EXAMINING THE ROLE OF LAND USE CHANGE AS AN ECOSYSTEM SERVICE ON WATERSHED MANAGEMENT

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ABSTRACT

Conversion of land-use change combined with urbanization on watershed can significantly impact the quality of ecosystem service. Land-use change become the main cause of the decline quality of ecosystem service. The relationship between ecosystem service and land-use change play a vital role to implement sustainable watershed management. Motivated by this fact, the objective of this study is to examine the role of land use change as an ecosystem service on watershed management by selecting the study area in the Love River watershed located in the center of Kaohsiung City, Taiwan. This study used Iso Cluster Unsupervised Classification to identify important land use types from the interpretation results of satellite imagery by using spatial analysis embedded with a geographical information system (GIS)-based model to examine the pattern of land-use changes. The analysis revealed a significant change in the proportions of the various land use types of the study area. Land use change, such as deforestation, urbanization, and agricultural expansion, is one of the primary drivers of biodiversity loss and ecosystem degradation. Land use change can disrupt the ecological processes that underpin ecosystem functioning, such as nutrient cycling and soil formation. By understanding the complex relationship between ecosystem services and land use change, this study can help the stakeholders to make regulations or other decisions.To advance future studies, it is necessary to develop a comprehensive ecosystem service and monitoring systems by using GIS-based spatial and temporal analysis.

Keywords: land-use changes, ecosystem service, GIS-based, watershed management

1. INTRODUCTION

The process of ecosystem service is strongly influenced by anthropogenic activities within a watershed. In general, the definition of ecosystem service is advantages both direct and indirect that human obtained from the process changes of environmental resources including land, water, vegetation and atmosphere into a flow of essential goods and services. Watershed as a complex system related to water and land in certain area that integrates various ecosystem variables and its processes. Motivated by this fact, the objective of this study is to examine the role of land use change as an ecosystem service on watershed management by selecting the study area in the Love River watershed located in the center of Kaohsiung City, Taiwan. As a provincial-level city with the fourth largest area and second largest population in Taiwan, Kaohsiung City has a strategic role in various sectors, including watershed management. This paper also focused on Sanmin District (Fig.1) because it has a unique geographical position and directly adjacent to the lower reaches of the Love River, the largest river that runs through Kaohsiung to the sea. Moreover, Sanmin District is also one of the districts with the third highest population density, which of course in the event of flooding due to both rainfall and typhoons can result in high potential casualties. The population density of Sanmin District when compared to other districts in Kaohsiung City

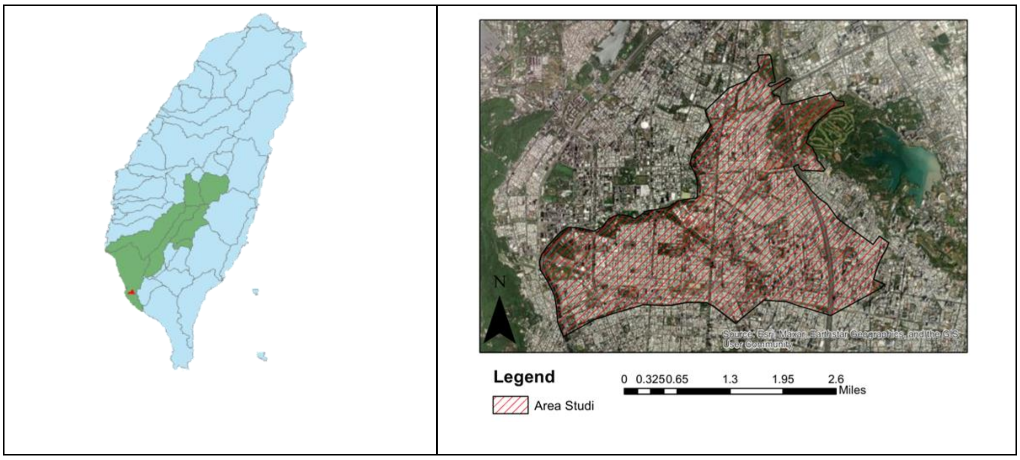

Figure 1. Location of Study Area

We hope to demonstrate the significance of sustainable land management for preserving the resilience and health of watersheds by analyzing the effects of various land use strategies on important ecosystem services, including soil conservation, carbon sequestration, water regulation, and biodiversity.

2. RESEARCH METODOLOGY

This paper has designed a modest research methodology that can be seen on Fig.2. Before analyzing with GIS, the study will select study area in *google earth pro* with format *keyhole markup language (.kml)* and convert into *shapefile polygon (.shp)* format as the basic data in GIS. Then, the Landsat 8 satellite images used in this study cover spectral bands Band 1 to Band 7, which were obtained through the official website of the United States Geological Survey (USGS). This data was then integrated into the land use analysis of the study area by adding the imagery as a dataset layer for further processing. The selection of spectral bands aims to capture various relevant spectral information, such as vegetation characteristics, water bodies, and residential areas. Land use classification in the form of vegetation areas, residential areas and water body areas can be determined by matching the basemap with the color class classification results captured by the Iso Cluster Unsupervised Classification feature (Fig. 2).

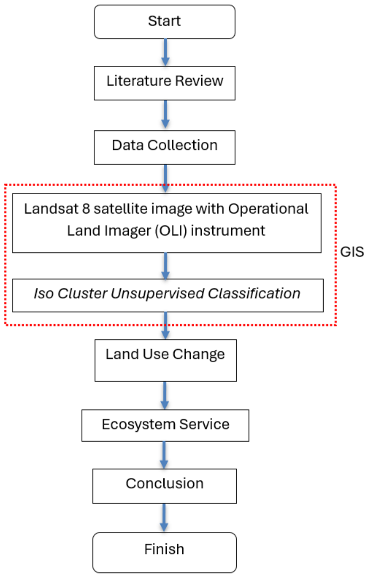

Figure 2. Research Methodology

3. LITERATURE REVIEW

3.1 Geographic Information System (GIS)

Geographic Information System (GIS) is a system that captures, stores, processes, and displays spatial information in an efficient and coherent approach. GIS applications have proven to be an essential tool in many sectors of knowledge such as in civil engineering, it can be applied to interpretate the topographic representation through Digital Elevation Method (DEM) data, hydrological modeling, water availability analysis, to drainage map and/or land use modeling. GIS databases can be obtained through various methods, which can be in the form of direct field observations or photogrammetry or satellite imagery (Fig.1). The type of satellite imagery itself varies depending on the sensor, resolution level and spectral band. Some satellites that are commonly used in land use and water analysis are Landsat and Sentinel.

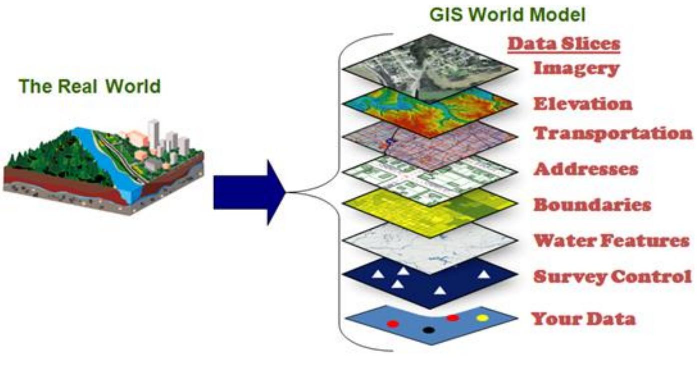

Figure 2. Integration of GIS

3.2 Ecosystem Service

For instance, ecosystem services or eco-services are defined as the goods and services provided by ecosystems to humans. Per the 2006 Millennium Ecosystem Assessment (MA), ecosystem services are "the benefits people obtain from ecosystems". Ecosystem services include food and drink, natural medicines, water supply, materials and renewable and non-renewable energy. The MillenMA), a major UN-sponsored effort to analyze the impact of human actions on ecosystems and human well-being, identified four major categories of ecosystem services: provisioning, regulating, cultural and supporting services (Fig. 3)

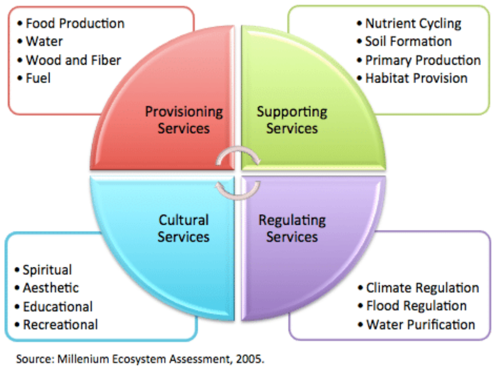

Figure 3. Ecosystem Services Categories

4. RESULTS AND DISCUSSION

The land use change analysis in this study was conducted in 2014 and 2023, with the aim of identifying significant land use changes that occurred in vegetation and residential areas. This approach allowed researchers to understand the dynamics of land use over a period of almost a decade. The result of land use types of selected study area in 2014 can be seen in Fig 4 with the distribution of land use in Fig. 5.

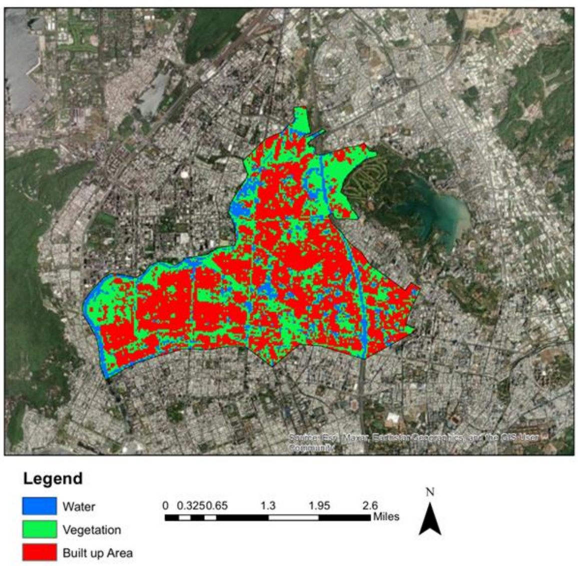

Figure 4. Result of Land Use Type of Study Area in 2014

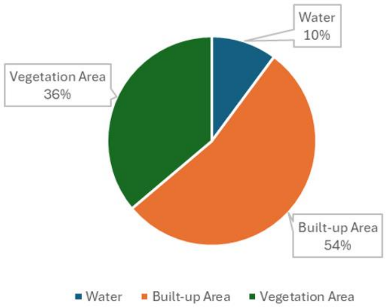

Figure 5. Result of Distribution of Land Use Type of Study Area in 2014

From Figure 5 above, it can be seen that more than half of the study area is filled by residential areas, namely 54%, while the vegetation area is only 36% and the water body area is around 10%. If you consider the development of infrastructure and industry that is growing every year, of course there can be an increase in the percentage of residential areas or residential areas. Therefore, a land use analysis of the study area in 2023 was conducted, the results of which are shown in Figure 6 and Figure 7.

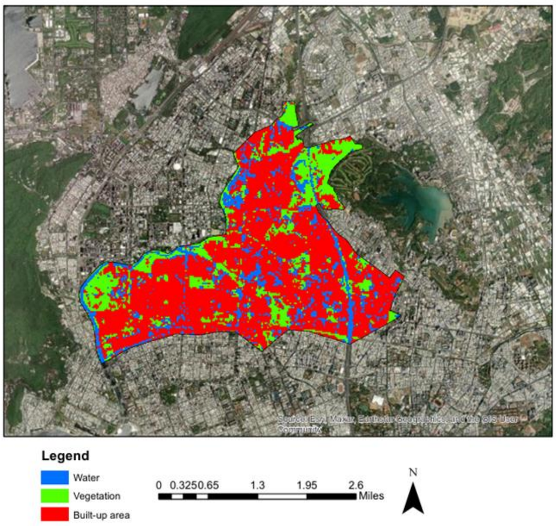

Figure 6. Result of Land Use Type of Study Area in 2023

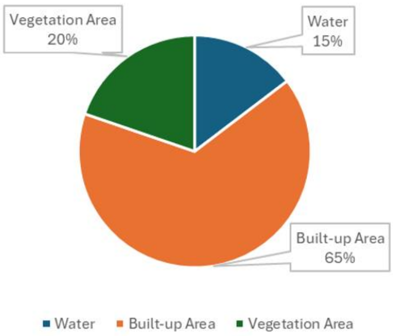

Figure 7. Result of Distribution of Land Use Type of Study Area in 2023

The results of the above analysis show significant changes between 2013 and 2023, with an increase in settlement area of 11% and a decrease in vegetation area of up to 16%. These changes have an unfavorable impact on ecosystem services, especially in water cycle management. The increase in settlement area is directly proportional to the reduction in water catchment area, which directly reduces the ability of rainwater infiltration into the soil. The decrease in vegetation area also affects water storage capacity and increases the volume of excess runoff.

Concerning the ecosystem services, the degraded condition of watershed due to land-use change has a significant impact on the quality of ecosystem service The activities of land use change such as deforestation, urbanization, and/or agricultural expansion, has been identified in this study as the primary drivers of the impact for the loss provision of ecosystem services like conversion of natural areas to unnatural areas such as agriculture that can reduce the availability of food, water, and other natural resources. Land use change also can impair the ability of ecosystems to regulate climate, purify water, and control pests and diseases (reduced regulating services). It causes effect in supporting service for example, deforestation can lead to increased greenhouse gas emissions and reduced carbon sequestration. Land use change can degrade cultural, aesthetical as well as educational landscapes and reduce opportunities for recreation and spiritual experiences (dismished cultural services).

5. CONCLUSION

The analysis revealed a significant change in the proportions of the various land use types of the study area. Land use change, such as deforestation, urbanization, and agricultural expansion, is one of the primary drivers of biodiversity loss and ecosystem degradation. Land use change can disrupt the ecological processes that underpin ecosystem functioning, such as nutrient cycling and soil formation. By understanding the complex relationship between ecosystem services and land use change, this study can help the stakeholders to make regulations or other decisions.To advance future studies, it is necessary to develop a comprehensive ecosystem service and monitoring systems by using GIS-based spatial and temporal analysis.

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