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*Editorial*

# Sustainable Applications of Remote Sensing and Geospatial Information Systems to Earth Observations

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**Abstract:** The Special Issue on "Sustainable Applications of Remote Sensing and Geospatial Information Systems to Earth Observations" is published. A total of 20 qualified papers are published in this Special Issue. The topics of the papers are the application of remote sensing and geospatial information systems to Earth observations in various fields such as (1) object change detection, (2) air pollution, (3) earthquakes, (4) landslides, (5) mining, (6) biomass, (7) groundwater, and (8) urban development using the techniques of remote sensing and geospatial information systems. More than 100 researchers have participated in this Special Issue. We hope that this Special Issue is helpful for sustainable applications.

**Keywords:** remote sensing; geospatial information systems; sustainable applications

## 1. Introduction

Over the past half-century, remote sensing (RS) and geospatial information system (GIS) technologies for sustainable applications have played an important role in making technology-oriented life possible. In particular, the tremendous advances in computer and space technologies have made human life easier. Moreover, RS and GIS technologies have been more essential for sustainable applications to the ecological, geological, physical, hydrological, and environmental research fields. The advances of RS and GIS technologies can also be found in other Special Issues [1–5].

The development of RS and GIS technologies have progressed rapidly, and the application results from the technology show high precision and accuracy. However, the sustainable application of RS and GIS has not yet been discussed. Thus, this special issue aims to create an interdisciplinary discussion forum on sustainable applications of RS and GIS to Earth observations. For this purpose, we collected and published 20 qualified papers in this Special Issue. The published papers cover important topics, including (1) object change detection, (2) air pollution, (3) earthquakes, (4) landslides, (5) mining, (6) biomass, (7) groundwater, and (8) urban development using the techniques of remote sensing and geospatial information systems.

## 2. Sustainable Applications of RS and GIS Technologies

Park et al. [6], in their paper entitled "Modified $S^2$CVA Algorithm Using Cross-Sharpened Images for Unsupervised Change Detection", propose an efficient method for reducing the false alarm rate (FAR) caused by the relief displacement and seasonal effects that occurs from multitemporal satellite images having high spatial-resolution. The key is to apply cross-sharpened images to unsupervised change detection algorithms in order to improve the performance of change detection. For this, the sequential spectral change vector analysis ($S^2$CVA) was used for this study. The results indicate that the proposed method efficiently reduced the FAR of change detection results.

Ma et al. [7], in their paper entitled "Variations in FINN Emissions of Particulate Matters and Associated Carbonaceous Aerosols from Remote Sensing of Open Biomass Burning over Northeast China during 2002–2016", analyze the spatial and temporal changes of particulate matter emission and related carbonaceous aerosol emissions in Northeast China from 2002 to 2016. From the results, they propose a scientific basis for establishing policies to reduce air pollution in China.

Alizadeh et al. [8], in their paper entitled "Social Vulnerability Assessment Using Artificial Neural Network (ANN) Model for Earthquake Hazard in Tabriz City, Iran", apply the ANN approach to estimate social vulnerability to earthquakes in the city of Tabriz in Iran. From their results, the very highly vulnerable area was only 0.77%, while the area of about 76.31% had a very low vulnerability. This research can be very helpful in social vulnerability studies to define earthquake risk mitigation policies and emergency planning and management to reduce disaster impacts.

Azeez et al. [9], in their paper entitled "Vehicular CO Emission Prediction Using Support Vector Regression Model and GIS", propose an efficient hybrid model through the integration of correlation-based feature selection (CFS) and support vector regression (SVR) models based on GIS technology to predict vehicle emissions at specific locations and times. Their study area is located in the urban area of Kuala Lumpur city, Malaysia. From the results, the validation accuracy of about 80.6% and the correlation coefficient of about 0.97 were respectively achieved, and the mean absolute error (MAE) and root mean square error (RMSE) were about 1.32 and 2.16 ppm, respectively. The result shows that their model can be a very promising tool to estimate traffic CO in urban areas.

Pourghasemi et al. [10], in their paper entitled "Assessment of Landslide-Prone Areas and Their Zonation Using Logistic Regression, LogitBoost, and NaïveBayes Machine-Learning Algorithms", perform landslide susceptibility mapping using three different models of LogitBoost (LB), logistic regression (LR) and naïve Bayes (NB). The study area is Jumunjin, South Korea. The performance of the three models was compared by using the area under the curve (AUC) method. The LB, LR, and NB models had AUC values of about 70.7, 84.2, and 85.2%, respectively. The LR and NB methods would likely be superior to the LB method. This approach would be useful for hazard mitigation and land-use monitoring.

Wu et al. [11], in their paper entitled "Remote Sensing Detection of Vegetation and Landform Damages by Coal Mining on the Tibetan Plateau", propose an automatic detection approach to identify mining activities from multiple satellite images. The performance of this approach was validated through recent mine developments at Muli Town in the northeastern part of the Tibetan Plateau. This research demonstrates that large environmental issues due to mine developments can be assessed by using multi-mission satellite images.

Blachowski et al. [12], in their paper entitled "Evolution of Secondary Deformations Captured by Satellite Radar Interferometry: Case Study of an Abandoned Coal Basin in SW Poland", used multi-temporal ERS-1, ERS-2, and Envisat C-band synthetic aperture radar (SAR) images to analyze ground movements of an enclosed coal mining basin known as Walbrzych Coal Basin in the southwestern part of Poland from 1995 to 2010. The results showed that (1) the post-mining ground motion process is very complex, and (2) the SAR interferometric (InSAR) technique has a distinct advantage that it can be used for historical studies.

Zabihi et al. [13], in their paper entitled "Multi-Criteria Analysis by Ordered Weighted Averaging (OWA): Toward an Integrated Citrus Management Strategy", propose a model based on the site location

assessment for citrus cultivation sites located in Ramsar, Iran, via a multi-criteria assessment (MCE) approach. The result shows how the multi-criteria approach can play an important role in making decisions to assess the suitability of citrus production.

Moparthy et al. [14], in their paper entitled "Can We Detect the Brownness or Greenness of the Congo Rainforest Using Satellite-Derived Surface Albedo? A Study on the Role of Aerosol Uncertainties", compare two different satellite-derived surface albedo products in the visible band in Congo, which is one of the tropical forest regions, and discuss the large discrepancy (~70%) between the products. The result indicates that the vegetation characteristics estimated from the satellite-based albedo products can be biased in tropical forest regions. In addition, the result shows that a remarkable increase (~14%) in total aerosols was observed.

Lee et al. [15], in their paper entitled "Groundwater Potential Mapping Using Data Mining Models of Big Data Analysis in Goyang-si, South Korea", map and analyze the groundwater potential in the city of Goyang in South Korea, and then perform a factor sensitivity analysis. They produced groundwater potential maps using the boosted classification tree (BCT) and frequency ratio (FR) models and validated the accuracy of the potential maps using the receiver operating characteristic (ROC) curve. From the result, the accuracy rates were about 69.39% and 68.31% in the BCT and FR models, respectively. It means that the approach used in this study can be useful for groundwater management.

Wang et al. [16], in their paper entitled "Ground Deformation Analysis Using InSAR and Backpropagation Prediction with Influencing Factors in Erhai Region, China", apply the small baseline subset (SBAS) approach to Sentinel-1 SAR images acquired from 2015 to 2018 in order to investigate the ground deformation patterns in the Erhai region located in Yunnan Province, China. RMSE between the simulated and SBAS-measured values was about 3.063, 1.003, and 1.119 mm, respectively, and the correlation coefficient (R) was 0.996. The result indicates that the proposed prediction model enables us to predict a precise ground deformation pattern.

Youssef et al. [17], in their paper entitled "Agriculture Sprawl Assessment Using Multi-Temporal Remote Sensing Images and Its Environmental Impact; Al-Jouf, KSA", performed a spatiotemporal analysis in the evolution of the agriculture activity in Al-Jouf, Kingdom of Saudi Arabia (KSA), using multi-temporal and multi-spectral satellite images. Environmental problems caused by uncontrolled agriculture activities were monitored in the study area. From the result, a regulated restriction must be implemented in the agriculture activities of KSA to decrease the environmental impacts.

Pham et al. [18], in their paper entitled "Landslide Susceptibility Assessment by Novel Hybrid Machine Learning Algorithms", performed landslide prediction using hybrid models in north Pithoragarh district, Uttarakhand, Himalaya, India. Additionally, they also performed a factor sensitivity analysis. It was found that one of most important factors was a land cover map, while the curvature map was not dependent on the landslide in this study. The result of this approach will be helpful for landslide damage management.

Ghodousi et al. [19], in their paper entitled "Evaluating Citizen Satisfaction and Prioritizing Their Needs Based on Citizens' Complaint Data", mined and analyzed data of a citizens' complaint system, which is called a "137 system" in Iran, (1) to prioritize the city's needs, and (2) to evaluate citizen satisfaction. For this, the Bees and K-means algorithms were applied. The results show the importance of descriptive results in providing a new perspective on citizens' needs.

Wang et al. [20], in their paper entitled "Analysis of Land Surface Deformation in Chagan Lake Region Using TCPInSAR", observed spatiotemporal surface displacements and surface displacement rates in Chagan Lake, China, using the temporarily coherent point InSAR (TCPInSAR) method during 5 years from 2006 to 2010. During the 5 years, the displacements of −46.7 mm/year to 41.7 mm/year were observed. The monitoring result can be helpful for the sustainable economic and ecological development in Chagan Lake.

Janizadeh et al. [21], in their paper entitled "Prediction Success of Machine Learning Methods for Flash Flood Susceptibility Mapping in the Tafresh Watershed, Iran", produce flood susceptibility maps in the Tafresh watershed, Iran, using the kernel logistic regression (KLR), functional tree

(FT), multilayer perceptron artificial neural network (MLP-ANN), quadratic discriminant analysis (QDA), and alternating decision tree (ADT) models. The flood occurrence database was made from 320 historical flood events, and eight factors were extracted for the models. The extracted factors were used as flood-dependent factors. The result shows that ADT is the best model.

Park et al. [22], in their paper entitled "Performance Evaluation of the GIS-Based Data-Mining Techniques Decision Tree, Random Forest, and Rotation Forest for Landslide Susceptibility Modeling", evaluated the landslide susceptibility mapping performance of three machine learning models, and compared among the accuracies of the models. The test site was Woomyeon Mountain, South Korea, and the three different models, such as the random forest (RF), rotation forest (RoF), and decision tree (DT) algorithms, were used. Fourteen dependent factors were extracted, and the 10-fold cross-validation approach was used for the model training and validation. The results indicate that the RoF is superior to DT and RF. This result can be used for landslide mitigation plans.

Pham et al. [23], in their paper entitled "A Novel Intelligence Approach of a Sequential Minimal Optimization-Based Support Vector Machine for Landslide Susceptibility Mapping", propose an efficient hybrid model to produce a precise landslide map. They call the hybrid model a sequential minimal optimization and support vector machine (SMOSVM). The performance of the SMOSVM method was evaluated in the Mu Cang Chai District, located in Yen Bai Province, Vietnam. The results show that the proposed SMOSVM model achieved a higher performance in the study area.

Han et al. [24], in their paper entitled "Performance of Logistic Regression and Support Vector Machines for Seismic Vulnerability Assessment and Mapping: A Case Study of the 12 September 2016 ML5.8 Gyeongju Earthquake, South Korea", assess and map seismic vulnerability of the 2016 Gyeongju earthquake in Gyeongju, Korea. The LR and support vector machine (SVM) models were used to assess and map the seismic vulnerability. In the SVM model, they used four kernels, such as sigmoid, radial basis function, polynomial, and linear. The achieved success rates were about 0.652, 0.630, 0.998, 0.842, and 0.649 in LR, SVM-sigmoid, SVM-radial, SVM-polynomial, and SVM-linear, respectively. The result indicates that the SVM method with the radial basis function kernel is superior to other methods. From the result, Hwangnam-dong and Jungbu-dong were selected as common vulnerable areas while Gangdong-myeon was chose as a common safe area.

Ghasemkhani et al. [25], in their paper entitled "Urban Development Modeling Using Integrated Fuzzy Systems, Ordered Weighted Averaging (OWA), and Geospatial Techniques", propose an efficient model for identifying the bare ground changes into an area built or developed. The proposed model is defined by the integration of fuzzy and OWA methods. The results show that the achieved accuracy was about 98.98%. It indicates that the proposed method has a higher accuracy in urban development modeling.

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## References

1. Lee, S. Editorial for Special Issue: Application of Artificial Neural Networks in Geoinformatics. *Appl. Sci.* **2018**, *8*, 55. [CrossRef]
2. Jung, H.-S.; Lee, S. Special Issue on Machine Learning Techniques Applied to Geoscience Information System and Remote Sensing. *Appl. Sci.* **2019**, *9*, 2446. [CrossRef]
3. Jung, H.-S.; Zhang, L.; Hong, S.-H. Advanced Sensor Technologies in Geospatial Sciences and Engineering. *J. Sens.* **2019**, 3095901. [CrossRef]

4. Jung, H.-S.; Lee, S.; Zhang, L. Sensor Technologies and Methods for Geoinformatics and Remote Sensing. *J. Sens.* **2019**, 3816727. [CrossRef]
5. Ryu, J.-H.; Jung, H.-S.; Lee, S.; Cui, T. Special Issue on Advances in Remote Sensing and Geoscience Information Systems of the Coastal Environments. *J. Coast. Res.* **2019**, *SI 90*, v–xi. [CrossRef]
6. Park, H.; Choi, J.; Park, W.; Park, H. Modified $S^2$CVA Algorithm Using Cross-Sharpened Images for Unsupervised Change Detection. *Sustainability* **2018**, *10*, 3301. [CrossRef]
7. Ma, G.; Zhao, T.; Kong, S.; Bao, Y.; Chen, C.; Gong, S.; Guo, J.; Yu, C.; Wu, M.; Chang, J.; et al. Variations in FINN Emissions of Particulate Matters and Associated Carbonaceous Aerosols from Remote Sensing of Open Biomass Burning over Northeast China during 2002–2016. *Sustainability* **2018**, *10*, 3353. [CrossRef]
8. Alizadeh, M.; Alizadeh, E.; Asadollahpour Kotenaee, S.; Shahabi, H.; Beiranvand Pour, A.; Panahi, M.; Bin Ahmad, B.; Saro, L. Social Vulnerability Assessment Using Artificial Neural Network (ANN) Model for Earthquake Hazard in Tabriz City, Iran. *Sustainability* **2018**, *10*, 3376. [CrossRef]
9. Azeez, O.S.; Pradhan, B.; Shafri, H.Z.M. Vehicular CO Emission Prediction Using Support Vector Regression Model and GIS. *Sustainability* **2018**, *10*, 3434. [CrossRef]
10. Pourghasemi, H.R.; Gayen, A.; Park, S.; Lee, C.-W.; Lee, S. Assessment of Landslide-Prone Areas and Their Zonation Using Logistic Regression, LogitBoost, and NaïveBayes Machine-Learning Algorithms. *Sustainability* **2018**, *10*, 3697. [CrossRef]
11. Wu, Q.; Liu, K.; Song, C.; Wang, J.; Ke, L.; Ma, R.; Zhang, W.; Pan, H.; Deng, X. Remote Sensing Detection of Vegetation and Landform Damages by Coal Mining on the Tibetan Plateau. *Sustainability* **2018**, *10*, 3851. [CrossRef]
12. Blachowski, J.; Kopeć, A.; Milczarek, W.; Owczarz, K. Evolution of Secondary Deformations Captured by Satellite Radar Interferometry: Case Study of an Abandoned Coal Basin in SW Poland. *Sustainability* **2019**, *11*, 884. [CrossRef]
13. Zabihi, H.; Alizadeh, M.; Kibet Langat, P.; Karami, M.; Shahabi, H.; Ahmad, A.; Nor Said, M.; Lee, S. GIS Multi-Criteria Analysis by Ordered Weighted Averaging (OWA): Toward an Integrated Citrus Management Strategy. *Sustainability* **2019**, *11*, 1009. [CrossRef]
14. Moparthy, S.; Carrer, D.; Ceamanos, X. Can We Detect the Brownness or Greenness of the Congo Rainforest Using Satellite-Derived Surface Albedo? A Study on the Role of Aerosol Uncertainties. *Sustainability* **2019**, *11*, 1410. [CrossRef]
15. Lee, S.; Hyun, Y.; Lee, M.-J. Groundwater Potential Mapping Using Data Mining Models of Big Data Analysis in Goyang-si, South Korea. *Sustainability* **2019**, *11*, 1678. [CrossRef]
16. Wang, Y.; Guo, Y.; Hu, S.; Li, Y.; Wang, J.; Liu, X.; Wang, L. Ground Deformation Analysis Using InSAR and Backpropagation Prediction with Influencing Factors in Erhai Region, China. *Sustainability* **2019**, *11*, 2853. [CrossRef]
17. Youssef, A.M.; Abu Abdullah, M.M.; Pradhan, B.; Gaber, A.F.D. Agriculture Sprawl Assessment Using Multi-Temporal Remote Sensing Images and Its Environmental Impact; Al-Jouf, KSA. *Sustainability* **2019**, *11*, 4177. [CrossRef]
18. Thai Pham, B.; Shirzadi, A.; Shahabi, H.; Omidvar, E.; Singh, S.K.; Sahana, M.; Talebpour Asl, D.; Bin Ahmad, B.; Kim Quoc, N.; Lee, S. Landslide Susceptibility Assessment by Novel Hybrid Machine Learning Algorithms. *Sustainability* **2019**, *11*, 4386. [CrossRef]
19. Ghodousi, M.; Alesheikh, A.A.; Saeidian, B.; Pradhan, B.; Lee, C.-W. Evaluating Citizen Satisfaction and Prioritizing Their Needs Based on Citizens' Complaint Data. *Sustainability* **2019**, *11*, 4595. [CrossRef]
20. Wang, F.; Ding, Q.; Zhang, L.; Wang, M.; Wang, Q. Analysis of Land Surface Deformation in Chagan Lake Region Using TCPInSAR. *Sustainability* **2019**, *11*, 5090. [CrossRef]
21. Janizadeh, S.; Avand, M.; Jaafari, A.; Phong, T.V.; Bayat, M.; Ahmadisharaf, E.; Prakash, I.; Pham, B.T.; Lee, S. Prediction Success of Machine Learning Methods for Flash Flood Susceptibility Mapping in the Tafresh Watershed, Iran. *Sustainability* **2019**, *11*, 5426. [CrossRef]
22. Park, S.; Hamm, S.-Y.; Kim, J. Performance Evaluation of the GIS-Based Data-Mining Techniques Decision Tree, Random Forest, and Rotation Forest for Landslide Susceptibility Modeling. *Sustainability* **2019**, *11*, 5659. [CrossRef]
23. Pham, B.T.; Prakash, I.; Chen, W.; Ly, H.-B.; Ho, L.S.; Omidvar, E.; Tran, V.P.; Bui, D.T. A Novel Intelligence Approach of a Sequential Minimal Optimization-Based Support Vector Machine for Landslide Susceptibility Mapping. *Sustainability* **2019**, *11*, 6323. [CrossRef]

24. Han, J.; Park, S.; Kim, S.; Son, S.; Lee, S.; Kim, J. Performance of Logistic Regression and Support Vector Machines for Seismic Vulnerability Assessment and Mapping: A Case Study of the 12 September 2016 ML5.8 Gyeongju Earthquake, South Korea. *Sustainability* **2019**, *11*, 7038. [CrossRef]
25. Ghasemkhani, N.; Vayghan, S.S.; Abdollahi, A.; Pradhan, B.; Alamri, A. Urban Development Modeling Using Integrated Fuzzy Systems, Ordered Weighted Averaging (OWA), and Geospatial Techniques. *Sustainability* **2020**, *12*, 809. [CrossRef]