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# Covid-19 Pandemic and Its Environmental Implications: An Investigation of Forest Fires in Northern Iran

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*ABSTRACT*

A global health and economic crisis was caused by a pandemic Covid-19 in 2020, which reduced human activity worldwide. As human activities decreased, researchers had the chance to evaluate the impact of humankind on the ecosystem as well as explore the causes behind natural occurrences like forest fires, which are mostly caused by humans. To assess the effect of quarantine on the forest fire situation in northern Iran. Twelve indicators were retrieved from Sentinel satellites, which represent four groups: land surface temperature, air pollutants, vegetation, and humidity. As indicated by preliminary results, the risk of fire decreased by about 34% in 2020 compared with 2018–2019; however, it subsequently increased again in 2021–2022. This leads to the conclusion that Covid-19 had a positive impact on forest health, but there was still an element of uncertainty as different ecological variables come into play. To evaluate this hypothesis in different regions, it is necessary to conduct additional studies, especially using ground-based data. In light of the adverse economic consequences of Covid-19, it is recommended that forest protection policies be implemented more effectively.

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## INTRODUCTION

The extent and frequency of wildfires have heightened in recent years, posing a threat to human health and negatively impacting the environment [1]. As a consequence of exposure to particulate matter in wildfire smoke, humans experience inflammation, oxidative stress, and acute respiratory tract infections such as bronchitis and pneumonia [2]. Natural disasters have also been shown to be associated with an increased risk of mental illness [3]. In a survey of 186 employees in Fort McMurray (Canada), which has been experiencing many natural disasters in recent years, it was found that employees exposed to natural disasters such as forest fires, floods, and Covid-19 crisis are more likely to suffer from post-traumatic stress disorder (PTSD) [4]. Approximately 684 million people have been infected by Covid-19 since the outbreak of SARS-CoV-2 in Wuhan (China) in December 2019 [5]. Following the outbreak of Covid-19 [6], governments implemented quarantines, which had many adverse effects on health [7], the economy [8], agriculture [9], and food security [10]. In spite of this, many researchers have noted that this crisis has caused some positive environmental effects, such as a reduction in air pollution because of a decrease in demand for energy [11, 12]. It has been shown in Italy that the reduction of human disturbance increases species richness in temporarily less disturbed habitats, increases the breeding success of aerial insectivorous birds, reduces road kill of amphibians and reptiles, and provides the opportunity to exploit habitat [13]. Multiple studies have examined the effects of quarantine on ecosystems, including forests, and it has been found that quarantine had an impact on fire rates through a variety of mechanisms [6]. From March to December 2020, active fires were reported decreased by 21% in US forests [14]. According to a study conducted in Siak Regency (Indonesia) using Sentinel-2 imagery, there were approximately 459.71 ha of burned areas in 2020, which is substantially less than in 2019 with 1236.8 ha [15]. The

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data from satellites has shown that the pandemic in Nepal has contributed to a decrease of 4.54% in the number of forest fire incidents and a decrease of 11.36% in the radiation power of fire, and the cause may be due to the restrictions on the movement of people [16]. A study conducted by Vadrevu et al. [17] in South and Southeast Asian countries indicated that the number of fire events in 2020 decreased between 2.88 and 79.43% compared to 2019.

However, deforestation is driven by complex factors that can change during social changes. In opposition to the findings presented above, some evidence points out that Covid-19 epidemic has led to the unauthorized and predatory annihilation of tropical forests in tropical countries. In 2020, there were 9,583 square kilometers of tropical forest areas classified as threatened by deforestation, which is over double the amount designated as threatened in 2019 [18]. Colombia experienced an increase in forest fires as a result of the quarantine, which was driven by a decline in the supervision provided by the state-level environmental protection agencies [6]. Furthermore, it was reported that the number of forest fires in South Asian countries such as Afghanistan, Sri Lanka, Cambodia, and Myanmar increased by 152, 4.9, 11.1, and 8.5%, respectively, in 2020 compared to 2019 [17]. As a result of Covid-19 quarantine, the management of protected areas has been suspended in some countries [19]. Wildfire management in 2020 was faced with unique challenges due to the fact that firefighting camps may provide an ideal environment for the transmission of Covid-19, which poses a significant challenge to the protection of forests [20]. During March to July 2020, when the management of protected areas was suspended in Madagascar, one of the world's most endangered biodiversity hotspots, forest fires were 76–248% higher than predicted [21]. Although the quarantine seemed to be beneficial to the conservation of biodiversity, some claims have been made in Africa that these effects will be extremely detrimental because funds have been cut, environmental protection agencies have been restricted in their operations, and there have been increased anthropogenic threats to nature [22]. A number of threats to biodiversity and protected areas have been exacerbated since the pandemic in Morocco as a result of quarantines and the termination of ecotourism activities [23]. Therefore, Covid-19 pandemic poses a potential threat to wildlife in Africa. A major impact of tourism loss is the reduction of income, which negatively impacts the management of wildlife species and habitats. It has been observed that the loss of tourism revenues reduces the capacity of wildlife conservation agencies [24].

The economic effects of Covid-19 crisis appear to have a significant impact on forest health in this context. Based on the study of Kustanti [25], the income of farmers surrounding Brwijaya University in Indonesia decreased by approximately 39% during the pandemic period. Based on interviews with 62 people and media analyses performed in Gandaki (Nepal), it is evident that the quarantine has suspended all types of forestry and ecotourism businesses and has increased illegal logging, hunting, and trafficking of animals. It was estimated that the forestry sector lost 9.6 million dollars, and small owners of private forests lost 0.24 million dollars [26]. During the economic crisis caused by the pandemic, many urban residents lost their jobs due to retrenchment and moved to villages. Their activities were initiated in the forest without understanding the forest fire prevention rules, thereby making the forest more vulnerable to fire. A study conducted by Rafii and Millang [27] in Sulawesi (Indonesia) found that approximately 78% of the 72% of people who work in forest areas were unaware of fire prevention laws. Hilsenroth et al. [28] determined that 39% of private forest owners in the southeast United States will likely change their forest management practices as a consequence of the pandemic. The factors that contributed to this change were the income derived from property, the effects of the pandemic on employment and income, and geography. Consequently, the pandemic had contributed to an increase in complexity and uncertainty in the wildfire response in the United States [29]. It is also unclear how the restrictions of Covid-19 affect the density and spread of forest fires, particularly in sub-Saharan Africa [30]. Numerous uncertainties exist regarding the effects of Covid-19 crisis on the economy and forests [31]. It is well known that forest fire risks are highly sensitive to changes in social and economic patterns since humans are both fire starters and suppressors [32]. Considering the uncertainty regarding the positive or negative impacts of Covid-19 crisis on forests, the present study intends to assess the condition of Hyrcanian forests situated in the north of Iran prior to, during, and after quarantines from 2018 to 2022.

## MATERIAL AND METHODS

### Study area

Iranian Hyrcany forests, which extend from Golestan to Ardabil provinces, provide a significant amount of goods and clean air to the country. It is estimated that these forests were created about 40 million years ago, around the third geological period, and have been home to hundreds of animal and plant species. Climates in this area can be classified as humid and hot during the summer, humid in the autumn, and mild during the winter. Hyrkani forest consists primarily of broad-leaved trees such as beech, maple, elm, alder, and fig. With a geographical location of 37°4' N and 49°52' E, the study area covers a total area of 1582 square kilometers in the north of Iran, between the regions of Pelang Dara, Sefidroud, Siahkol, Lahijan, and Amlesh (Figure 1).

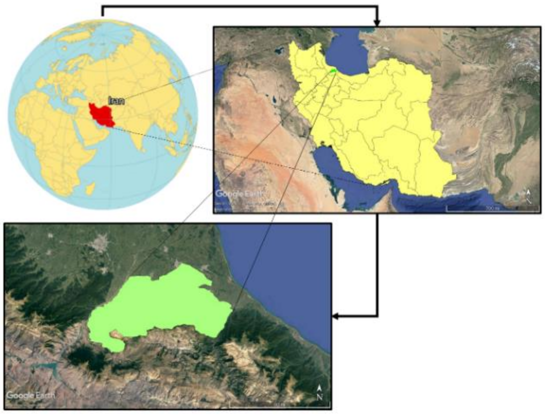

**Figure 1.** An outline of the study area. The earth image was extracted from GIS Geography [33]

**Data**

The main data source used in this study was Sentinel Hub database, which contains data from several satellite series. The Sentinel Hub enables users to access data from Sentinel series satellites, Landsat, and other providers easily and without having to deal with issues of synchronization, storage, processing, compression algorithms, metadata, or sensor bands [34]. Four types of indicators were used to evaluate the state of forests before, during, and after quarantines, including ground surface temperature, fire risk potential, air pollutants, vegetation, and plant and soil moisture. Twelve indicators were obtained by uploading the polygon of the study area prepared by Google Earth Pro in the Sentinel Hub system and extracting the data, which includes Thermal IR fire emission bands F1 and F2 (Sentinel 3-SLSTR), Burn Area Index (BAI) (Sentinel 2-L2A), Normalized Burn Ratio (NBR) (Sentinel 2-L2A), Aerosol 340 and 380 nm (Sentinel 5-P), Carbon monoxide (CO) (Sentinel 5-P), Normalized Difference Vegetation Index (NDVI) (Sentinel 2-L2A), Enhanced Vegetation Index (EVI) (Sentinel 2-L2A), Atmospherically Resistant Vegetation Index (ARVI) (Sentinel 2-L2A), Terrestrial Chlorophyll Index (OTCI) (Sentinel 3-OLCI), Normalized Difference Water Index (NDWI) (Sentinel 2-L2A), and Normalized Difference Moisture Index (NDMI) (Sentinel 2-L2A).

Sentinel-3 SLSTR consists of two dedicated channels, F1 and F2, which are used to measure the land surface temperature (LST) (in degrees Celsius). It is possible to monitor fires and high temperatures at a resolution of one kilometer using these channels. In the daily weather report [35], the air temperature is not equal to the LST. Burned areas have BAI values ranging from -1 to 1, and active fires have BAI values ranging from 1 to 6. The mediterranean regions are primarily responsible for calibrating these values. To estimate burn severity, the normalized burn ratio is frequently used. It uses near-infrared (NIR) and short-wave infrared (SWIR) wavelengths. The near-infrared part of the spectrum of vegetation that is healthy has a high reflectivity, and the short-wave infrared part has a low reflectance. A burned area, however, shows a high short-wave infrared reflectance but a low near-infrared reflectance. Consequently, darker pixels indicate areas that have been burned. A range of -1 to 1 is considered the data range for NBR. A qualitative index that indicates the presence of layers of suspended particles in the atmosphere is called the aerosol index. Airborne particles, such as dust from deserts and volcanic ash piles, can be estimated using this index. An aerosol containing UV–absorbing components has a positive value, and there are two wavelength pairs for which this index is calculated: 380/340 nm and 388/354 nm. As an important atmospheric gas, carbon monoxide (CO) is a major air pollutant in some urban areas. The density of carbon monoxide in a column of air is measured in moles per square meter ($mol/m^2$) [36].

The greenness and density of vegetation are measured and analyzed using the NDVI index. The reflection of light at certain wavelengths by plants is used to determine the status of vegetation. A value between -1 and 1 is considered to be its range. Water can be identified by negative NDVI values (values near -1). Typically, zero values (-0.1 to 0.1) indicate barren areas of rock, sand, or snow. A low value indicates shrublands and grasslands (approximately 0.2 to 0.4); however, a high value indicates temperate rainforests and tropical rainforests (values close to 1) [37]. A vegetation index that is optimized for soil background signals and the effects of the atmosphere is the Enhanced Vegetation Index (EVI). It is generally recognized that healthy vegetation has an EVI value of between 0.20 and 0.80, with a range of -1 to 1. Although EVI is calculated similarly to NDVI, it allows for the correction of some distortions in reflected light resulting from airborne particles and ground cover under vegetation [38]. A vegetation index that minimizes atmospheric scattering is known as Atmospheric Resistant Vegetation Index (ARVI), and it is particularly useful for areas with high atmospheric aerosol concentrations. There is a range between -1 and 1, with green vegetation normally corresponding to values between 0.20 and 0.80. Among the vegetation indices, it is the first time that is relatively insensitive to atmospheric factors [39].

For the purpose of determining the characteristics of water bodies, the Normalized Difference Water Index (NDWI) is the most effective measurement. NDWI highlights water bodies using the green and near-infrared bands because water absorbs light strongly in the visible-to-infrared spectrum. There is a value greater than 0.5 for water bodies, such as plants. A change in the water content of a body of water is monitored by this index. There is a normalized moisture difference index (NDMI) used by plant scientists to determine the amount of water in plants and to monitor drought conditions. The range of the NDMI is from -1 to 1. Negative NDMI values (values close to -1) are indicative of barren soil. Generally, water stress is associated with values between -0.2 and 0.4. A high canopy without water stress is indicated by a positive value (approximately 0.4 to 1). For each of the above indicators, the average data for each year was collected for the period 2018–2022.

## RESULTS AND DISCUSSION

The preliminary findings demonstrated that Thermal F1 in 2020 decreased significantly compared to the period of 2018–2019, while between 2021 and 2022, it showed a trend toward increasing. Prior to 2020, there was no fixed and clear trend, but from 2020 to 2022, there was an increasing trend in thermal F2. BAI witnessed only one sharp surge in 2020. In comparison to the years preceding and following Covid-19 crisis (2018 and 2022), NBR revealed a downward tendency (-34%). The decline in LST statistics may be attributed to a rise in humidity (NDMI) in 2020. The NDWI, on the other hand, lacks evidence of any distinct changes. Aerosol levels showed a declining tendency between 2019 and 2021 but a rising pattern in 2022. The CO index did not demonstrate remarkable variations. Notwithstanding the NDVI and ARVI revealing a decline in vegetation in 2020, the EVI showed generally stable vegetation status throughout all time periods. A completely opposite trend was observed between 2020 and 2022 for OTCI compared to NDVI and ARVI. Figures 2 and 3 represent the process of changing the data for the aforementioned indicators. Geographic distributions and changes from 2018 to 2022 are depicted in Figures 4, 5, and 6.

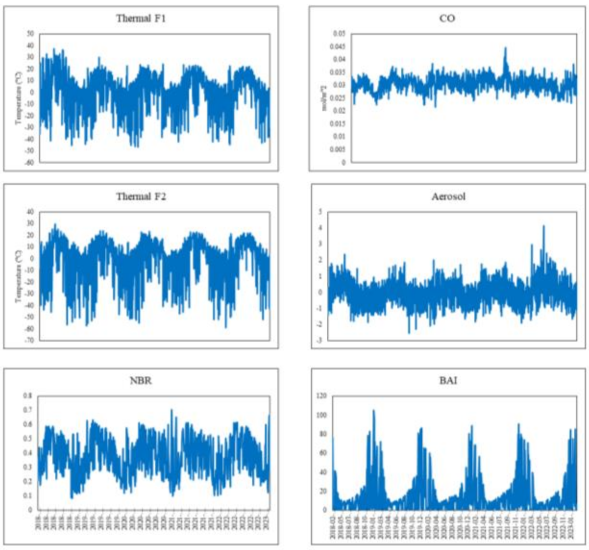


**Figure 2.** The trends in LST, fire risk, and air pollutants from 2018 to 2022

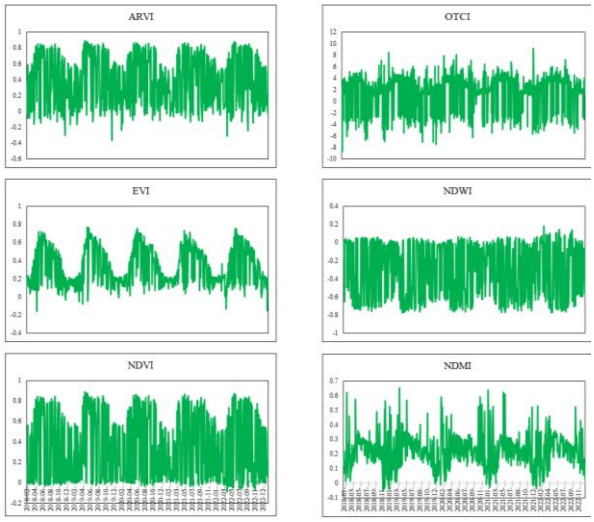


**Figure 3.** The trends in the vegetation and moisture indexes from 2018 to 2022

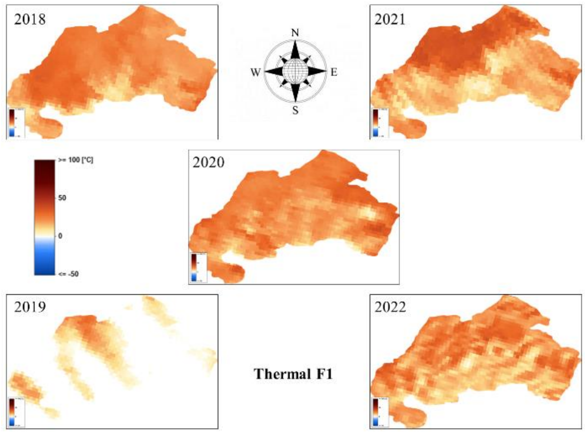


**Figure 4.** Map of the geographical distribution of LST (Thermal F1) from 2018 to 2022 in the study area

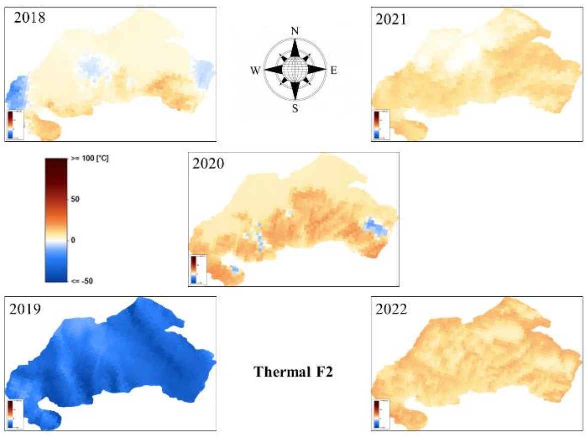


**Figure 5.** Map of the geographical distribution of LST (Thermal F2) from 2018 to 2022 in the study area

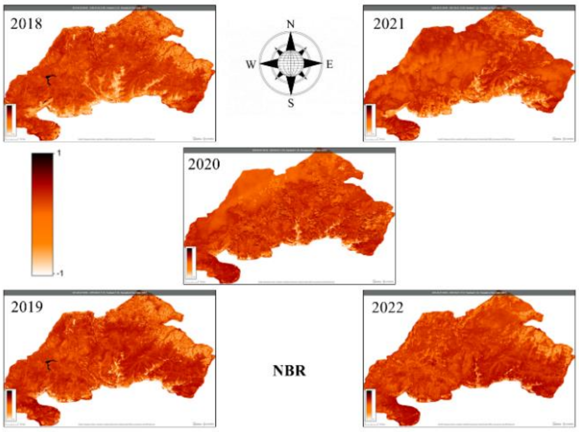


**Figure 6.** Map of the geographical distribution of NBR from 2018 to 2022 in the study area

According to the obtained findings, the risk of wildfire in the investigated zone during quarantine is most probably lowered following a decline in LST and NBR; although, there is still some uncertainty surrounding it. As is evident from the EVI, there was no change in vegetation, while NDMI increased during the stated period, which could be a contributing factor to the decrease in LST. Therefore, Covid-19 is unlikely to have adverse consequences for Iranian forests. Nevertheless, forest fires are expected to increase due to climate change in the next few decades [40]. The effects of climate change, drought, and the invasion of forest pests and pathogens contribute to increased fire risk [41]. Given that wildfires are more frequently triggered by humans than by natural factors, the lockdowns presented an ideal opportunity to explore the consequences of large-scale alterations in human activity on wildlife. Promoting an understanding of species vulnerability and its influence on tourism should pave the way for sustainable tourism management as well as biodiversity protection in the post-Covid-19 world [42]. Edgeley and Burnett [43] demonstrated that household responses to Covid-19 as a crisis promoted their comprehension of fire threats and preventive measures in Arizona (USA). Aside from enhancing the public's consciousness, policies and measures to minimize wildfires should be adopted to mitigate deforestation and air pollution [44, 45]. Burning biomass and destroying vegetation causes various pollutants to be released into the atmosphere, which has a negative impact on air quality, the climate, and human health.

Collaboration between government organizations, particularly in impacted areas, and scientific institutes assists in the evaluation and administration of issues concerning the environment [46, 47]. In order to achieve global climate policy goals and support low-income countries in reaching their Sustainable Development Goals (SDGs), forestry programs led by civil society organizations (CSOs) play a critical role. The spread of Covid-19, however, has led to unprecedented financial challenges for these organizations, reducing their ability to combat deforestation and forest destruction [48]. Because financial resources are allocated to other sectors, such as health, it cannot be guaranteed that protection agencies will make contributions. Several policy actions can be executed to lower ecosystem hazards, including maintaining appropriate conservation funding, developing crisis response strategies, updating wildlife trade protocols, and encouraging research studies, along with establishing a comprehensive tourism recovery plan to deal with Covid-19 and potential pandemics in the future [13].

## CONCLUSION

Covid-19 had a negative impact not only on the economy and the health of the public but also on all aspects of society and the environment. The majority of studies on the environmental effects caused by Covid-19 have mainly focused on reducing greenhouse gas emissions, improving air quality in urban areas, improving water quality, reducing fire incidents, and addressing the positive effects on ecosystems. Nonetheless, some evidence points to an increase in deforestation as a result of reduced surveillance and the economic crisis, which contradicts the hypothesis that quarantines and reduced human activities are positively impacting the environment. This study aimed to evaluate the aforementioned hypothesis in a forest area in northern Iran, which is an ideal location for tourism and wood harvesting. Although satellite data indicated there was no significant difference in the vegetation in the region between pre-Covid-19 and post-Covid-19, the fire risk in 2020 has decreased by about 34% in comparison to pre-Covid-19. Nevertheless, it increased again during the years 2021–2022. Overall, Covid-19 may have a positive impact on forest health, but many environmental factors may influence this outcome. It is, therefore, crucial to conduct more research, especially using ground-based data, to determine whether Covid-19 crisis is impacting forests or not. Deforestation is likely to increase given the trend of population growth, climate change, and the economic implications of Covid-19, which should concern governments across the globe. Furthermore, financial support is essential to prevent bankruptcy caused by economic crises and to preserve the natural resources of the planet.

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## CONFLICT OF INTEREST

The author declares that there is no conflict of interest for the present study.

## REFERENCES


1. Naqvi, H.R., Mutreja, G., Shakeel, A., Singh, K., Abbas, K., Naqvi, D.F., Chaudhary, A.A., Siddiqui, M.A., Gautam, A.S., Gautam, S., and Naqvi, A.R., 2023. Wildfire-induced pollution and its short-term impact on COVID-19 cases and mortality in California. *Gondwana Research*, 114, pp.30–39. Doi: 10.1016/j.gr.2022.04.016
2. Navarro, K.M., Clark, K.A., Hardt, D.J., Reid, C.E., Lahm, P.W., Domitrovich, J.W., Butler, C.R., and Balmes, J.R., 2021. Wildland firefighter exposure to smoke and COVID-19: A new risk on the fire line. *Science of The Total Environment*, 760, pp.144296. Doi: 10.1016/j.scitotenv.2020.144296
3. Sugg, M.M., Runkle, J.D., Hajnos, S.N., Green, S., and Michael, K.D., 2022. Understanding the concurrent risk of mental health and dangerous wildfire events in the COVID-19 pandemic. *Science of The Total Environment*, 806, pp.150391. Doi: 10.1016/j.scitotenv.2021.150391
4. Agyapong, B., Eboreime, E., Shalaby, R., Pazderka, H., Obuobi-Donkor, G., Adu, M.K., Mao, W., Oluwasina, F., Owusu, E., Greenshaw, A.J., and Agyapong, V.I.O., 2021. Mental Health Impacts of Wildfire, Flooding and COVID-19 on Fort McMurray School Board Staff and Other Employees: A Comparative Study. *International Journal of Environmental Research and Public Health*, 19(1), pp.435. Doi: 10.3390/ijerph19010435
5. Worldometers, Coronavirus Cases, 2023. Available online from https://www.worldometers.info/coronavirus/
6. Amador-Jiménez, M., Millner, N., Palmer, C., Pennington, R.T., and Sileci, L., 2020. The Unintended Impact of Colombia's Covid-19 Lockdown on Forest Fires. *Environmental and Resource Economics*, 76(4), pp.1081–1105. Doi: 10.1007/s10640-020-00501-5
7. Haileamlak, A., 2021. The impact of COVID-19 on health and health systems. *Ethiopian Journal of Health Sciences*, 31(6), pp.1073
8. Kolahchi, Z., De Domenico, M., Uddin, L.Q., Cauda, V., Grossmann, I., Lacasa, L., Grancini, G., Mahmoudi, M., and Rezaei, N., 2021. COVID-19 and Its Global Economic Impact. pp 825–837
9. Zarei, M., and Kaviani Rad, A., 2020. Covid-19, Challenges and Recommendations in Agriculture. *Journal of Botanical Research*, 2(1), pp.12–15. Doi: 10.30564/jrb.v2i1.1841
10. Rad, A.K., Shamshiri, R.R., Azarm, H., Balasundram, S.K., and Sultan, M., 2021. Effects of the COVID-19 Pandemic on Food Security and Agriculture in Iran: A Survey. Sustainability 13
11. Mousazadeh, M., Paital, B., Naghdali, Z., Mortezania, Z., Hashemi, M., Karamati Niaragh, E., Aghababaei, M., Ghorbankhani, M., Lichtfouse, E., Sillanpää, M., Hashim, K.S., and Emamjomeh, M.M., 2021. Positive environmental effects of the coronavirus 2020 episode: a review. *Environment, Development and Sustainability*, 23(9), pp.12738–12760. Doi: 10.1007/s10668-021-01240-3
12. Kaviani Rad, A., Shariati, M., and Zarei, M., 2021. The impact of COVID-19 on air pollution in Iran in the first and second waves with emphasis on the city of Tehran. *Journal of Air Pollution and Health*, 5(3). Doi: 10.18502/japh.v5i3.5391
13. Manenti, R., Mori, E., Di Canio, V., Mercurio, S., Picone, M., Caffi, M., Brambilla, M., Ficetola, G.F., and Rubolini, D., 2020. The good, the bad and the ugly of COVID-19 lockdown effects on wildlife conservation: Insights from the first European locked down country. *Biological Conservation*, 249, pp.108728. Doi: https://doi.org/10.1016/j.biocon.2020.108728
14. Poulter, B., Freeborn, P.H., Jolly, W.M., and Varner, J.M., 2021. COVID-19 lockdowns drive decline in active fires in southeastern United States. *Proceedings of the National Academy of Sciences*, 118(43). Doi: 10.1073/pnas.2105666118
15. Mustofa, M.H., Syaufina, L., and Puspaningsih, N., 2022. The estimated total area of forest fire in Siak Regency, Riau Province during the early period of COVID-19 outbreak. In: IOP Conference Series: Earth and Environmental Science. IOP Publishing, p 12008
16. Paudel, J., 2021. Short-run environmental effects of COVID-19: Evidence from forest fires. *World Development*, 137(1), pp.105120. Doi: 10.1016/j.worlddev.2020.105120
17. Vadrevu, K., Eaturu, A., Casadaban, E., Lasko, K., Schroeder, W., Biswas, S., Giglio, L., and Justice, C., 2022. Spatial variations in vegetation fires and emissions in South and Southeast Asia during COVID-19 and pre-pandemic. *Scientific Reports*, 12(1), pp.18233. Doi: 10.1038/s41598-022-22834-5
18. Brancalion, P.H.S., Broadbent, E.N., De-Miguel, S., Cardil, A., Rosa, M.R., Almeida, C.T., Almeida, D.R.A., Chakravarty, S., Zhou, M., Gamarra, J.G.P., Liang, J., Crouzeilles, R., Hérault, B., Aragão, L.E.O.C., Silva, C.A., and Almeyda-Zambrano, A.M., 2020. Emerging threats linking tropical deforestation and the COVID-19 pandemic. *Perspectives in Ecology and Conservation*, 18(4), pp.243–246. Doi: 10.1016/j.pecon.2020.09.006
19. Anand, A., 2022. Lockdowns and fire in Madagascar's parks. *Nature Sustainability*, 5(7), pp.557–558. Doi: 10.1038/s41893-022-00885-w
20. Thompson, M.P., Bayham, J., and Belval, E., 2020. Potential COVID-19 Outbreak in Fire Camp: Modeling Scenarios and Interventions. *Fire*, 3(3), pp.38. Doi: 10.3390/fire3030038
21. Eklund, J., Jones, J.P.G., Räsänen, M., Geldmann, J., Jokinen, A.-P., Pellegrini, A., Rakotobe, D., Rakotonarivo, O.S., Toivonen, T., and Balmford, A., 2022. Elevated fires during COVID-19 lockdown and the vulnerability of protected areas. *Nature Sustainability*, 5(7), pp.603–609. Doi: 10.1038/s41893-022-00884-x
22. Lindsey, P., Allan, J., Brehony, P., Dickman, A., Robson, A., Begg, C., Bhammar, H., Blanken, L., Breuer, T., Fitzgerald, K., Flyman, M., Gandiwa, P., Giva, N., Kaelo, D., Nampindo, S., Nyambe, N., Steiner, K., Parker, A., Roe, D., Thomson, P., Trimble, M., Caron, A., and Tyrrell, P., 2020. Conserving Africa's wildlife and wildlands through the COVID-19 crisis and beyond. *Nature Ecology & Evolution*, 4(10), pp.1300–1310. Doi: 10.1038/s41559-020-1275-6
23. Cherkaoui, S., Boukherouk, M., Lakhal, T., Aghzar, A., and El Youssfi, L., 2020. Conservation Amid COVID-19 Pandemic: Ecotourism Collapse Threatens Communities and Wildlife in Morocco. *E3S Web of Conferences*, 183, pp.01003. Doi: 10.1051/e3sconf/202018301003
24. Kideghesho, J.R., Kimaro, H.S., Mayengo, G., and Kisingo, A.W., 2021. Will Tanzania's Wildlife Sector Survive the COVID-19 Pandemic? *Tropical Conservation Science*, 14, pp.194008292110126. Doi: 10.1177/19400829211012682
25. Kustanti, A., 2021. Income adaptation of farmers as long covid-19 pandemy on sustainable ub forest management: a case from Indonesia. *IOP Conference Series: Earth and Environmental Science*, 883(1), pp.012069. Doi: 10.1088/1755-1315/883/1/012069
26. Laudari, H.K., Pariyar, S., and Maraseni, T., 2021. COVID-19 lockdown and the forestry sector: Insight from Gandaki province of Nepal. *Forest Policy and Economics*, 131, pp.102556. Doi: 10.1016/j.forpol.2021.102556
27. Rafii, A.M., and Millang, S., 2021. Implications of the COVID-

19 pandemic on fire hazards forest and land in Barru District, South Sulawesi. *IOP Conference Series: Earth and Environmental Science*, 886(1), pp.012001. Doi: 10.1088/1755-1315/886/1/012001

28. Hilsenroth, J., Grogan, K.A., Crandall, R.M., Bond, L., and Sharp, M., 2021. The Impact of COVID-19 on management of non-industrial private forests in the Southeastern United States. *Trees, Forests and People*, 6, pp.100159. Doi: 10.1016/j.tfp.2021.100159
29. Thompson, M.P., Belval, E.J., Dilliott, J., and Bayham, J., 2021. Supporting Wildfire Response During a Pandemic in the United States: the COVID-19 Incident Risk Assessment Tool. *Frontiers in Forests and Global Change*, 4. Doi: 10.3389/ffgc.2021.655493
30. Kganyago, M., and Shikwambana, L., 2021. Did COVID-19 Lockdown Restrictions have an Impact on Biomass Burning Emissions in Sub-Saharan Africa? *Aerosol and Air Quality Research*, 21(4), pp.200470. Doi: 10.4209/aaqr.2020.07.0470
31. Wunder, S., Kaimowitz, D., Jensen, S., and Feder, S., 2021. Coronavirus, macroeconomy, and forests: What likely impacts? *Forest Policy and Economics*, 131, pp.102536. Doi: 10.1016/j.forpol.2021.102536
32. Rodrigues, M., Gelabert, P.J., Ameztegui, A., Coll, L., and Vega-García, C., 2021. Has COVID-19 halted winter-spring wildfires in the Mediterranean? Insights for wildfire science under a pandemic context. *Science of The Total Environment*, 765, pp.142793. Doi: 10.1016/j.scitotenv.2020.142793
33. GIS Geography, Iran map, 2022. Available online from https://gisgeography.com/iran-map/
34. Kaviani Rad, A., Shariati, M., and Naghipour, A., 2022. Analyzing relationships between air pollutants and Covid-19 cases during lockdowns in Iran using Sentinel-5 data. J Air Pollut Heal. doi: 10.18502/japh.v6i3.8233
35. ESA, Land Surface Temperature, 2023. Available online from https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-slstr/overview/geophysical-measurements/land-surface-temperature
36. Tropomi, Carbon Monoxide, 2023. Available online from http://www.tropomi.eu/data-products/carbon-monoxide
37. EOS, NDVI: Normalized Difference Vegetation Index, 2023. Available online from https://eos.com/make-an-analysis/ndvi/
38. NASA Earth Observatory, 2000. Available online from https://earthobservatory.nasa.gov/features/MeasuringVegetation/measuring_vegetation_4.php
39. EOS, Vegetation Indices To Drive Digital Agri Solutions, 2022. Available online from https://eos.com/blog/vegetation-indices/
40. Stephens, S.L., Agee, J.K., Fulé, P.Z., North, M.P., Romme, W.H., Swetnam, T.W., and Turner, M.G., 2013. Managing Forests and Fire in Changing Climates. *Science*, 342(6154), pp.41–42. Doi: 10.1126/science.1240294
41. Auer, M.R., 2021. Considering equity in wildfire protection. *Sustainability Science*, 16(6), pp.2163–2169. Doi: 10.1007/s11625-021-01024-8
42. Newsome, D., 2021. The collapse of tourism and its impact on wildlife tourism destinations. *Journal of Tourism Futures*, 7(3), pp.295–302. Doi: 10.1108/JTF-04-2020-0053
43. Edgeley, C.M., and Burnett, J.T., 2020. Navigating the Wildfire–Pandemic Interface: Public Perceptions of COVID-19 and the 2020 Wildfire Season in Arizona. *Fire*, 3(3), pp.41. Doi: 10.3390/fire3030041
44. Sanap, S.D., 2021. Global and regional variations in aerosol loading during COVID-19 imposed lockdown. *Atmospheric Environment*, 246, pp.118132. Doi: 10.1016/j.atmosenv.2020.118132
45. Rad, A.K., Shamshiri, R.R., Naghipour, A., Razmi, S.-O., Shariati, M., Golkar, F., and Balasundram, S.K., 2022. Machine Learning for Determining Interactions between Air Pollutants and Environmental Parameters in Three Cities of Iran. *Sustainability*, 14(13), pp.8027. Doi: 10.3390/su14138027
46. Farias, D.F., Souza, T., Souza, J.A.C.R., Vieira, L.R., Muniz, M.S., Martins, R.X., Gonçalves, Í.F.S., Pereira, E.A.S., Maia, M.E.S., and Silva, M.G.F., 2020. COVID-19 Therapies in Brazil: Should We Be Concerned with the Impacts on Aquatic Wildlife? *Environmental Toxicology and Chemistry*, 39(12), pp.2348–2350. Doi: 10.1002/etc.4888
47. Kaviani Rad, A., Zarei, M., Pourghasemi, H.R., and Tiefenbacher, J.P., 2022. The COVID-19 crisis and its consequences for global warming and climate change. In: Computers in Earth and Environmental Sciences. Elsevier, pp 377–385
48. Mohan, M., Rue, H.A., Bajaj, S., Galgamuwa, G.A.P., Adrah, E., Aghai, M.M., Broadbent, E.N., Khadamkar, O., Sasmito, S.D., Roise, J., Doaemo, W., and Cardil, A., 2021. Afforestation, reforestation and new challenges from COVID-19: Thirty-three recommendations to support civil society organizations (CSOs). *Journal of Environmental Management*, 287, pp.112277. Doi: 10.1016/j.jenvman.2021.112277

**Persian Abstract**

**چکیده**

شیوع همه گیری کووید-۱۹ در سال ۲۰۲۰ سبب ایجاد یک بحران بهداشتی و اقتصادی جهانی و متعاقبا کاهش فعالیت های انسانی شد. با کاهش فعالیت‌های انسان، فرصتی برای پژوهشگران پدید آمد تا به بررسی تاثیر انسان بر اکوسیستم و علل رخدادهای طبیعی همچون آتش سوزی جنگل ها بپردازند. به جهت ارزیابی اثرات قرنطینه بر وضعیت آتش‌سوزی در جنگل‌های شمال ایران، داده های مربوط به ۱۲ شاخص از چهار گروه دمای سطح زمین، آلاینده‌های هوا، پوشش گیاهی و رطوبت از مجموعه ماهواره‌های سنتینل دریافت گردید. تجزیه و تحلیل ها نشان داد که خطر آتش سوزی در سال ۲۰۲۰ در مقایسه با ۲۰۱۸-۲۰۱۹ حدود ۳۴ درصد کاهش یافت. در عین حال، متعاقبا در سال‌های ۲۰۲۱-۲۰۲۲ افزایش یافت. در نتیجه کووید-۱۹ احتمالا تاثیر مثبتی بر سلامت جنگل دارد، اما این نتیجه همچنان با عدم قطعیت همراه است؛ زیرا عوامل اکولوژیکی مختلفی در این رخداد نقش دارند. مطالعات آینده برای ارزیابی مجدد این فرضیه در سایر مناطق باید از داده های زمینی نیز استفاده نمایند. با توجه به پیامدهای منفی کووید-۱۹ بر اقتصاد، توصیه می‌شود سیاست‌های حفاظت از جنگل‌ها به طور موثرتری اجرایی شوند.