Spatial analysis and machine learning prediction of forest fire susceptibility: a comprehensive approach for effective management and mitigation

Publons ID	(not set)
Wos ID	WOS:001217950000001
Doi	10.1016/j.scitotenv.2024.171713
Title	Spatial analysis and machine learning prediction of forest fire susceptibility: a comprehensive approach for effective management and mitigation
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Publish Date	MAY 20 2024
Journal Name	SCIENCE OF THE TOTAL ENVIRONMENT
Citation	18
Abstract	Forest fires (FF) in tropical seasonal forests impact ecosystem. Addressing FF in tropical ecosystems has become a priority to mitigate impacts on biodiversity loss and climate change. The escalating frequency and intensity of FF globally have become a mounting concern. Understanding their tendencies, patterns, and vulnerabilities is imperative for conserving ecosystems and facilitating the development of effective prevention and management strategies. This study investigates the trends, patterns, and spatiotemporal distribution of FF for the period of 2001-2022, and delineates the forest fire susceptibility zones in Odisha State, India. The study utilized: (a) MODIS imagery to examine active fire point data; (b) Kernel density tools; (c) FF risk prediction using two machine learning algorithms, namely Support Vector Machine (SVM) and Random Forest (RF); (d) Receiver Operating Characteristic and Area Under the Curve, along with various evaluation metrics; and (e) a total of 19 factors, including three topographical, seven climatic, four biophysical, and five anthropogenic, to create a map indicating areas vulnerable to FF. The validation results revealed that the RF model achieved a precision exceeding 94 % on the validation datasets, while the SVM model reached 89 %. The estimated forest fire sus- ceptibility zones using RF , SVM techniques indicated that 20.14 % and 16.72 % of the area, respectively, fall under the " Very High Forest Fire " susceptibility class. Trend analysis reveals a general upward trend in forest fire occurrences (R 2 = 0.59), with a notable increase after 2015, peaking in 2021. Notably, Angul district was identified as the most affected area, documenting the highest number of forest fire incidents over the past 22 years. Additionally, forest fire mitigation plans have been developed by drawing insights from forest fire man- agement strategies implemented in various countries worldwide. Overall, this analysis provides valuable insights for policymakers and forest management authorities to develop effective strategies for forest fire prevention and mitigation.
Publish Type	Journal
Publish Year	2024
Page Begin	(not set)
Page End	(not set)
Issn	0048-9697
Eissn	1879-1026
Url	https://www.webofscience.com/wos/woscc/full-record/WOS:001217950000001
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