A Comparison of Classification Techniques for Monitoring and Mapping Land Cover and Land Use Changes in the Subtropical Region of Thai Nguyen, Vietnam

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Abstract

Deriving land cover/land-use information from earth observation satellite data is one of the most common applications for environmental monitoring, evaluation and management. Many parametric and non-parametric classification algorithms have been developed and applied to such applications. This study looks at the classification accuracies of three algorithms for different spatial and spectral resolution data. The performance of Random Forest (RF) was compared to Maximum Likelihood (MLC) and Artificial Neural Network (ANN) algorithms for the separation of subtropical land cover/land-use categories using Sentinel-2 and Landsat 8 data. The overall, producers' and users' accuracies were derived from the confusion matrix, while local land use statistics were also collected to evaluate the accuracy of classified images. The accuracy assessment showed the RF algorithm regularly outperformed the MLC and ANN in both types of imagery data (>90%). This approach also exhibited potential in dealing with the challenge of separating similar man-made features such as urban/built-up and mining extraction classes. The ANN algorithm had the lowest accuracy among the three classification algorithms, while Landsat 8 imagery was most suitable for the classification of subtropical mixed and complex landscapes.

As the RF algorithm demonstrated a robustness and potential for mapping subtropical land cover/land-use, this study chose it to monitor and map temporal land cover/land-use changes in Thai Nguyen, Vietnam between 2000 and 2016. The results of this temporal monitoring revealed that there were substantial changes in land cover/land use over the course of 16 years. Agricultural and forest land decreased, while urban and mining extraction land expanded significantly, and water increased slightly. Changes in land cover/land-use are strongly associated with geographic locations. The conversion of agriculture and forest into urban/built-up and mining extraction land was detected largely in the Thai Nguyen central city and southern

regions. In addition, further GIS analysis revealed that approximately 69.6% (100.2km^2) of new built-up areas had occurred within 2km of primary roads, and nearly 96% (137.6km^2) of new built-up expansion was detected within a 5-km buffer of the main roads. This study also demonstrates the potential of multi-temporal Landsat data and the combination of remote sensing, GIS and R programming to provide a timely, accurate and economical means to map and analyse temporal changes for long-term local land use development planning.

Keywords: Random forest; Land cover mapping; Remote Sensing; Vietnam

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List of Abbreviations

ROI: Region of Interest

DN: Digital Number

ETM+: Enhanced Thematic Mapper Plus

OLI/ TIR: Operational Land Imager/ Thermal Infrared

GIS: Geographic Information System

RS: Remote Sensing

MLC: Maximum Likelihood Classifier

ANN: Artificial Neural Network

RF: Random Forest

CART: Classification and Regression Tree

PCA: Principal Component Analysis

TOA: Top of Atmosphere

ENVI: Environment for Visualizing Images

NDVI: Normalized Differenced Vegetation Index

UTM: Universal Transverse Mercator

WGS84: World Geodetic System 84

NASA: National Aeronautics and Space Administration

USWGS: United States Geological Survey

VNIR: Visible/Near-infrared

SWIR: Shortwave Infrared

RGB: Red, Green and Blue

PCC: Post Classification Comparison

TNMT: Thai Nguyen Department of Natural Resource and Environment