Opportunities in using visual IOT in the mitigation for peatland area

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Abstract. Peatland cover over 400 million hectares of the Earth surface. It stores massive amount of carbon pool. They play major roles in accommodating the Earth global warming. But the logging activities from development agriculture site, and housing, has disturbed the ecosystem of peatlands habitat. Thus, urgent action from worldwide is required to protect and restore the peatlands. This includes raising the peat surface water level to avoid drying to mitigate fire. Canal blocking was done as one of the strategies to raise it. However, too high-water level might contribute to another problem, flooding. Hence, continuous monitoring is required to ensure the water level is maintained within the optimum level. This project explains the proposed system for water level detection on peatland areas using visual Internet of things (IoT). In addressing the power consumption issue a mechanism to enable power to be used only when necessary was introduced. This mechanism will only awake the camera when a certain threshold is reached and triggered the camera to capture the image. The proposed system includes the use of Raspberry Pi and camera as device to capture image with integration of Arduino to acquire sensors reading. The image is then processed and finally transmitted over cloud network. The outcome of this project produced camera-based water level detection prototype. The scope for this project is to highlights on Brunei peatland areas located at Badas, Brunei.

1. Introduction
In general, peatlands are wetland ecosystems characterized by accumulation of peat. Peatlands has the ability to store more carbon than all of the vegetation on earth. And it is crucial to maintain its existence since currently the planet earth is under global warming threats. Organizations or agencies around the world such as Wetlands International has been taking part in peatland restoration plan. Peatlands stores huge amount of carbon dioxide and have been claimed as the important part of world global gas emission stability [1]. In recent years, most of peatland areas especially in Southeast Asia has been destroyed for various activities such as agriculture, housing development, and plantations. These leads to degradation of peatland forest and could possibly increases risk in terms of peat ecological reductions.

According to [2], Peatland restoration is the best way to combat against world climate change. Most widely practiced restoration plan is based on management of hydrological peatland forest. This can be easily done through blocking of canals which will raise the water level on peatlands. In general, rainy season is when most of the region experience the highest annual rainfall. One of the key components of hydrological cycle is rainfall. It is important to understand how rainfall could affect peatlands water level. Peatland has ability to store very high amount of water up to 8 times of the peat volume [3]. Also, according to [4], the water table rises in the rainy season and the water may appears...
above peat surface. Rainy season is beneficial for peatland ecosystem. However, with poor restoration strategy, peatland area might encounter high amount of water level which leads to issues to users. Whereas in dry season, there is low rainfall recorded throughout the period. Impacts on peatland are more severe during this season compare to rainy season. This is because drying peatland are highly flammable, if peat forest fire occurs, haze always happen which could lead to health problems especially thick smoke released by burnt peat [5] and peat forest fire can also lead to the loss of habitat and species that are special and unique within peat environment. Moreover, the water level in peat during dry season can drop below soil surface [4]. The risk of fires increased dramatically of peat dried out. Canal blocking restoration is expected to maintain peatland wetness to prevent from fires. But, blocking of canal is useless without monitoring its water level. Hence, certain minimum threshold is needed to resolve issue of water level

2. Context Brunei Darussalam
In Brunei Darussalam, around 16% of the country is occupied by peat swamp forest. Peatland in Brunei are mostly found along Badas area in Belait District. And 20% of peat swamp cover the entire part of the District. Badas Peat Swamp forest is considered critical habitat under the 5th National report to the Convention on Biological Diversity due to its high biodiversity value. In Badas, the canopy is almost 100% dominated by Shorea albida as known as Alan tree, one of the endangered species endemics in Borneo that is highly threatened with the current ecosystem. In support and initiative of Brunei Darussalam through forestry department, all illegal logging activities of peat swamp forest are prohibited. Information obtained from JASTRE showed that in recent years drainage and disturbance activities around peat swamp forest such as sand mining has also been stopped. Several mitigation efforts have also been done in order to ensure that the disaster occurrences within peatland area are minimized and further contained. As been done in Central Kalimantan, canal blocking strategies was used for hydrological restoration to increase the water table [6]. Similarly, in Brunei a joint effort by a number of stakeholders to peatland in Brunei, are aiming to raise the peat water surface to conserve the area. A Biodiversity Action Plan (BAP) project of Brunei Shell Petroleum Company Sdn Bhd (BSP) in collaboration with Wetlands International is via canal blocking, which was proven successful. Continuous monitoring via human patrol has shown that the water level has risen and the occurrence of forest fires has also reduced. However, overflowing of water from canals due to poor water management disturbs the peatland ecosystem and may as well contributes to flowing on the nearby areas. The continuous water table monitoring was done manually by installing subsidence poles to the peat surface on peat canals where the water level depth parameter was taken manually. This kind of traditional method of capturing data takes time and prone to human error. Therefore, the needs of wireless technology to capture real time data should be implemented in this era of technology.

3. Peatland water level monitoring
Keeping track of peatland restoration is important to ensure improvement of the water level. Monitoring of surface water flow on peatland canals can provide information on the height of peat water level. The height of water determines whether the water is sufficient enough for wetness of peatlands. In swamp peatland, water level fluctuations often impact the ecosystem. If water level observed are high, it may reduce plant productivity, which later causes harmful effects on peat formation [7]. Aside from that, peatland monitoring can help to mitigate fire and flood. The act of maintaining the water level to avoid drying is vital in which it can potentially reduce the possibilities of forest fire [8]. This monitoring of the water level, not only can avoid forest fire but also restoring peatland ecosystem and contribute to mitigate flood by monitoring the high-water level. The height of surface water level is usually measured in the canal using staff gauge with the purpose to determine and verify the effects of canal blocking in raising water height on peatlands. As the data recorded is important for peatland management analysis. They currently rely on the traditional manual water level monitoring by taking notes on the site using
form as shown in figure 1. Unfortunately, Peatland area are usually covered with species including animals and plants. This can be dangerous for workers to be there especially when there are wild animals. By using Internet of Things (IoT) technologies, human presence will not be necessary on the site to take the reading. In fact, as long as there is network connection, workers can remotely measure and monitor the level without having to be on the site.

![Table](image)

**Figure 1.** Form to keep measurement of the parameters of blocked canal [9]

### 4. Water level Monitoring using Internet of things

Nowadays, with the improvements of technologies, the water level monitoring system allows users to get notification about the water level. Normally, the monitoring of water level is done in context of agriculture, fishing industry, aquaculture, flooding prevention and tank levels. This can be done by the use of Internet of Things technologies (IoT). According to [10], technological water level measurement is classified into four different ways. There are pressure[11] where the system will need more sensors in order to get better accuracy, supersonic waves [12], where it’s not always suitable in harsh environment, heat [13], where the sensors need to be properly insulated and visual image processing[14] where the challenge is on the additional storage issues [4].

Hence in the context of water level monitoring for peat with the use of IoT will easily allow remote monitoring without having to be on site. The most recent approach of IoT is the use of visual data such as images and videos. The concept of visual IoT requires visual sensing nodes which is the camera to capture visual data, gateways that enables communication between nodes and servers to store visual data. According to [4], visual IoT becoming popular due to its benefits in providing rich visual data. The visual data is useful for analytics and thus providing accurate result based on the image processed. For example, in manufacturing industry, IoT system equipped with camera can helped to detects abnormal operation, in traffic surveillance, crime detection system and in [15] for agriculture to observe changes of weather and crops by deploying WiFi cameras to capture daily images and thus allow farmers to make decision for their crops.

### 5. Proposed System

The proposed system for the water level detection on peatland uses visual IoT to mitigate disaster occurrence in peatland area. By having to incorporate visual IoT, the data gathered will be more significant as the other parameters recorded will be verified with the image captured. This can help the
local authority to react immediately from the notification provided by the system. In maintaining the water level is at its optimum, continuous monitoring is required hence a threshold value needs to be set. A mechanism has been introduced in addressing the power consumption issue to enable power for the camera to be used only when necessary. Two parameters are taken into consideration: i) too wet which will lead to flood and ii) too dry detected by temperature will lead to fire where both scenarios will be verified by the marker of the staff gauge. During wet season, the amount of rainfall will be high, this will trigger the camera to wake up and capture the image which will then be send together with the rainfall reading. While during dry season, the camera will be triggered by the temperature reading. If the reading is too high together with the humidity, this will trigger the camera and image captured will also be send to verify the environment.

5.1. System Prototype
The prototype has a dashboard which retrieves sensor readings from the web-servers periodically. The web-server collects data from the sensors deployed in the peatland area. The overall procedure is shown in figure 2 shows how the prototype is made up of 4 components. Each component plays an important role in making sure that the adoption of visual IoT works. For the staff gauge, this will be the base on the captured image which contains marker for water level estimation. Next the camera, which is triggered to capture image. Then the rain gauge which will be used to trigger to wake up the camera. And finally, the distance covered which will depend on the camera quality and the kind of image we want to capture. Figure 3 shows the overall prototype overview and figure 4 is the developed prototype. Both camera parts and threshold marker are placed together on a container and separated within a distance. The distance needs to be identified based on camera projection to the set threshold marker. The distance depends on camera lens focal length. The smaller the focal length, the wider the angle of viewing, but the details are less sharp. Whereas, the higher the focal length, the sharper and the further the object can be detected.

![Figure 2. Prototype design](image-url)
Figure 3. Overview of prototype.

Figure 4. Developed prototype

5.2. Prototype Design and Implementation of Visual IoT

The prototype is built upon two development microcontroller boards Arduino and Raspberry Pi. Arduino will capture all the four important parameters recorded: Temperature, humidity, hourly rainfall and daily rainfall respectively. These data are then sent to Raspberry Pi which will then record the image to be uploaded together at the server side. The connection to the internet is made to push data to the server hosting the database, dashboard and notification. Before we explained our proposed algorithms, which are embedded into the prototype, we defined the variables. We assume in our algorithms; the tipping bucket has a maximum rain threshold value of $R_{v_{\text{max}}}$ while the temperature sensor has a maximum temperature threshold value of $CT_{\text{max}}$. And for the water level from the staff gauge, minimum threshold is below $T_1$ for low water level and $T_3$ for maximum threshold for high water level.

Figure 5 shows how the proposed algorithm works, by first starting the system to check if current rain value from the tipping bucket has reached the maximum threshold value or not. If maximum then this will initialize the camera and capture the image. Current water level value, $CW$ will then be extracted from the image and then saved. This value is then checked for high threshold, $T_3$. All of these data will then be pushed to the database together with the image to be send to the server to notify the
relevant authorities via SMS and WhatsApp. Similarly, if the current rain value was less than the maximum set value then the temperature will be checked. If the current temperature, $CT$ has reached the maximum threshold $CT_{\text{max}}$, similarly, this will initialize the camera to capture image. But if both rain value and temperature value did not reach the maximum threshold values then the camera is still put at sleep mode. Hence able to conserve the power of the system and only store image data when necessary. The web dashboard will then contain information about the current peatland environment such as temperature, humidity, rainfall and water level value. But the most interesting feature is that, the end users are able to view processed water level image. The reading of this water level is done automatically where the system upon triggered will capture the image and processed it further to confirm the case. The water level reading will be highlighted and read which, user can then verify whether the water level data is valid and verified further using the image captured.

![Flowchart of dry and wet camera wakes up](image-url)

**Figure 5.** Flowchart of dry and wet camera wakes up
6. Real deployment concerns
The developed solution has shown 6 main areas to consider in order to deploy it in the real environment. First is the distance which depend on the kind of camera used. Second the position of the staff gauge either within the canal or outside the canal, this will determine the threshold minimum and maximum for the water level $T_1$ and $T_3$. Third the tipping bucket so that it is not covered by dry leaves. Fourth on the box where the microcontroller are fixed, need to consider ants repellent, to cover holes so rats nor ants will not nest in it, to use reflection paint so the box will not generate too much heat and fifth the image will require the use of WIFI, 3G connection to connect to the internet else the visual IoT will not be implemented. Lastly the power source for this solution will rely on the use of solar panel. Additionally, in case where we are monitoring a larger area, triangulation of data will help in making sure that we do not miss any of the monitored area. The data from all sensors will need to be aggregated properly and delivered to the web-server with desired Quality of Service (QoS).

7. Conclusion
The solution for water level monitoring provide a good opportunity in adopting visual IoT in mitigating peatland disaster. By having this system, peatland management and authorities can react quickly in case the water level reaches danger zones. This early type of warning system benefits communities. The system potentially could solve problems such flooding and drying of peatlands, saving peat ecosystem, and many more. The prototype was built along with Arduino and Raspberry Pi and other equipment’s which are based on visual Internet of Things. The implementation of the prototype is quite cheap and affordable. Both possible occurrence of fire nor flood can be mitigated in advance by ensuring the water level does not reached the threshold values set. Other IoT sensor parameters collected can further be verified and confirmed with the image captured. Especially with the use of social media, emergency alert can be made directly via WhatsApp and strengthened and confirmed with the image captured. However, the project is on the early phase of deployment. The next phase could be the prototype can be developed and deployed into real peatland environment where it can benefit multiple agencies especially peatland communities. There are more areas that will need to be considered in order to make visual IoT one of the best options in any disaster management especially in providing the correct viable data. But before that can be achieved the expansion of the use of visual IoT will be on the storage requirements, night vision, image captured at night time, image resolution as well as matters that affect the equipment such as the lenses for it to ensure outdoor environment [16]. Moreover, since the future system needs to be deployed in the real environment, protective cases should be installed on camera to endure outdoor environment [17].

8. References
[1] Holden J 2005 Peatland hydrology and carbon release: Why small-scale process matters. Philosophical Transactions of the Royal Society A: Mathematical Physical and Engineering Sciences 363(1837) pp 2891-2913
[2] Parish F, Siri A, Charman D, Joosten H, Minayeva T, Silvius M and Stringer L 2008 Assessment on Biodiversity and Climate change Main Report
[3] Jaya A, Raya U P and Inoue T 2007 Geohydrological conditions of the developed peatland in Central Kalimantan
[4] Rieley J 2014 Tropical peatland – The amazing dual ecosystem: coexistence and mutual benefit.
[5] Fitrianti U and Afief M 2017 Proof that canal blocking at peatlands in Sungai Ahas Central Kalimantan not improve water quality 10(3) pp 24-31
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