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Information Framework of Pervasive Real Time Monitoring System: Case of Peat Land Forest Fires and Air Quality in South Sumatera, Indonesia

Siti Nurmaini¹, Reza Firsandaya Malik², Deris Stiawan², Firdaus¹, Saparudin¹, Bambang Tutuko¹

¹ Robotic and Control Research Lab. Computer Engineering Department, Universitas Sriwijaya

² Computer Networking Research Lab. Computer Engineering Department, Universitas Sriwijaya

sitinurmaini@gmail.com, rezafm@unsri.ac.id, deris.stiawan@gmail.com, virdauz@gmail.com, saparudinmasyarif@gmail.com

Abstract. The information framework aims to holistically address the problems and issues posed by unwanted peat and land fires within the context of the natural environment and socio-economic systems. Informed decisions on planning and allocation of resources can only be made by understanding the landscape. Therefore, information on fire history and air quality impacts must be collected for future analysis. This paper proposes strategic framework based on technology approach with data fusion strategy to produce the data analysis about peat land fires and air quality management in in South Sumatera. The research framework should use the knowledge, experience and data from the previous fire seasons to review, improve and refine the strategies and monitor their effectiveness for the next fire season. Communicating effectively with communities and the public and private sectors in remote and rural landscapes is important, by using smartphones and mobile applications. Tools such as one-stop information based on web applications, to obtain information such as early warning to send and receive fire alerts, could be developed and promoted so that all stakeholders can share important information with each other.

1. Introduction

Indonesia peat land and forest fires occur during the dry season on an almost annual basis, burning vast areas of peat land and forest across the archipelago. When peat layers are dry, fires can burn roots and underground organic matter for up to months at a time, and spread below the surface very quickly. From the data of terrestrial ecosystems of Southeast Asia, around 25 million hectares of peat land area and 70% of those found in Indonesia. Peatlands are the most important area for the storage of carbon, equal to all other terrestrial biomass and twice as much of all forest biomass. In case of peatland fires in Indonesia, is estimated cause by emissions by 2 billion tones of CO₂ per year, equivalent to almost 4% of the emissions caused by global fossil fuels. Indonesia air pollution was extremely poor in late 2000, due to haze from massive peat land fires in South Sumatera and Kalimantan [3]. Peatland forest fires in South Sumatera are contributing to the extremely poor air quality and spewing greenhouse gases into the atmosphere. Not only do they pose an immediate threat to human health and wildlife, haze from the fires also disrupts transport and the economic activities of millions of people. The



results are devastating loss and irreparable damage to the environment and atmosphere, due to 30 % of carbon dioxide is released to the atmosphere [2].

One of the biggest threats in this century, is the declining the environmental quality in the world, due to it can reduce the level of human well-being because of disruption in human health [1]. The most important problems for stopping forest fires is the difficulty to find the exact location of the fire and no evidence to determine who is responsible for it. Moreover, the fire control is hard, because the process of detection and prevention occurred when a fire is widespread. Thus it is impossible to be done at that time. Early warning and initial data from monitoring system about pollution levels in central cities is key to provide adequate information to citizens and take actions to reduce it.

To overcome such problems and to produce the impact of policies that have been made by governments and public institutions regarding air pollution, it can be achieved through increased public awareness of the need for clean air and healthy. It is because the impact will be felt bad for human health if air pollution continues to rise. The slightest increase in air pollution within a certain time can cause various symptoms of the disease and lead to various health risks. Due to smoke particles from burnt wood are almost entirely $< 1 \mu\text{m}$ in size and mostly ranged from 0.15 to $0.4 \mu\text{m}^6$. Real-time air pollution monitoring including concentration of particulate matter (PM_{10}), sulphurdioxyde (SO_2), nitrogen dioxide (NO), carbon monoxide (CO), and ozone (O_3) very necessary to provide updated data on the daily air quality. If the data can be monitored in real time, the air pollution control will be easier to be done. All of the process to overcome bad impacts from air pollution, in order to protect human beings and other living things.

In 2015, Indonesia's Pollutant Standards Index (PSI) which incorporates PM_{10} , SO_2 , CO, O_3 , NO increased above 2,000. Any score above 350 is considered hazardous to human health. Indonesia's National Disaster Mitigation Agency reports that 135,000 Indonesians are suffering from respiratory problems. For long time the peat fires have had negative impacts on economy, human health, environment, and climate. Greenpeace notes that Indonesia's fires in 2015 will release more carbon to the atmosphere. The estimation between 0.81 and 2.57 Giga Tonnes of carbon emissions were released. Peat land fires produce large amount of dangerous haze and deteriorate air quality; the dense haze also causes various health problems.

Currently, there are fast developments in pollution monitoring technique. Intelligent sensors and satellite imageries are being applied worldwide. Free-access sensing images provide a big opportunity to track the change and support ground-based observations effectively and continuous monitoring capacity makes sensors become very efficient in supporting government decision making. Besides, the involvement of citizens in monitoring is receiving more attention since local knowledge and aspiration can ensure the sustainability of projects. This paper proposes the information framework from the decision making planning until the platform technology to solve various problems concerning primary and secondary pollutants in the air. Primary pollutants emitted directly on the pollution sources and secondary pollutants formed when other pollutants interact with the atmosphere or referred to as a major pollutant.

2. Peat Land Forest Management

The frequency and extent of peat and forest fire events in Indonesia implies that effective fire-prevention measures and early-control systems are not yet in place. This is partly attributed to the absence of village-level management bodies, which are tasked to prevent and mitigate devastating forest and peat land fires. Furthermore, peat land's geographical conditions and characteristic terrain, coupled with the lack of access roads, often pose considerable challenges in conducting patrols and the early suppression of fires. Low awareness about the causes and impacts of peat land fires and the lack of coordination among local government authorities, business players and local communities also undermine efforts at proper land management.

It must make a commitment to cumulate the management effects which focus on the outcome achievements, understand the effects of multiple development including the new and the existing pressures, risk assessment, collaborative work that shared responsibility for action, and improve the economic integration and the environmental and social considerations. It follows an adaptive control

version in which selection-makers research from experience and new facts and adapt to changing social expectations and needs. Overall performance control, with pollutants prevention principles, is important to supplying information on environmental situations and identifying the need for any changes and modifications on an ongoing foundation.

To make changes to the management of cumulative impacts, required a control framework. Next will be a concept that became the basis of the Management framework in terms of joint ownership, accountability, clear management in a dynamic information database. All of these principles should be used to establish measurable criteria so that all the goals that have been made can be achieved in accordance with the desired. The illustration of the interconnectedness of national, provincial, and regional air quality and peat and forest fire plans is presented through Figure 1.

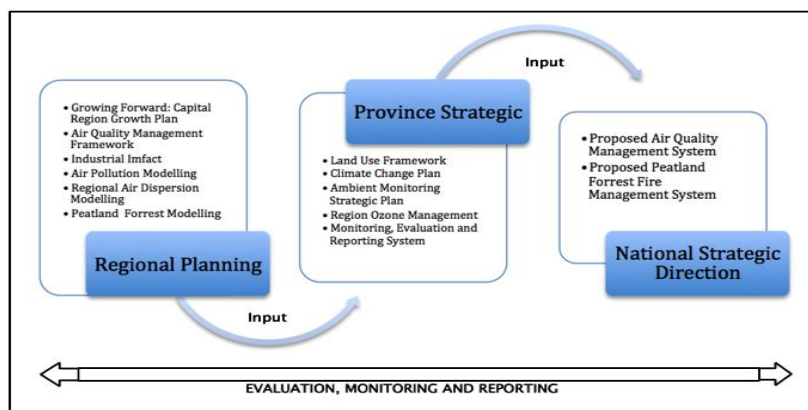
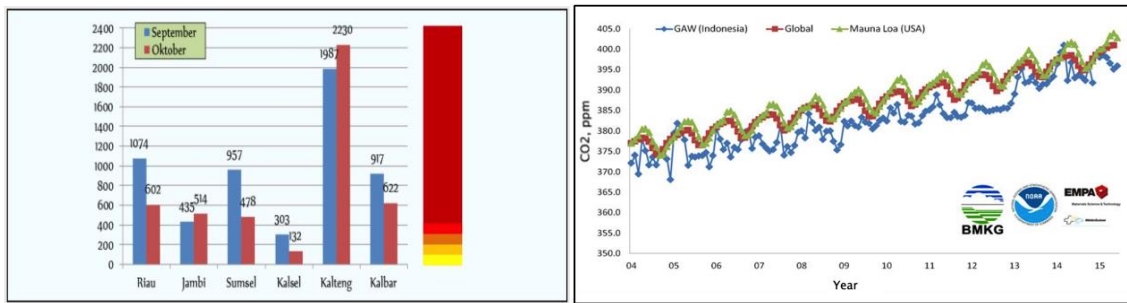


Figure 1. Proposal of strategic framework for inter-region planning

The aim of the strategic framework to assist stakeholders in carrying out their responsibilities at the time, and the right conditions. The process of such framework to align each policy will be developed or revised at the regional, provincial or national. This framework is proposed to assist stakeholders to develop the capacity in order to perform their responsibilities in a timely manner. It became a process to align framework updates with other policies being developed or revised at a regional, provincial or national level.

Previous study about the air pollution and forest fires with many tools are proposed, from ground-base sensors to data collected by satellites [4-8]. Many, identification of potential hot-spot and fire zones has been done by remote sensing strategy. Everyday satellites have been monitoring the hotspot area. In general, all the forest fires in South Sumatra detected using equipment that only measures in near real time by Moderate Resolution Imaging Spectroradiometers (MODIS) [8][9]. The MODIS instruments capture of about all of Earth's apparent every day and can ascertain hot spots acquired by fires [8]. However, not easy for detecting fire from space. The Smoke or clouds can blemish an instrument's adeptness to sense fires on the surface. Clouds over south Sumatera are absolutely close, the acclimate can still affectation as obstacle. Moreover, low-temperature or smouldering, underground fires, which are accepted in South Sumatra, sometimes cannot be detected at all. Fires in burn area, from surface until bake is not only in the surface, but as well in the underground. Acclimate altitude accept cogent influences on blaze behavior. Figure 2(a), shows the hotspot sample in Indonesia, while peat land forest fire in 2015.



(a) Hotspot data in 2015 (b) Comparison of CO2 concentration
Figure 2. Indonesian Hotspot and Air Pollution

The sample of carbon emission detection in 2015 comparison between Indonesia (GAW), global and Mauna Loa (USA) can be shown in Figure. 2 (b). The value can cause various health problems. Only a few organizations collect the data of such high quality. Even so, this limits the amount of environmental monitoring data that is often available for exposure and health assessments. Hence, getting the right air pollution sensors are also critical in this part of the air pollution management research.

3. Framework Design

Currently, Indonesia only have 43 conventional stations measurement for daily air quality monitoring, but only 17 in active condition and 2 of which are in South Sumatera. However, static air quality measurement stations in a city is expensive cost of building and maintaining. These monitoring systems are usually complex, inflexible, and time consuming, and they provide spatial resolution in the order of several hundred kilometres [10]. Indonesia doesn't have ground-base sensor especially for detection peat land forest fire, only use a satellite data. Such problem makes the air quality management issues in South Sumatera become more complex, because the purpose of the amount and the ability of environmental monitoring devices increase continuously, with the specifications of the device technology is reliable and sturdy. The monitoring system must be able to detect and analyse indications of peat fires and the impact on air quality. One monitoring technology being developed today are wireless sensor networks and monitoring with unmanned aerial vehicles (UAVs).

Ground-base sensor technology is kind of static sensor that is able to send environmental data without using wires is expected to become one of the development of applied technology that can support forest conservation program [11]. In the WSNs detection, many sensors are deployed in the target area to measure environmental data such as, SO₂, CO, O₃, NO, PM₁₀, and PM_{2.5} for daily air quality. Rapid developments in technology led to the production of small, low-cost air pollution sensors to symbolize the future of air quality monitoring.

However, many potential issues which arise as a result of these studies including,

1. Mobile technologies for monitoring air pollution levels and source of pollution;
2. Real time air pollution application on a smart phone, the data pollution will be shares and interacted to the public;
3. Mathematical models are used to combine spatial and temporal data through the integration of monitoring data with the data fusion method;
4. Utilization of remote sensing satellite technology to improve the process of forecasting and estimation of air quality and exposure assessment;
5. Real time monitoring through a network to facilitate the detection distance and large area of which are covered.

4. System Architecture

For overcoming such issues in environmental monitoring, we propose low cost pervasive wireless sensor network management as shown in Figure 3. It means the sensors have characteristic simple and

cost effective through protocol 802.15.4 or Zigbee. Such module ensures data communication at all times while allows to send SMS alerts according to defined thresholds. The sensors use the battery as a power supply, for making the sensor network in a longtime operation and ensuring a virtually perpetual operation, solar panels can recharge the batteries. The sensors on board have several gas sensors, it produces a heterogeneous sensor motes. For monitoring environmental pollution, and peat land forest fires, the sensor network operation based on the same network.

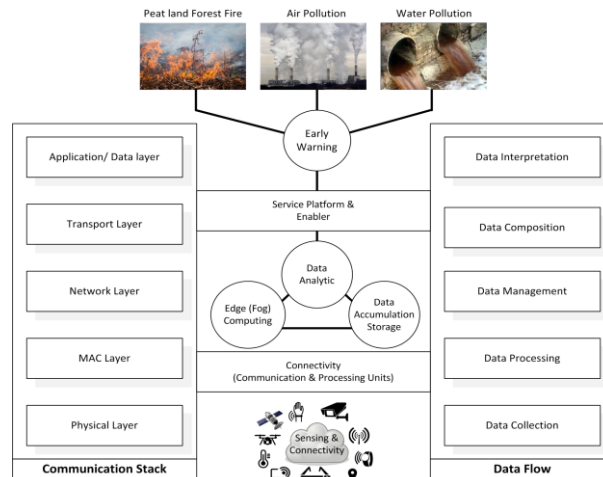


Figure 3. Proposed of information framework of pervasive monitoring system

In Figure 3, describes a process of implementation of air quality sensor network applications that will be used. One type of sensor platform that is ground-based sensor. These sensors will take air quality data directly at the location of peatland and forest fires. Detection system will record the results of air quality measurements into a set of data in certain intervals based on the level of pollutant contamination. The air quality data that has been generated is sent to the base station via wireless communication. It would be very useful to make a situation analysis in the burn area. In the proposed platform, ground-based sensor consisting of air quality sensors, heat sensor and infrared camera to monitor the condition that occurs before, during and after the fires.

Ground-base of the sensor is required since the sensor system with remote sensing method with satellite technology is difficult to obtain accurate data, because of fires difficult to monitor. Clouds and smoke often cover the spread of fire in the fire. So, the estimation data on the dot summer forest fires and air pollution would occur in combination. To produce more accurate data.in this project WSNs with mobile technology for air pollution monitoring, unmanned aerial vehicle (UAVs) with infra-red camera for light and fire detection to give early detection of peat land forest fires and satellite for mapping the hotspot in the burning area are combined. The sources of data observations are used to measure air quality in real-time and forecast the peat land fire data. Analysis of all data, by fusing them with data obtained from statistical or deterministic air pollution model. The combination satellite and ground observations are integrated into a computer model to predict the future location of pollution and peat land fire. The information fusion processes at the heart of system framework to exploit the capabilities offered by geographic information systems (GIS) and for the assimilation of the three data sources such as ground-base analytical measurements, satellite observation, and remote sensing by UAVs. The framework of monitoring system is proposed in Fig. 4.

4. Data Fusion Approach

Currently, many researchers have been developed a method that is in the process combining observational data in the form of an objective mathematical model. Such a method is called data fusion approach. In the context of wireless sensor network, it will produce a high-density value. Due to the data coming from various sources detection and sensor devices are different will be combined in

order to find the most optimal of data with the smallest probability error value and generate high robustness. In observation of environmental quality can improve the accuracy of the value of all the observational data that has been done, because in the process of data fusion use monitoring data from various sources including the data history. The results can be able to improve their skills in mapping the value of the air quality in an environment, because all the data is the data from various sources contribute significantly. In this paper source of data from four sources including ground-base sensor, remote sensing with UAVs, data from satellite and historical data as presents in Figure. 4.

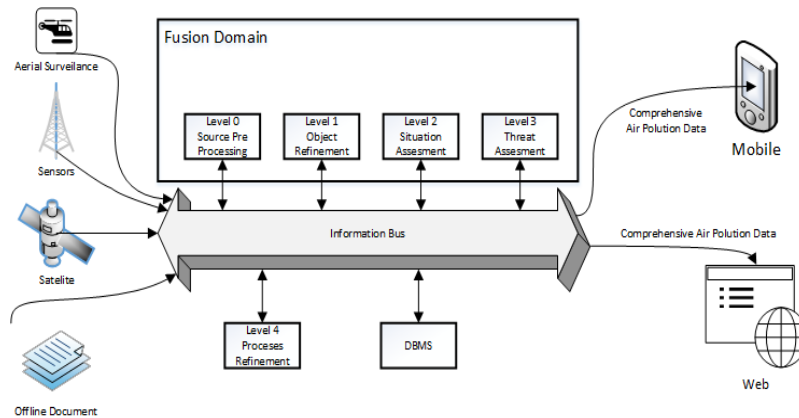


Figure 4. Data sources for monitoring system

The available data fusion approach can be classified into four nonexclusive categories, data smoothing, data analysis, modelling and data control. The fusion level is a part of all process is divided 4 levels and all the process are presented in Figure 5.

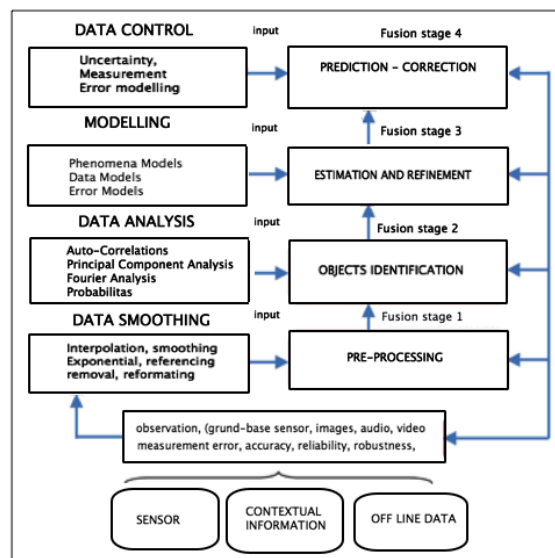


Figure 5. Data Fusion Approach

5. Conclusion

Based on some of the resumes that have been done in the previous section, the peat land and forest fires seriously produce impacts on the climate change. The impact that occurs is not only in the decrease in human health, but also affects in the economic, social, cultural and even cause increased the Indonesian mortality. Nowadays reducing peatland and forest fires is a high priority for the Indonesian government. However, every steps that must be taken by the government should not only

in the form of regulations on paper, but also depend on its implementation at the local level and provincial areas. Effective measures should involve the community. With increasing public awareness of its dangers how the impact caused by the peatland and forest fires, the expected implementation of the working steps which have been collated the government will produce a significant reduction in the rate of fire. The propose framework of monitoring system is expected to present the data in the form of a peat land fire indication for the vast land even, early warning and daily air quality in South Sumatra. The propose framework encompasses the complete information system, from the sensory level and networking support structure through to data management and Cloud based integration of respective systems and services. The information is used to disaster early warning, to increase public awareness of environmental pollution and health effects, and as the data analysis for the government to make policy.

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