Drone Services and Application for Paddy Fertilizing and Oil Palm Mapping for Climate Change

Norsida Man (1), Hidayah Hassim (1), Nabara Isah Sehu (1), Nik Norasma (1)

[1] Universiti Putra Malaysia, 43000 Serdang, Selangor, Malaysia
Email: norsida@upm.edu.my; hidayah1604@gmail.com; nabaraisah@gmail.com; niknorasma@upm.edu.my

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ABSTRACT: Climate change is having a major impact on food security. More than 815 million people are chronically hungry and 64 percent of the chronically hungry are in Asia. The world needs to increase food production by almost 50 percent by 2050 to feed a population of nine billion, yet resources such as land and water are becoming more and scarcer. The other factor is mainly due to large differences in the level of adoption of selected agricultural technologies and the underlying determinants of adoption of these technologies. Farming communities and others involved in agriculture have to adapt agriculture to climate change and other challenges. In this context, ICT-driven tools and technologies to enhance decision making through accurate, reliable and timely information have an important role to play. Agriculture has to look towards emerging technologies for solutions to overcome some of the challenges facing it. Adoption of improved agricultural technologies is fundamental to transformation of sustainable farming system and a driving force for increasing agricultural productivity. It is a tool needed to improve sustainable agriculture, a way of reconciling the necessity for sustainable and profitable food production, improve productivity and food security. Adoption of the drone with other improved agricultural technologies are fundamental to transformation of sustainable farming system and a driving force for increasing agricultural productivity, which later results in socio-economic development. Drone is commonly defined as a flying robot. The formal definition for a drone is an Unmanned Aerial Vehicle or UAV. Drones are different from other aircrafts as they do not carry a human pilot. They are often controlled by an onboard computer that is flying autonomously through software-controlled flight plans embedded in software that works in conjunction with onboard sensors and Global Positioning Systems (GPS). As agricultural drone technology continues to gain in popularity, farmers are learning the benefits of this growing, emerging technology. As rice is playing dominants role to Malaysia food security, there are major and minor granary areas where Malaysia depending for. However, there are variations in agricultural productivity in different granary areas across the country. Among the factors that contribute to this situation are the drought, floods, pests and disease, agronomic practices, climate change as well as source and water management. Meanwhile, oil palm becomes an increasingly important source of vegetable oil for its production exceeds soybean, sunflower, and rapeseed. The growth of the oil palm industry causes degradation to the environment, especially when the expansion of plantations goes uncontrolled. Remote sensing is a useful tool to monitor the development of oil palm plantations. In order to promote the use of remote sensing in the oil palm industry to support their drive for sustainability, this study provides an understanding toward the use of remote sensing and its applications to oil palm plantation monitoring. So, this study will cover on how drone technology assists the paddy farming and oil palm plantation sector to identify and

solve the problems in agriculture area of study.

1. INTRODUCTION

The main income source in Malaysia is an agriculture sectors because more than 50% population depend on farming and related works and hence agriculture in Malaysia is a backbone for Malaysian Economy. A plausible reason that impacts of climate change on agriculture have received much attention in Malaysia is its importance as a major national Gross Domestic Product (GDP) contributor (Department of Statistics Malaysia, 2018). So, improve traditional farming into precision or smart farming; industrial development reaches to fourth level is initiated to use this revolution in agricultural sectors on large scales so that it can be effectively utilized to improve the farming yield effectively. The reality is that very little innovation has taken place in the industry of late. Malaysia needs drastic change: following the current path will not solve the problem. To meet these challenges will require a concerted effort by governments, investors, and innovative agricultural technologies.

The traditional approach of crop production is undergoing a fundamental transformation. The first technology revolution in agriculture made impressive strides: Between 1961 and 2004, cereal yields in East Asia rose by 2.8 percent a year, or over 300 percent over the period, enabled by modern farming practices, including irrigation, use of fertilizers and pesticides, and the development of new and more productive crop varieties (World Bank 2008). But efficiency gains are dropping: The rate of yield increases has slowed. And the challenges are greater: The world has to produce 70 percent more by 2050, using less energy, fertilizer, and pesticide while lowering levels of GHGs and coping with climate change. Agriculture 4.0 will need to look at the production level, using technology not simply for the sake of innovation but to improve and address the real needs of the farmers. As much as Malaysia depends upon the agriculture, still it is far short from adapting latest technologies in it to get good farm.

Developed countries have already started use of UAV's in their precision agriculture (Natu 2016; Zhang and Kovacs 2012), photogrammetry and remote sensing (Colomina and Molina 2014; Everaerts 2008). It is very fast and it could reduce the work load of a farmer. In general, UAVs are equipped with the cameras and sensors for crop monitoring and sprayer's for fertilizers and pesticide spraying. In agriculture, the first UAV model is developed by Yamaha (Giles and Billing 2015).Unmanned helicopter Yamaha RMAX was introduced for agriculture pest control and crop monitoring applications. However, Yamaha stopped their production in 2007. A technical analysis of UAVs in precision agriculture is to analyze their applicability in agriculture operations like crop monitoring (Bendig, J., Bolten, A., Bareth 2012), crop height Estimations (Anthony et al. 2014), pesticide Spraying (Huang et al. 2009), soil and field analysis (Primicerio et al. 2012). In Japan, the selling price of Yamaha's 'R-Max 3880' is about 10 million Japanese yen, but Japanese local governments would subsidize the purchase 50% of the selling price. The after-sales service is very thorough and there are lots of authenticated salvage shops all over the nation. If the UAV break down, the UAV could be repaired in the 24-hour salvage shop. The high price of the drone made it hardly own by farmers but its convenient application in agriculture emerge various government initiative to reduce the burden on the price.

Rice (Oryza sativa L.) is the second most cultivated cereal crop and the most consumed staple food in the world, since more than three billion people rely on rice as their primary source of food (Dimitris et al. 2019). As a main highlight production crop, rice has been a prime focus for the development of integrated remote sensing and information and communications technology (ICT) based monitoring, mapping and yield estimation systems in South

Asian and Southeast Asian countries in order to target food security, which is closely connected to the livelihoods of smallholder farmers. Several projects on rice such as Remote Sensing Based Information and Insurance for Crops in Emerging Economies (RIICE) which then divided into Phase-I, Phase-II, and Phase-III have already made significant impacts in terms of rice monitoring, mapping and also forecasting. This integrated system combining remote sensing, crop modelling, web geographic information system (GIS), smartphone, unmanned aerial vehicles (UAV), and Amazon Web Services (AWS) has generated promising results in all countries.

These advances will let production to be more profitable, efficient, safer, and environmentally friendly. The implementation of drones in the fields of sustainability and scientific research is already an application that will catalyst more and more changes in production of oil pam. Old technologies must be maximized, and new ones generated. Agriculture 4.0, the coming agricultural revolution, must be a green one, with science and technology at its heart. The ability to collect high spatial resolution aerial images using drones is changing the way the oil palm growers are approaching the business (Marinello et al. 2016). Conventional methods of practicing precision agriculture in oil palm plantations such as remote sensing precision agriculture of oil palm is one of the largest markets in Malaysia that will be hit by UA Vand robotics. This technology has been widely applied in agricultural studies including crop conditions (Houborg et al., 2009), soil properties (Lo´pez-Granados et al., 2005), water content (Meron et al., 2010) and weed distribution (de Castro et al., 2012), among others. Satellites and aircraft platforms are conventionally used to acquire local to global remote sensing data with limited applicability in precision agriculture due to inadequate spatial and temporal resolutions and strong interference of weather conditions (Herwitz et al., 2004).

2. UNMANNED AERIAL VEHICLE (UAV)

Unmanned Aerial Vehicle is basically one of the Remote Sensing Platforms are evolving as an important, reasonable, component of precision farming and crop development. It allows observer and/or sensor to be above the target/phenomena of interest. UAV is an autonomous aerial vehicle which is piloted remotely and uses aerodynamic forces for lifting and can carry various types of payloads. It is important to point out that there is slight difference between drone and UAV. Drone stands for Dynamic Remotely Operated Navigation Equipment which has zero intelligence. No communication during fly and the results such as photographs or images are typically not obtained until it is returned to the base. On the other hand, UAV have some ability of performing ‘automatic intelligence’ in the form of communication capacity with its controller and to return payload data like images of different spectral resolutions, together with its different state of information (Austin, 2010).

3. CLIMATE CHANGE IMPACT

Climate change is a fact and it is rapidly altering the environment. The degree of manmade emissions of greenhouse gases (GHGs) has reached the highest in history, according to a 2014 report of the Intergovernmental Panel on Climate Change (IPCC). A side effect of climate change is an increase in the variability of precipitation and a rise in the frequency of droughts and floods, which tend to reduce crop yields (FAO, 2016). However, increasing variability of precipitation and more droughts and floods is likely to reduce yields. Climate change will contribute to existing long-term environmental problems, such as groundwater depletion and soil degradation. The rate of yield increases has slowed and the challenges are greater. The world has to produce 70 percent more food by 2050, using less energy, fertilizer, and pesticide while lowering levels of GHGs and coping with climate change. Drones are even having a substantial effect on how we study and mitigate climate change. Here are five examples.

3.1 Collecting Data

Drones play an increasingly important role in the study of climate change because they're excellent tools for data collection. They can be outfitted with a range of sensors and sent over remote or hard-to-access areas to quickly collect information. Previously, scientists would have collected this data using satellites, planes, helicopters or by going out on foot. Using drones makes this data collection must faster, safer and cost-effective. Scientists can use drones, also called unnamed aerial vehicles (UAVs), to assess the impacts of climate change. For example, researchers from Nicholls State University are using drones to track erosion on Louisiana's barrier islands. Researchers from Cornell are using UAVs to measure surface reflectivity of parts of the earth's surface, which deals with whether the ground is absorbing or reflecting sunlight, resulting in either heating or cooling.

3.2 Planting Trees

Planting trees helps to fight climate change because plants absorb the greenhouse gas carbon dioxide. Trees, of course, also have a range of other environmental benefits. The research being conducted by the Cornell scientists mentioned above relates to this. Measuring surface reflectivity allows researchers to determine the ideal places to plant trees to fight global warming. Planting trees in an area with lots of highly reflective snow, for example, could result in warming because it makes the surface darker. Areas with low reflectivity are ideal for planting trees. UAVs can also help with planting trees. A company called BioCarbon Engineering has built drones that can plant seeds in precise locations at a rate of 120 per minute. That's much faster than a human worker could.

3.3 Reducing Waste

The construction sector is responsible for 25 to 40 percent of the solid waste stream in the U.S. It's difficult to accurately predict how much material you'll need for a construction project, and because of this, as much as 15 percent of the material ordered for construction ends up in a landfill. Excess waste is bad for the environment, but construction materials can be especially carbon-intensive. Cement manufacturers, for example, produce about five percent of global CO_2 emissions. Construction equipment also typically runs on diesel and produces substantial emissions. Drones allow construction site managers to get an overhead view of their work sites, which enables them to improve their project planning and their progress monitoring. Using UAVs, workers can calculate the available stockpile of materials and then order more if needed or cancel unnecessary orders. Getting an overview view of the area also enables better planning of movement around the site, potentially reducing emissions from vehicles

3.4 Decreasing Travel-Related Emissions

Twenty-three percent of transportation emissions from medium-duty and heavy-duty trucks, the kind used to ship packages to homes, businesses and warehouses. Numerous companies are now exploring drones to help them increase efficiency and reduce emissions of their delivery services. A recent study confirmed that, in some cases, using drones would produce fewer emissions than using trucks. The exact savings varied based on numerous factors, and the researchers noted that drones are only practical for certain small packages. Using a drone to deliver a small package in California, the study found, resulted in 54 percent less greenhouse gas emissions than using a diesel truck. In Missouri, the difference was 23 percent.

3.5 Inspecting Renewable Energy Equipment

Switching to renewable energy is critical for fighting climate change. Drones provide many benefits to renewable energy companies and, as a result, are lowering the cost of renewable energy. Utilities can use drones to inspect wind turbines and solar fields. Inspecting a wind turbine is typically a dangerous operation in which a worker must climb to the top of the turbine and then inspect while suspended from cables. Drones eliminate the need for this, improving worker safety. Drones can also inspect large fields of solar panels much more quickly with a drone than with human inspectors, saving the utility time and money. Using UAVs can also speed up residential rooftop solar installations, as inspecting the roof with a drone can reduce solar system measurement times by 50 percent. As drones become more advanced and affordable, they're having a more significant impact on more sectors. One area where they're making a substantial difference is climate change. UAVs are turning out to be an excellent partner in the fight to study climate change, slow it down and mitigate its impacts.

4. NEED OF INDUSTRY 4.0 IN AGRICULTURE SECTOR

Regular machines in agriculture is being converted to self-aware and self-learning machines needs Industry 4.0 to enhance overall performance and maintenance management with the surrounding interaction. The main needs of Industry 4.0 in agriculture sectors aims at the construction of an open, smart manufacturing platform for real time data monitoring, tracking the status and positions of product as well as to hold the instructions to control farming processes. Digitalization in agriculture sectors exposed new standpoints for youth generation with all elements in supply chain is being intricate through co-innovative approach which set to correct direction. The traditional approach of the food industry is undergoing a fundamental transformation. The first technology revolution in agriculture made impressive strides: Between 1961 and 2004, cereal yields in East Asia rose by 2.8 percent a year, or over 300 percent over the period, enabled by modern farming practices, including irrigation, use of fertilizers and pesticides, and the development of new and more productive crop varieties (World Bank, 2008).

Agriculture 4.0 is using new technology not simply for the sake of innovation but to improve and address the real needs of the farmers. Modern farms and agricultural operations will work differently, primarily because of advancements in technology, including sensors, devices, machines, and information technology. Future agriculture will use sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and GPS technology, to list a few. These advances will let businesses be more profitable, efficient, safer, and environmentally friendly. Agriculture 4.0 will no longer have to depend on applying water, fertilizers, and pesticides across entire fields. UAVs are capable of observing the crop with different indices (Efron, 2017). The UAVs are able to cover up hectares of fields in single flight.

5. ADOPTION OF UAV FOR PADDY FERTILIZING

Rice production annually contributes to almost 3 million MT national consumption. However, arable land for rice production is reduced due to land conversion to non-agriculture activities. Thus, in order to keep up with the same production level, management reformation and utilization of the technology is necessary for better farm management.

Spraying operation in a rice field is considered as the most harmful operation since the operator has to deal with the toxic chemicals and prolong and frequent exposure. Drone provides an effective method for such operation by reducing time of operation at least about one-third compared to the conventional. Muazu et al. (2015) reported that both fertilizing, and spraying operations constituted about 63.42% of the total cost expenditure in North-West Selangor (i.e. 36.78% in fertilizing and 26.64% in spraying). An average paddy farmer there spent relatively very high investment of about RM1436.51 per ha per season for the fertilizing operating cost was about RM1040.49 per ha per season for the spraying operation. Thus, decreasing the operating costs for both fertilizing, and spraying operations would promise for a better average gross margin to the current paddy farmers in Malaysia. With the cost uncertainty near future of the pesticide product and the labor, there is a need to find a cheaper and effective method for the spraying effectively. In such alternative, the drone spraying system has been adopted. The drone was designed to fly at low altitude of several meters, the spraying effect can be controlled in the active area (Huang et al., 2008). The issues, possibly raised from the used of drone in the rice field will be regarding the environmental impact in term of the drift (Xinyu et al., 2014, Morshed et al., 2014, and Weppner et al., 2006) to the operator or residential area, as well as a calibration procedure for a specific liquid used at a desired rate of application (Faiçal et. al., 2014). However, the effectiveness of the drone in pesticides spraying in rice production operation is yet to be confirmed and required further research which is the main focus of this research.

A crop monitoring and pesticide spraying UAVs are developed consisting of an automated drone system and sprinkling system with multi spectral camera. The sprinkling system is attached to the lower region off the UAV which has a nozzle beneath the pesticide tank to sprinkle the pesticide towards downstream. First monitoring is done by multi spectral camera, the camera scans the whole crop field and generates a spatial map. This map manifests the condition of the crop through NDVI and then the farmer evaluates which type of pesticides/fertilizers apply on the crop

6. ADOPTION OF UAV FOR OIL PALM MAPPING

UAV drones can be well adapted for oil palm plantations, where field work is tedious. They allow observation of individual palm trees and can operate unnoticed and below cloud cover that prevents larger high-altitude aircraft and satellites from performing the same mission (Sinha et al., 2016). Moreover, they can be deployed quickly and repeatedly, and they are less costly and safer than piloted aircraft, are flexible in terms of flying height and timing of missions, and can obtain very high-resolution imagery. As an aerial remote sensing platform, a UAV drone must be adapted to satisfy the basic requirements of image data collection from oil palm plantation. Other than the selection of proper sensors, the stability and accuracy are vital to provide geo-referenced images for extraction of useful information. Adoption of UAV technology for oil palm plantations involves integration of vision sensors, machine vision algorithms, and control system for: 1) yield monitoring and yield mapping; 2) automated airborne pest monitoring using thermal cameras; 3) identification and counting of specific insects from very high-resolution optical images; 4) development of decision support system (DSS) using geo-referenced images as a basis for a GIS-based system giving oil palm growers the possibility to incorporate data directly to their precision farming platforms; 5) identification and mapping of Ganoderma disease using hyper spectral camera; 6) automated retrieving of oil palm canopy chlorophyll and nutrient content from multispectral and hyper spectral UAV acquired images; and 7) dynamic Web mapping and inventory management of oil palm productivity using in situ sensors.

6.1 Oil Palm Health Assessment and Disease Detection

Health assessment in oil palm plantations is crucial for spotting fungal infection and bacterial disease on the palms. By aerial scanning the plantation using visible RGB camera, NIR, hyper spectral, and multispectral sensors, it is possible to identify temporal and spatial reflectance variations before they can be detected by naked eyes and associate these changes with palms heaths for an early response. For instance, NDVI cameras can calculate the vegetation index describing the relative density and health of the palms, and thermal camera can show the heat signature of different spots in the plantations. A conceptual demonstration of a UAV remote sensing platform equipped with NDVI sensor for oil palm health assessment. For the detection of Ganoderma boninense, which is a serious threat to oil palm plantations in Malaysia and has caused great losses to healthy palms. This disease causes both basal stem rot and upper stem rot and remains South East Asia's most devastating oil palm diseases, with direct loss of the stand, reduced yield of diseased palms, and the resultant requirement for earlier replanting. Using naked eye, the Ganoderma

6.2 Pest Monitoring

Oil Palm growers lose some portion of their yields to insects and pests' infestation. Traditional methods of locating pests in thousands of hectare plantations are not effective. For example, early detection of an invasive pest like rats in palm plantations with labor requires a great amount of time and luck. Obviously, conventional methods are not accurate, and plantation managers have to make an educated guess before sending the crew to a large field to check for infested spots. For the purpose of pest monitoring, a solution is to have a UAV imagery platform equipped with a thermal camera and high-resolution RGB vision sensors for accurate identification of the spots in the oil palm plantations fields that are diagnosed with specific insects and pests.

6.3 Yield Monitoring

A rapid yield estimation method for characterization oil palm phenotype can be developed using evolving UAV technology through periodic high-resolution spectral imaging as required during the growing season. UAV-based multispectral imaging could not only be capable of estimating yield potential for breeding studies but potentially can be used by growers for predicting yield and thus, the market value of oil palm. Quantification of FFB from UAV stream images for yield map creation is the first step toward practicing PA in oil palm plantations. With the available high-tech imaging sensors and using real-time image processing and remote sensing techniques (i.e., pixel-based or object-based (Kurkute, 2018), template matching (Liu et al., 2018; Ras, Hammerstein, and Rekha, 2011) image analysis, learning algorithms methods for classification (Bagheri, 2017; Zhang and Kovacs, 2012) and for extracting useful information from an image), it is possible to measure oil palm yield on much smaller scales.

One of the benefits of using autonomous UAV is their affordable price and lower cost per each mission flight that make them suitable for academic research in yield monitoring applications. The idea is to evaluate the feasibility of having UAV agent robots that can fly over and inside oil palm plantations and collect high-resolution detailed photos from different angles for automated creation of yield maps. These maps can tell growers where and when to apply the optimal amount of inputs (i.e., fertilizer, pesticide, water) for creating further sustainability. Such technology is highly demanded by oil palm growers as a fast, accurate, and reliable tool for estimating palm numbers and FFB in large-scale plantations.

7. CONCLUSION

The implementation and integration of the new information into agricultural business processes is required to truly tap the potential of drone solutions and advanced image data analytics in the industry. Drone technology and advanced image data analytics tools are of great potential for the agriculture industry. Drone solutions can be implemented in a range of applications throughout the whole process from precise mapping for planning purposes, assessing the condition of crops and plants, to precise crop spraying. Further study on the usage of drones and UAVs can also be so handy in managing any situations regarding climate change. As main contributed crops for the economic, paddy and oil palm should be taken the urge to imply drone and UAV as their on-farm technology implementation. But with as all other tools, the right strategy and setup is required to fully leverage the technology available. With the booming industry of drone technology and sensors, and the availability of image data processing and analytics tools, the technology mix for the required solutions must be planned cautiously to maximize the benefits while optimizing the costs.

Therefore, the requirements regarding precision, resolution and layers of data employed must fully reflect the requirements of any specific use and thus should be planned on a project basis. Lastly, once the optimal solution is developed and the data acquired does not exceed processing capabilities, the information extracted needs to be fully implemented and integrated into the business process. However, once the required technology mix is deployed, the analytical capabilities are optimized and the solution is fully integrated into business processes, the full potential of the technology is ready to be exploited and the productivity improved substantially. Maximizing yields and limiting the workload and thus the costs of goods will be vitally important in the ensuing decades of unprecedented growth of agricultural product demand that we face globally and particularly in the Asia-Pacific region.

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