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Application of Remote Sensing for Environmental Management in Vietnam

Thanh Tri Tu
MSc., Lecturer at Faculty of Geographic Information Systems and Remote Sensing,
Ho Chi Minh City University of Natural Resource and Environment,
Ho Chi Minh City, Viet Nam

Abstract. Remote sensing technology has become an important tool for environmental management in Vietnam. The country has a diverse range of environments, from dense forests to vast agricultural lands and coastlines, making remote sensing an ideal method for monitoring and managing natural resources. In this study, some examples of remote sensing applications for environmental management in Vietnam were studied in detail.

Keywords: remote sensing, environmental management, Vietnam's Delta Mekong

Introduction

Remote sensing and Geographic Information Systems (GIS) are two powerful tools that are often used together in environmental management, urban planning, agriculture, and natural resource management (Manson et al., 2015). Remote sensing involves the collection of data from aerial and satellite sensors, which capture information about the Earth's surface and atmosphere. GIS, on the other hand, is a computer-based tool that allows for the management, analysis, and visualization of spatial data. Remote sensing data, such as satellite imagery, can be imported into a GIS, where it can be used to create maps and analyze spatial patterns (Bégué et al., 2018). For example, remote sensing data can be used to detect changes in land use over time, such as the expansion of urban areas or the deforestation of forests. The data can then be analyzed in a GIS to understand the causes and consequences of these changes.

Remote sensing technology has been used in various environmental management applications such as forest monitoring, crop management, urban planning, disaster management, and water resource management. For example, remote sensing can help in monitoring forest cover changes and identifying areas where deforestation is occurring. It can also be used to monitor crop growth and identify areas where irrigation is needed. Therefore, remote sensing is a valuable tool for environmental management as it allows us to gather information about the Earth's environment in a non-intrusive way. The data collected through remote sensing can help us to better understand the environment, make informed decisions about its management, and ensure sustainable use of natural resources (Loisel et al., 2017).

Vietnam is a country that faces numerous environmental challenges, such as air pollution, deforestation, water pollution, and soil erosion, among others. The government has recognized these challenges and is taking steps towards environmental management and sustainable development. One of the key strategies for environmental management in Vietnam is the development of policies and regulations aimed at protecting the environment (Le Thi Minh, Vu, & Nguyen, 2021). The government has implemented various laws and regulations that cover environmental protection, biodiversity conservation, and natural resource management. These policies have helped to control pollution levels, prevent illegal logging and wildlife trading, and promote sustainable practices. Another important aspect of environmental management in Vietnam is the promotion of public awareness and education. The government has launched campaigns to educate the public on environmental issues, and to encourage sustainable behaviors such as waste reduction, recycling, and energy conservation. This has helped to raise awareness among the population, and to encourage people to take actions to protect the environment. Vietnam is also making significant efforts towards promoting

renewable energy and reducing greenhouse gas emissions (Ngoc et al., 2020). The government has set ambitious targets for increasing the use of renewable energy, and has implemented policies to support the development of solar, wind, and hydropower projects. The country is also investing in clean transportation and energy-efficient buildings to reduce carbon emissions.

Remote sensing has proven to be an effective tool for environmental management in Vietnam. It allows the collection of data on a large scale, which is essential for decision-making and monitoring purposes. In this study, some examples of remote sensing applications for environmental management in Vietnam were studied in detail.

Application of Remote Sensing for Environmental Management

Forest Monitoring

One of the main applications of remote sensing in Vietnam is forest management. The use of remote sensing for forest monitoring has been a valuable tool in Vietnam, where deforestation and forest degradation are significant concerns. The tropical forest ecosystems of Vietnam have a well-deserved reputation for both tremendous diversity and distinctiveness. Since the 1990s, Vietnam's forests have been undergoing a shift from a state of net deforestation to a state of net replanting. Deforestation and forest degradation are still going on in Vietnam, despite the fact that the country's forest cover has risen. In the early years of the 21st century, Vietnam ranked among the top countries in terms of the total amount of tree cover that was lost (Hansen et al., 2013). In the study on drivers of deforestation and forest degradation in Vietnam, Khuc et al. (2018) used geographic information system (GIS) tools, a structural regression model (structural model), and a regression tree method to quantify the extent as well as the approximate causes of deforestation and forest degradation in Vietnam (Figure 1) (Van Khuc et al., 2018). The obtained results revealed that around 1.77 and 0.65 million ha of forests were lost and degraded, respectively, between 2000 and 2010. Deforestation and forest degradation were most notable in the north central, northeast, central highland, and northwest areas of the nation. There were several underlying indicators of deforestation and forest degradation including initial forest cover, per capita income, agricultural production, governance, population growth, food, and poverty. These findings illustrate several important policy implications for forest restoration and the REDD+ program in Vietnam: Vietnam should focus most strongly on reducing poverty, preserving existing forests, improving provincial-level governance, and controlling population growth. Avowedly, remote sensing data can provide a rapid, cost-effective method for monitoring forest cover changes and can help in decision-making for forest conservation and management.

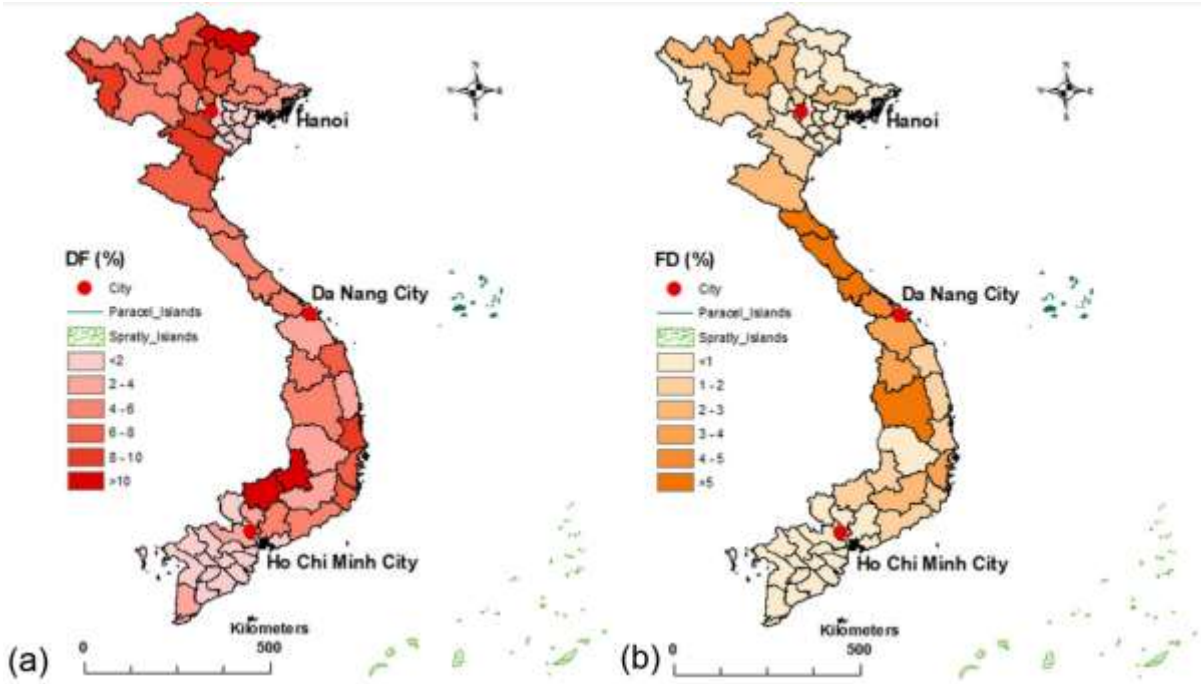

Figure 1. Map of deforestation (a) and forest degradation by province in Vietnam between 2000 and 2010 (Van Khuc et al., 2018)

Water Quality Monitoring

Vietnam's Mekong Delta region is home to one of the world's most productive and diverse ecosystems, but water quality is a significant concern due to pollution and sedimentation (Paik et al., 2020). Remote sensing has been used to monitor water quality in the region, providing an effective tool for environmental management. In a study conducted by Nguyen et al. (2020), Sentinel-2A imagery was used to map the distribution of suspended solid concentration in the water of Vietnam's Mekong Delta rivers (Nguyen et al., 2020). The study revealed that the highest concentration of suspended solid was found in the lower reaches of the river, which could affect water quality and aquatic life. The distribution of suspended solid concentration in the surface water in An Giang province, Mekong Delta is shown in Figure 2. In the province of An Giang, the lowest values for the suspended solids content in surface water are 5,17 mg/l and 35,09 mg/l, while the highest values are 171.24 mg/l and 343,73 mg/l, respectively. The downstream of the Hau River has the highest concentration of suspended matter in surface water. Moreover, the suspended solid concentration concentrates mainly on the Hau River bank and flood areas outside the dike zone. Thus, remote sensing data can provide a useful tool for monitoring water quality and detecting changes in water bodies.

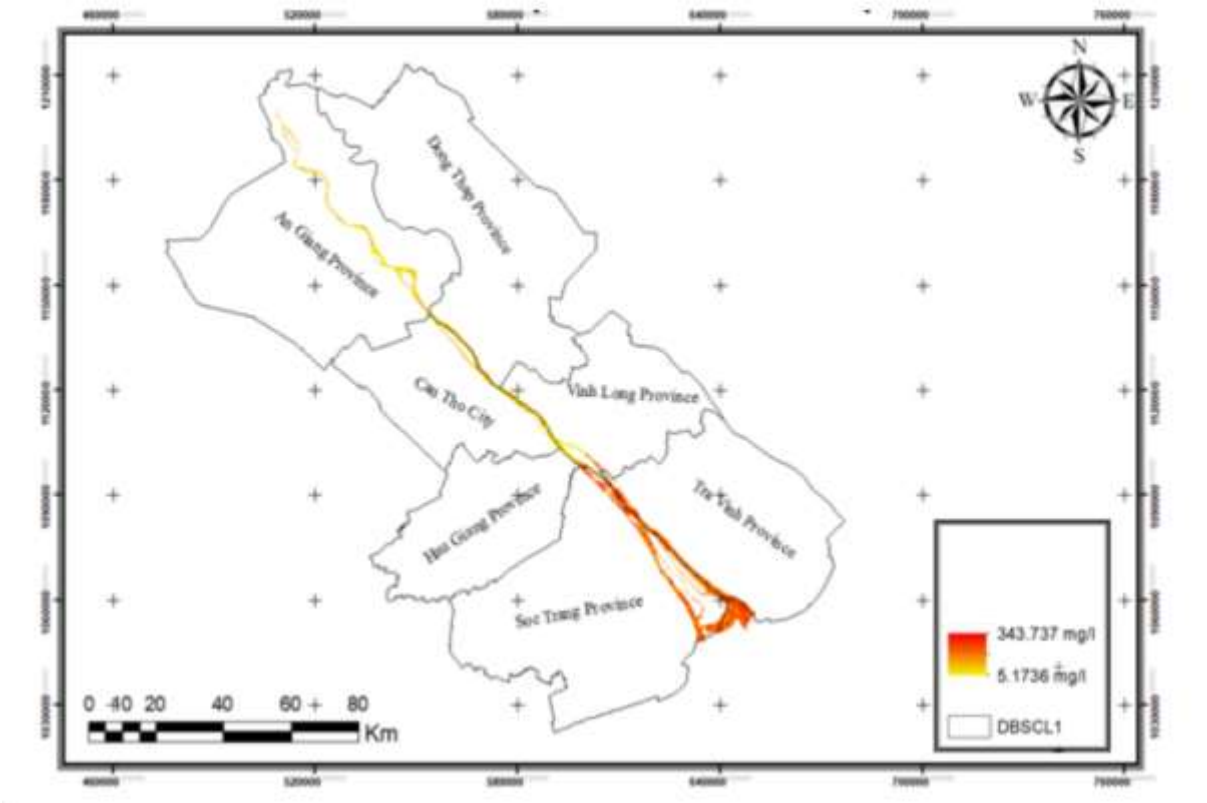

Figure 2. The suspended solid concentration distribution on surface water in An Giang province (Nguyen et al., 2020)

Coastal Zone Management

Vietnam's coastline is an essential resource for the country, providing food, income, and a range of ecological services. However, coastal zones are highly vulnerable to changes due to natural and human-induced factors. Remote sensing has been used to monitor the changes in the coastal zone of Vietnam, providing valuable data for environmental management. In a study conducted by Lin et al. (2021), high-resolution satellite imagery was used to map the coastline and detect shoreline changes over a 13-year period (2006-2019) (Lin, Van Onselen, & Vo, 2021). The study revealed that the coastline had changed significantly due to erosion, sediment deposition, and human activities. Case studies along the central coast of Vietnam reveal linkages between the building of coastal engineering structures and coastal erosion and landform changes through the analysis of aerial pictures and field visits. Due to the installation of coastal engineering works in harbours and along the coastline, such as seawards and groins, there has been an increase in downdrift side erosion in recent decades. Moreover, due to extreme seasonal variations, many residential neighborhoods near the coastline and newly constructed beach resorts are in danger of collapse, and ecosystems are degrading further. For the successful control of coastal erosion, it is required to investigate and monitor the erosion-causing mechanisms, which can vary between coastal sections. When local sites are investigated in more depth, appropriate management strategies can be devised and adapted to local conditions. Before implementing a new management style, it is vital to have a solid grasp of the environmental, geographical, and socioeconomic context (Lin, Van Onselen, & Vo, 2021). In general, remote sensing data can provide useful information for coastal zone management and decision-making for sustainable development.

Land Use Planning

Dong Thap Muoi area is an important agricultural area, providing food and income for millions of people (Le et al., 2018). Remote sensing has been used to support land use planning in the region, providing a useful tool for environmental management (MohanRajan, Loganathan, & Manoharan, 2020). In a study conducted by Nguyen et al. (2021), Landsat imagery was used to classify land use and land cover types in the region. The study revealed that agricultural land was the dominant land use type, accounting for 45.1% of the total land area in 2020 (Binh et al., 2021). The forest has been drastically reduced from 14.4 percent of the entire area in 1990 to barely 5.5 percent in 2020 (Figure 3). During the same period, the built-up area expanded from 0.3% to 6.2% of the total land area. This research may assist the government draft exploitation policies for Dong Thap Muoi's socioeconomic growth and develop a new, stable, and sustainable ecosystem while boosting the region's advantages and establishing a diverse agricultural structure early on. Thus, remote sensing data can provide useful information for land use planning and management, helping to ensure sustainable development in the region.

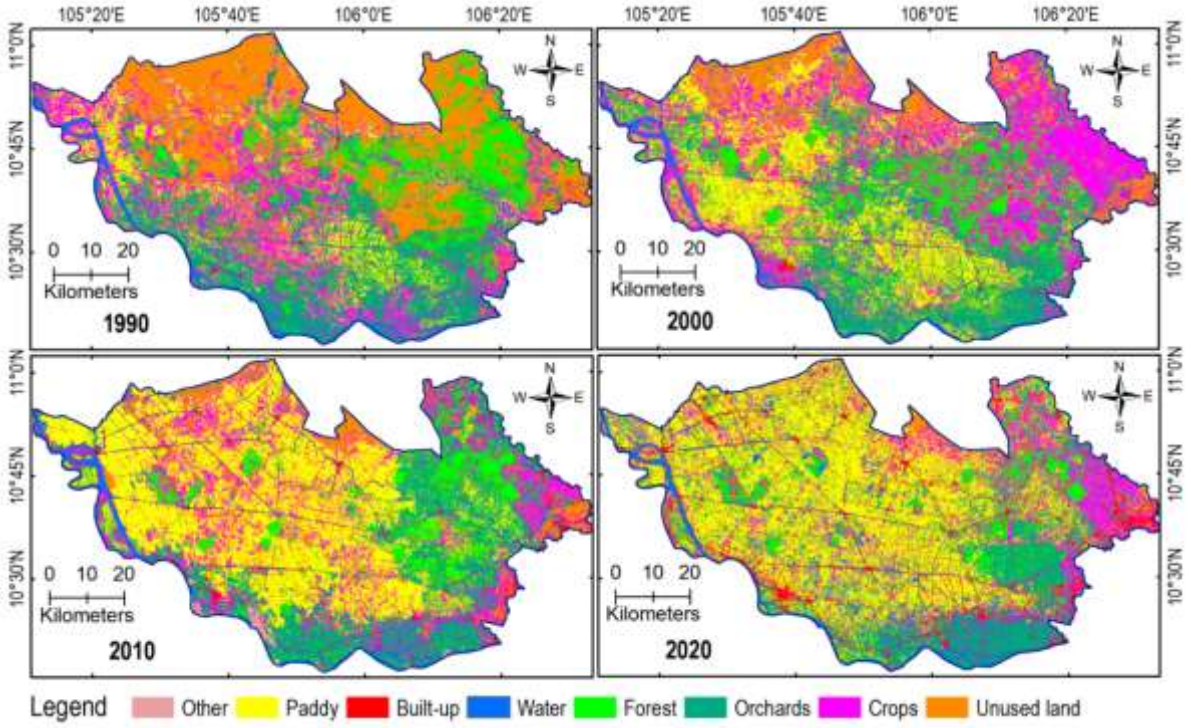

Figure 3. Classes of land use and land cover in the Dong Thap Muoi area over a 30-year period (1990-2020) (Binh et al., 2021)

Natural Disaster Monitoring

Vietnam is highly prone to natural disasters such as floods and landslides, which can cause significant damage to infrastructure, agriculture, and human lives. Remote sensing has been used to monitor natural disasters, providing valuable information for disaster management and mitigation. In a study conducted by Tran et al. (2022), Synthetic Aperture Radar (SAR) imagery was used to map the surface water and monitor flood extents in the Vietnam's Mekong Delta (Tran, Menenti, & Jia, 2022). Using the flood mapping technique, 56 flood maps were constructed with permanent water eliminated. Figure 4a depicts six flood maps corresponding to surface water maps, illustrating a considerable change in the extent of flood waters in An Giang province during the 2017 flood event. The flood began at the beginning of August, grew

significantly in August and September, and then decreased gradually from the beginning of October until November. During the flood, vast tracts of rice fields in the southern and central regions of An Giang province were submerged.

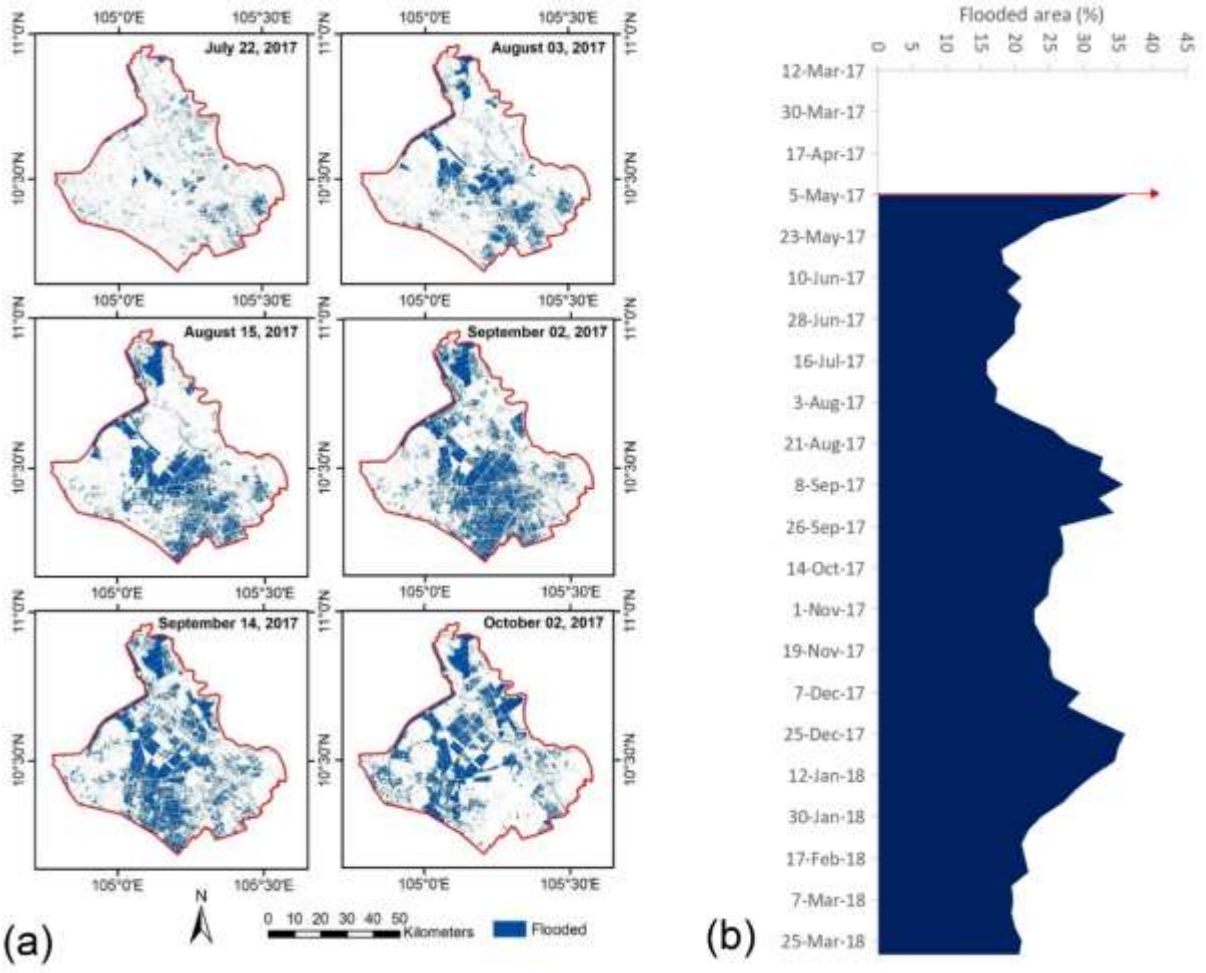

Figure 4. Flood extent maps during the flood event in 2017 using the change detection-based time series analyses on the derived surface water maps derived from the Sentinel-1 SAR data (a) and percentage of the flooded area in An Giang province in 2017–2018 (b) (Tran, Menenti, & Jia, 2022)

The study also revealed that more than 36% of agricultural land in this region was affected by the flood, especially in May and December (Figure 4b). These months are the primary months for the sowing period of summer-autumn and winter-spring rice seasons in An Giang province (Phan et al., 2018). Although the flood in the Vietnam's Mekong Delta is annual from August to November, it is worth characterizing flooded areas caused by agricultural activities or natural flood events. Thus, remote sensing data can provide a rapid and effective tool for natural disaster monitoring and management, helping to reduce the impact of disasters on human lives and livelihoods.

Conclusion

Overall, remote sensing technology has become an important tool for environmental management in Vietnam. It provides valuable information that is used to make informed decisions about natural resource management, disaster risk reduction, and sustainable development.

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