Generating the 100,000-year Frequency Wildfire Hazard Map Near Kori Nuclear Power Plant

Kyungmin, Kim [a], Dongchang, Kim [b], Seunghyun, Eem [b*]
[a]*Major in Plant System Engineering, School of Convergence & Fusion System Engineering, Kyungpook National Univ., Gyeongsang-daero 2559, Sangju, 37224*
[b]*Department of Convergence & Fusion System Engineering, Kyungpook National Univ., Gyeongsang-daero 2559, Sangju, 37224*
** Corresponding author: eemsh@knu.ac.kr*

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1. Introduction

Wildfires can damage the power grid and cause a Loss of Off-site Power (LOOP) at Nuclear Power Plants (NPPs), which could lead to a critical nuclear accident. In Korea, there have been two cases of nuclear reactors shutting down and one case of emergency diesel generators starting up due to loss of transmission lines caused by wildfires[1]. In addition, as climate change is expected to increase the frequency of wildfires due to higher maximum temperatures and lower relative humidity, there is a need to assess the safety of NPP against wildfire[2]. Therefore, a methodology was developed for generating a wildfire hazard map in 2023, and generated with a 100-year frequency was conducted for the Hanul NPP[3]. This study used the developed methodology to generate the Kori NPP hazard map, which has the highest population density around the NPP.

2. Creating Wildfire Simulation Input Data

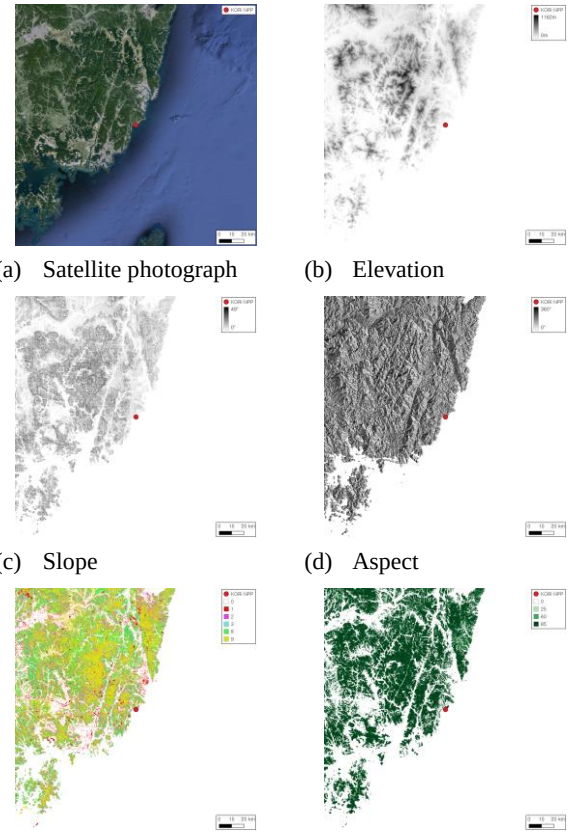
Wildfire simulation programs are required to generate wildfire hazard map. FlamMap, a wildfire analysis program developed by the U.S. Department of Agriculture, was used[4]. To analyze wildfires, create a Landscape(LCP), which is multi-band raster data containing topographic and clinical information of the area of interest. Additionally, wildfire context variables that affect the spread of wildfires are needed. A Monte Carlo Simulation(MCS) was performed using the generated data.

2.1. Setting the Area of Interest

The area of interest's radius was derived by multiplying the wildfire duration with the wildfire spread rate. The wildfire duration was set to 1.9 hours, which is the average of wildfire durations from 2013 to 22 years provided by the Korea Forest Service. The spreading speed of a typical wildfire is 4 km/h, so the radius was set to 8 km [5]. Therefore, a 16 km × 16 km square area of interest centered on the Kori NPP was established.

2.2. Creating LCP Data

The LCP has the required information on elevation, slope, aspect, canopy cover, fuel model, and additional information on stand height, Canopy Base Height (CBH), and Canopy Bulk Density (CBD). The required information is based on the 'DEM_90M' provided by the National Spatial Data Infrastructure Portal and the 'Land Cover Medium Classification' provided by the Ministry of Environment. The additional information is used to account for spotting fire, which is one of the ways wildfires spread. Stand height, CBH, and CBD were used with default values provided by FlamMap, which are 15m, 1m, and 0.2kg/m3, respectively. The required information and satellite image are shown in Figure 1.



(a) Satellite photograph (b) Elevation
(c) Slope (d) Aspect
(e) Fuel models (f) Canopy cover
Fig. 1. LCP Elements

2.3. Creating Wildfire Context Variables

The wildfire context variables include wildfire duration, wind direction, wind speed, and ignition point location. Wildfire duration was obtained by fitting a lognormal distribution to 13-22 years of wildfire data provided by the Korea Forest Service and randomly sampling according to the distribution. Wind direction was assumed to be uniformly distributed and sampled integers between 0° and 360°. Wind speed was sampled by fitting a lognormal distribution to the data from Busan, Ulsan, and Yangsan stations, the three stations closest to the Kori NPP, and randomly sampling from the distribution. Ignition point locations were randomly sampled from forests within the area of interest.

3. Generating 100,000-year Frequency Wildfire Hazard Map Near Kori NPP

It was assumed that all ignitions are uniformly distributed in forested areas. Over the ten years from 2013 to 2022, the number of wildfires in the Busan and Ulsan regions was divided by the forest area in each region to calculate the number of wildfires per unit area in both regions. Then, the forest area of each region in the area of interest was multiplied by the wildfires per unit area. The values of the two regions were added together and divided by ten years to derive the annual number of wildfires in the area of interest, which is 1.231 per year. In this study, 123,100 analyses were performed to generate a 100,000-year frequency wildfire hazard map. The wildfire hazard map of Kori near the Kori NPP is shown in Figure 2.

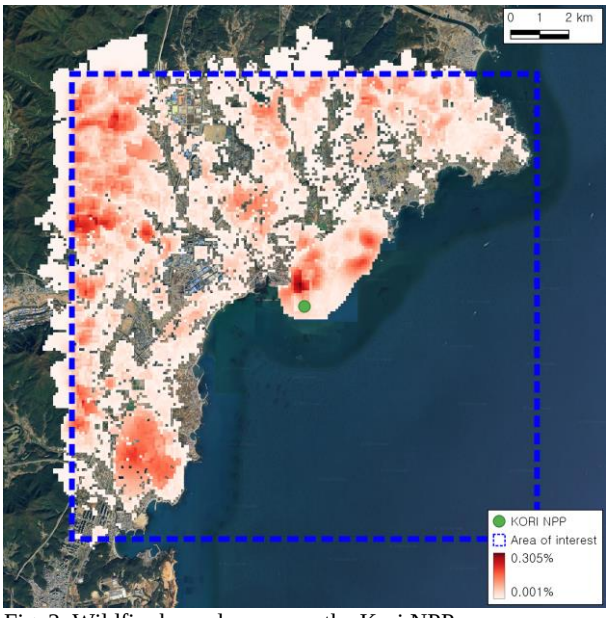


Fig. 2. Wildfire hazard map near the Kori NPP

4. Conclusions

The necessity to evaluate the safety of NPPs against wildfires has increased. Therefore, the wildfire hazard generate methodology developed in 2023 was applied to the Kori NPP to generate a 100,000-year frequency wildfire hazard map near the Kori NPP. There are parts of the NPP where forest fires do not spread due to the presence of cities. However, given that structure fires caused 6% of the wildfires from 2013 to 23, fires from cities could pose a risk to the NPP. Furthermore, the actual probability is higher than the hazard map result because it does not consider the increased frequency of wildfires due to climate change. The developed methodology and hazard maps for wildfire hazards are expected to help assess the safety of off-grid power grids and power plant systems against wildfires.

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