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Opinion

Wildfires: A rising hazard for infrastructure resilience

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The latest wildfires around the globe are evidence of growing global temperatures that are a threat to infrastructure resilience. Wildfires are exacerbated by drought and parched conditions, disease, dry lightning and increased interaction between humans and forests leading to accidental as well as purposeful ignition. Megafires, which are more than 10,000 hectares in extent, is especially a problem at the wildland-urban interface, and a consequence of a century of fire suppression and climate warming [1].

Canadian temperatures have reached 40 °C and last year temperatures in British Columbia reached 49.6 °C with several notable wildfires. Wildfire hazard is classified as high in Pakistan due to dry conditions and gusty winds. Hundreds of acres of Makhniyal forest have already been destroyed this year creating CO_2 emissions (and fueling climate change) as well as reducing the area's capacity to capture CO_2 in future years. Climate change is linked also to the increase in wildfires in many forested regions. A vegetation fire is overall neutral in terms of CO_2 effects after a period of regrowth of about 20 years, however smoldering and peat fire is a larger issue for emissions and climate change because organic soils regenerate over a much longer time period [2].

The worst wildfires include the 2018 California wildfires which destroyed 22,751 buildings and the 2019–20 Australian bushfire season which burned 16,000,000 acres. Global experience of massive wildfires used to be one per year on average, but numbers have grown in recent years, however, overall there is a reduction in global wildfires balanced out by reduced fires in savannahs and grasslands, mainly in Africa, but also in South America and Australia. These reductions are partly due to the conversion of land to agricultural use as well as changing rainfall patterns which are reducing the flammability of grasslands.

Europe experienced record wildfire destruction in 2022. Wildfires are affecting not just Mediterranean countries like Spain, Portugal, and France but also interior countries like Romania, Austria, and Germany. Successive heat waves have sparked wildfires and subsequent drought has had severe consequences for the loss of agricultural products and other food. Italy's Lake Garda is at its lowest level ever recorded, while the water level along Germany's Rhine River was at risk of falling so low that it could become difficult to transport goods including coal and gasoline for energy and transport systems. Traffic has already slowed dramatically and more frequent and longer heat waves are expected.

Damage may arise from direct flames and radiation exposure as well as from ember storms and low-level surface fire. The locations of infrastructure assets and their broader geography must be considered in terms of wildfire risk, and the introduction of zoning as is done for flooding would be useful. Materials used for infrastructure buildings and operations must be protected and the use of inflammable materials avoided. Wildfires also affect the ability of the supply chain to provide products and services to infrastructure which are located in wildfire hazard areas. They may severely affect emergency response and recovery of failed infrastructure systems, for example when wildfires take down transmission lines.

The causal relationship between wildfires and post-fire flooding and debris flows is well understood [3]. Burned areas are susceptible in the first one or two years after a wildfire due to less vegetation, reduced soil infiltration capacity and stability, and possible hydrophobic layers created by extreme heat. The

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multi-hazard situation of a wildfire and a rare storm event is capable of producing a 1 in 1000-year flood. The cost of dealing with severe flooding is a fraction of the cost of preventative measures against wildfire hazards. For example, the Schultz Fire, Arizona, 2010 was followed by summer flooding and led to costs 10 times larger than mitigation costs.

Wildfires may also impact source water quality and have implications for water treatment and finished water quality, as well as the biological activity of microbes and fungi in forest ecosystems which may increase the spread of antibiotic resistance in drinking water treatment plants. Wildfire smoke also creates pollution in the atmosphere with economic, social, and environmental consequences which is creating demand for smoke avoidance investments [4].

The most common impacts on transportation systems are on evacuation because transportation system redundancies are limited with few options for wildfire evacuation at the wildland-urban interface, and on the temporary closure of roadways due to direct threat or loss of visibility. Rarely mentioned is the potential direct or indirect degradation the fire causes to transportation infrastructure (except wood built) perhaps because material damage to roadways and bridge structures occurs only in severe conditions but these may be expected to occur more often in the future. The indirect impact may arise from the increased likelihood of future landslides, rockslides, and avalanches, loss of control systems (e.g., traffic lights), and traffic signage.

Planning and assessment of wildfire threats need to quantify uncertainty due to future vegetation and climatic conditions. Coniferous vegetation can increase the likelihood of an intense wildfire damaging powerline infrastructure whereas poorly regenerated burned areas can provide a protective influence. Wildfire probability will increase into the future, with strong, weather-induced inflation in the number of annual ignitions and wildfire spread potential.

Preparation and proactive action will reduce the impact of wildfires on infrastructure. Mitigation can include maintenance of vegetation that may ignite due to wildfire infrastructure. As climate changes, it could be beneficial from a wildfire perspective to incorporate trees and shrubs from drier environments which retain more moisture and consequently burn less efficiently. But this is in direct opposition to national park strategies which promote endemic species.

Air quality and the availability of some transport modes may be compromised creating conditions where staff cannot travel to work and operate infrastructure. When infrastructure fails critical services are compromised and recovery may be delayed, for example, a power cut will mean water cannot be pumped by fire crews. Managing fuel and the threats of stored fuel igniting from wildfires is critical. Communications channels must be protected from wildfires as they are critical during emergencies and recovery, but they are also needed for early warning, detection, and forecasting information which supports decision-making. Proactive action is needed in preparedness, fuels management, post-fire restoration, and fire science such as that provided in The US Infrastructure Law [5] and advocated in the United Nations Principles for Resilient Infrastructure [6].

Decision-makers should expect an increase in the frequency of wildfires. For areas that already have experienced wildfires, the duration of the fire season is likely to increase because of longer periods without rain during the fire season. The severity of disruptions from wildfires is also increasing due to higher temperatures and closing the gap in the design limits of existing infrastructure systems. Infrastructure resilience is expected to become more challenging not just from the risk of wildfires but by cascading effects of wildfires.

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