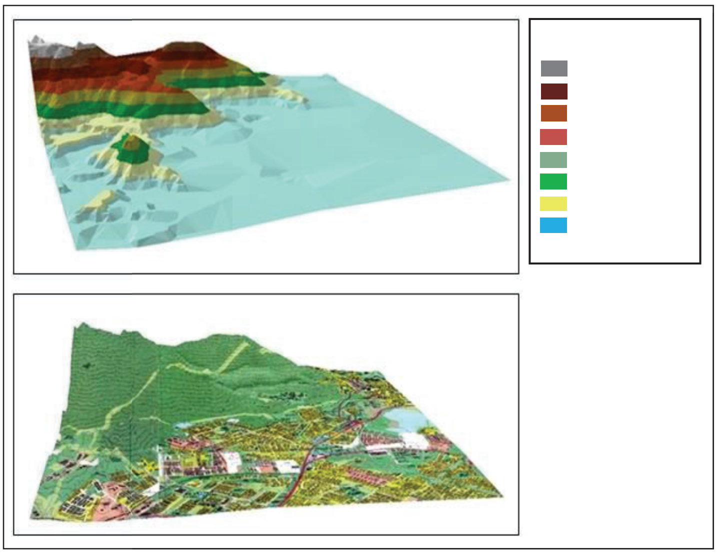

Figure 2. DEM and overlay on topographic map of FRIM area and the surroundings

The construction of DEM was to obtain the elevation range of the area. Elevation data were essential to determine the tendency of encroachment (accessibility) of land-use activities of the area. The heightsfor the constructed DEM range from 50 meters to 600 meters. The equal interval elevation of 9 classes was used to classify the contour.

Figure 2 shows the DEM (the upper image) and the overlaying of DEM onto the topographic map (the lower image) of the area and its surrounding. Figure 2 showed the undulating surface of the area. The forest area covered the hilly part while the built-up area covered the flat part. In particular, it showed that the south-eastern part experienced a major build-up especially housing which may be due to the urbanizing activities. It also showed some built-up areas right next to the FRIM border with some encroachments while the north-western part of the FRIM area appeared to be intact with forest. This was maybe due to the area was gazetted as a permanent forest reserve for water catchment purposes by The Forestry Department.

4. Discussion and Conclusion

Most of the changes in LULC occurred in the east and southeast of FRIM areas, with some encroachmentof built up into the FRIM areas. This might be due to the increased population that required more land clearing for settlement. Results demonstrated that urban expansion was the main reason for the area changes. The intactness of CAs and biodiversity may lose at the expanse of built-up (housing) areas.The study contributed to investigating the spatio-temporal changes as the driving factors on the CAsthat could provide credible associations for future land use management and economic development, in various areas, as well as promoting biodiversity conservation of FRIM. The study emphasized the important link between LULC changes and impacts on the function and structure of sustainability of biodiversity in CAs. It is vital to explore how LULC responds to SDG 15 transformation and to ensure sustainable urban development.

This study could be served as a reference and basis for improving decision-making involving the management of land resources, and contribute to a trade-off between urban expansion and the reductionin biodiversity conservation. The study also demonstrated that the advancements in Remote Sensing and Geographical Information System (GIS) technologies provide powerful tools for mapping and detecting changes in LULC. Particularly, this study shows the importance of such information could be gathered by integrating various techniques ranging from remotely sensed images and also GIS which provides such reliable information.

5. Recommendations for criteria of CABZs

LULC changes contributed a significant impact to conservation areas. In the case of the FRIMNatural Heritage Site, it may jeopardize the intactness of its ecosystem for biodiversity conservation. Thus, BZs could potentially reduce fragmentation and provide layers around CAs. The LULC maybecome factors in determining the criteria for buffer zone (BZ); size, width, and types, for FRIM particularly, and other terrestrial conservation areas generally. The study suggested that the area with higher prone to encroachment (lower elevation and flat) required bigger and wider BZ. However, the area with lower prone to encroachment (higher elevation and undulating) required smaller and narrowerBZ

Beyond these findings, further challenges were continuously put forward for specific alternative strategies and future planning for improving the environmental conservation and biological diversity to reduce the impact of human activities in the study area and elsewhere in Malaysia. The study strongly suggested a further exploration on buffer zone establishment, as vital for FRIM area, Thus, it might be contributed to providing better insight to the policy-makers, in their effort to formulate more effective ways for enhancing sustainable development. Although the study showed the convenience of Remote Sensing and GIS, for future study the use and integration of other data set such as high-resolution remotesensing images such as IKONOS, other Spatio-temporal data, and techniques related to policies might be essential.

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