**Team Space:**
https://joinlaunchpad.com/#/projects/3037/forestry-for-a-sustainable-future

# FORESTREE

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## What is the Problem?

Peatlands are **tropical moist forests** found in Russia, Indonesia, the USA, Canada, Finland, Congo, and other parts of the world. They are the most extensive terrestrial carbon storage on Earth, **absorbing** more carbon than any other type of vegetation. Indonesia is home to **23% of the world's total tropical peatlands**, with 21 million hectares that store 57 million metric tons of carbon, which is almost 55% of the world's tropical peatland carbon. However, peatlands in Indonesia are prone to fires due to deforestation, drainage, droughts, and ineffective management practices. When **destroyed**, peatlands release all the carbon dioxide and other emissions it absorbs, actively contributing to more emissions. Worldwide, damaged peatlands release almost 6% of global anthropogenic CO2 emissions annually. Peatland fires often survive under the soil, where they spread to neighbouring forests **unseen** for months. Due to the important role peatlands have in storing carbon, facilitating biodiversity, water resource management, and local community livelihoods, we believe that protecting Indonesia's peatlands is vital, especially in abundant peatland regions like Indonesia.

## What is Our Solution?

Our solution aims to mitigate the negative impacts of peatland forest fires through the **application of emerging technologies**, including an **Internet of Things (IoT)** system to seamlessly communicate forest data between several devices; **Cyber-Physical Systems (CPS)** to collect; **Machine Learning (ML)** to process data and classify on-fire and vulnerable regions; and **Long Range Wide Area (LoRa)** networks to automate the start of increasing the presence of soil water. The moisture of soil and groundwater is vital for the **sustainability and livelihood of peatlands** because it decreases the effects of hydrological droughts that cause forest fires. Water helps with the cycle of soil nutrients and accelerates the decomposition of organic matter. We will source **water** from rivers, canals, and dam reservoirs, where not only infrastructure already exists, but are also close proximity to populated regions.

**IoT**

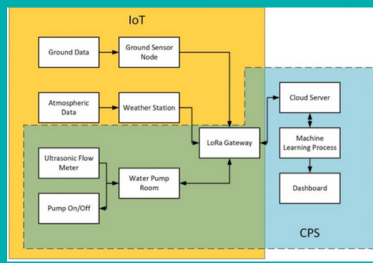
**WSN**

**LoRa**

**CPS**

**ML**

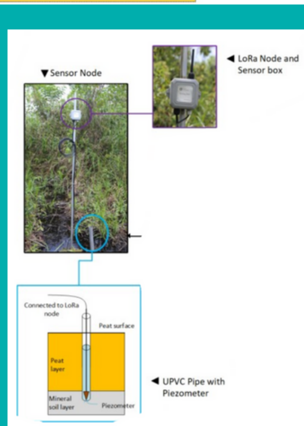
An **Internet of Things (IoT)** system will be applied to sense, communicate, and analyze data on physical, chemical, environmental, and biological factors at forest sites to foster informed decision-making for sustainable forest management. For our solution, IoT will provide real-time data on factors like moisture, air temperature, relative humidity, and the presence of greenhouse gasses such as carbon dioxide, carbon monoxide, and methane. Based on such information, a region will be classified as high-risk for a fire, having a fire, or not having a fire.



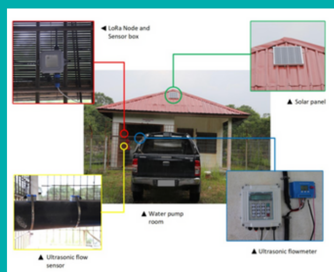

A critical component of our IoT system is **Wireless Sensor Network (WSN)** sensor nodes. They are infrastructure-free, wireless networks that monitor physical and environmental conditions. Since our solution is focused on peatland forest fires, the measure points we will compute include temperature, light intensity, humidity, soil pressure, moisture, carbon dioxide, carbon monoxide, methane, and more. Data will be constantly calculated and updated by the mounted sensors using a microcontroller transceiver module to accurately detect fires or high-risk zones based on the thresholds set on the program. If a fire is detected, this information is communicated directly to the responsible party or to a CPS system through network paths like LoRa.

**Why are WSN sensor modes ideal for Indonesian peatlands?**

1. **Energy Efficient:** Able to generate energy using free-standing solar panels and consumes little power.
2. **Resilient Design:** Using a spherical shape design, the sensor nodes can withstand damage caused by environmental conditions and animals, and avoid disturbance to local ecosystems.
3. **High Accuracy and Early Detection:** Sensors are placed in multiple places within a region, and are in direct contact with the soil it's collecting data from unlike satellites.
4. **Remote Access:** WSN can be mounted nearly anywhere in a forest even if there is no installed network connectivity because the transceiver module has a built-in network infrastructure and power supplied using solar energy.
5. **Adaptable:** The program can be easily modified and adapted based on changing environmental or physical factors.




**Long Range Wide Area (LoRa)** is a robust wireless modulation technique derived from Chirp Spread System (CSS) technology. LoRa is ideal for managing great volumes of messages from thousands of sensor nodes scattered across large forest areas making it ideal for our solution. LoRa gateway will aggregate the data collected by WSN sensor nodes and upload it to a cloud server that is a reliable, quick, and cost efficient data transmission method.




**Cyber-Physical Systems (CPS)** combine the dynamics of the physical processes, with networking and software, incorporating data into embedded computer systems to monitor and control physical systems. These interactions create feedback loops where physical processes affect computations and vice versa. Data gathered from WSN sensor nodes are communicated to the CPS system through LoRa, which is synchronized with soil water level data. Real data collected enables CPS to determine under what conditions to activate and trigger water automation accordingly. If triggered, the water pumps in the CPS will conduct hydrological management in the affected forest area. A dispersion of an appropriate volume of water to the appropriate area can reduce the presence of fires or the risk of fires.

A **Machine Learning (ML)** model will analyze WNS data to predict the trend of groundwater in the peatlands. First, past forest soil water levels will dictate the model, but with each new data point transmitted by WSN, the model's repository of soil water level data is compounded, thereby continually improving its accuracy. Threshold ratios will be created using existing data collected from controlled fires. In our research, we found that temperature and light intensity ratios should be higher than 1 in fires, and generally range from 1.05-1.15; humidity and carbon monoxide levels should be less than 1 in fires, generally between 0.8-0.95.

## Hypothesis

Given the importance of peatlands in combating climate change and the destruction they are experiencing, our solution focuses on **mitigating the negative impacts of the increased frequency and intensity of peatland fires in Indonesia**. These impacts, including increased greenhouse gasses, degrading biodiversity, weakening local economies, and implications on the physical health of local citizens are wide-reaching and severe. Through our solution's integration of IoT, WSN, LoRa, CPS, and ML, we aim to effectively mitigate the **threats** of existing and potential forest fires to Indonesian peatlands and **restore the sustainability** of peatlands.

## Research Plan

To solve the alarming problem of peatland fires, our solution uses **multiple nuanced, technological steps**. Our research plan will analyze the **applicability** of our technology in all Indonesian peatland regions and the management process that comes with it.

To test our solution, we will use many **simulations**, such as the NS-3 network simulator, MIMIC IoT Simulator, and COOJA simulator, and continue to conduct scholarly research on Indonesian peatlands and wildfire statistics. First, we will set up all the technologies involved in our solution in a sample simulation. Using data collected about the conditions of certain peatland regions, we will input sample data into the simulation to test how the connected technological devices will react. Second, we will record primary or initial data on the peatland, such as groundwater level, air temperature, humidity, and gas emissions. By **analyzing** high-risk and zones presently on fire, we can accurately create thresholds of different variables the WSN collects and ML computes. These numbers are important to analyze because factors like altitude, size, season, and more can change the threshold values of fire risk and intensity. We will have one **control group** of no fire, then multiple experiment groups with different independent variable values that may or may not be telltale signs of fire beginnings.

Alongside conducting simulations and robust scholarly research, we will reach out to experts and professionals in peatland management, wildfire studies, environmental engineering, and IoT to further **enhance** our findings by adding new perspectives and feedback. Limitations that we will need to overcome and analyze throughout our research include governmental regulations (private vs. public forests), Indonesia's style of farming, costs, and ways to **seamlessly integrate our solution** into natural ecosystems.