# FORESTREE | Executive Summary

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## Problem Statement

Peatlands are one of the **world's largest carbon sinks**, storing more than **twice** the amount of carbon stored in forests despite their significantly smaller surface area. However, with rising temperatures, and the illegal draining and deforestation of these **rich ecosystems**, peatland fires have significantly increased within the past few years. Along with it is the loss of the **abundance of wildlife and biodiversity**. Not only does it affect plants and animals that reside in peatlands, but also local communities whose infrastructure is destroyed and air quality is plummeting–with PM2.5 concentrations almost double the recommended value by the WHO's Air Quality Guidelines. Economically, in 2015 alone, Indonesia suffered a loss of USD 28 billion solely due to peatland fires.

## Hypothesis

Our solution will effectively utilize emerging, affordable, and efficient technology to effectively monitor Indonesian peatland regions and automate action. Using **IoT, WSN, LoRa, CPS, and ML**, our solution will be easy-integrated into natural ecosystems and provide accurate, live data on specific parameters over large regions. Should a region be classified as having a fire, local firefighters would be altered about the exact location and extent of the threats. Given the **significant destruction**, peatland fires have environmentally, economically, and socially, it is confident that this technology will be critical for the **mitigation and prevention** of fires and Indoesnia's path to sustainability.

## Solution

Our solution consists of **the application of an integrated network of emerging technologies to continuously detect and evaluate peatland forest fires and risks**. A network of sensor nodes will be placed around a given peatland environment, taking accurate, real-time measurements of parameters that are correlated with forest fire risk, including, but not limited to, temperature, humidity, CO levels, and light intensity. A GPS node will be used for easy location determination. This data is **synchronized** through a microcontroller, and wirelessly **transmitted** to a LoRa gateway and then LoRa network server.

From that point, data is analyzed by a **Machine Learning (ML) algorithm called an Artificial Neural Network (ANN)**. The relative risk of the parameter data is determined through a **Fire Weather Index (FWI)**, which assigns numerical values to certain sets of conditions to give an overall assessment of fire risk and guide our physical and digital output processes. The ANN **"learns"** the FWI and assigns the correct numeral value to the data that it receives. If it is deemed that there is a present fire or extreme fire risk, then the CPS is activated.

The CPS is composed of a **microcontroller**, which **"translates"** data into a physical process. It is connected to the existing **canals** in the region and uses techniques such as canal backfilling, canal blocking, and deep walls to increase groundwater levels and ease the peat dryness that facilitates fire spread. We will expansively install CPS, covering all necessary peatland areas, and near pre-existing drainage, canal infrastructure to increase and maintain surface water levels. As implied, this component does not eliminate fire risk or fire itself, which is why a **digital communication** process to local firefighters and trained volunteers are communicated via a phone notification through an app. With the increased training that these groups have been receiving through sustainable development programs, these individuals will be able to pinpoint the fire risk and act accordingly, utilizing their unique traditional knowledge of the local environment. Overall, the unique communication and indexing capabilities of our solution are accommodated to the Indonesian peatland environment to mitigate the negative environmental, economic, and social impacts of peatland fires.

To understand the conditions that could ignite a fire in the peatlands, we analyzed data to understand the correlation between groundwater levels and water retention in the soil. This data analysis is part of our solution as it allows us to understand the threshold when our mitigation system would trigger to release water and **reduce the risk and intensity of forest fires**. In addition to understanding the correlation between groundwater levels and water retention in the soil, we analyzed temperature data to understand when local authorities would be informed of a potential fire. Though these thresholds were set based on open-access articles, we foresee them to become more and more accurate and personalized to the peatland region as the machine continues to gather and "learn" data. Based on our data analyses, we created thresholds for the Fire Weather Index (FWI) to demonstrate values our ML model will evaluate.

## Impact

Overall, our solution uses **wireless communication and data indexing** to foster the collection of information and **automation** of action over vast and diverse peatland forest areas. It is not only **accurate**, but **affordable**, **efficient**, and **easily integratable**. By allowing fast action to suppress fires and **mitigate risk**, we are confident that Indonesia will **prosper** economically, socially, and environmentally. In the **future**, as our technology continues to be adopted, we foresee it to impact other industries such as agriculture and policy accountability.