IMPLEMENTING PRECISION AGRICULTURE IN THE OIL PALM INDUSTRY: A CASE OF OIL PALM MANAGEMENT SYSTEM (OPAMS)

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To my beloved parents, sister, my wife, my two sons, and all my beloved friends

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ABSTRACT

Sustainable agriculture slowly replaces the conventional agriculture practice as due to the need of having sustainable agriculture management to address mainly food scarcity issue over the world; and at a micro-level it's advancement of technological means in order to adapt to the macro environment changes. The need of drastic changes in the global food system in order to achieve a more sustainable agriculture is inevitable. Agriculture industry stakeholders, especially those in oil palm industry, reckon the significance of pursuing sustainability due the competitiveness in the industry. Moreover, rigorous requirements which imposed by sustainable organizations and authorities has given rise to the industry stakeholders for continually seeking for better solutions to minimize the total operating cost. Yet even though these scenarios are what satisfies and act as the market drive to promote the research in precision technologies, the practices of precision technologies in Malaysia's oil palm industries still lack in its pace. This research aims to develop a sustainable precision agriculture management system for the oil palm industry. Through semi-structured interview session, industry stakeholders revealed their perceptions on precision agriculture technologies. They also shared their experiences and obstacles they encountered during the implementation of precision agriculture technologies in their organization. The research then moved forward to the development of Oil Palm Management System (OPAMS) which serves as a monitoring and data management system to justify the decision making in oil palm plantation operational process to achieve sustainable goal. The system assists them in monitoring, control and properly manages their resources, including fertilizers, chemical, pesticides, energy and water with better efficiency. The research raised the awareness of precision agriculture practices in oil palm industry, allow industry stakeholders taking sustainability into account while making operating investment and management decisions.

ABSTRAK

Pertanian yang lestari telah menggantikan amalan pertanian konvensional dalam menangani isu kekurangan makanan seluruh dunia; dan pada peringkat mikro, ia meningkatkan kemajuan teknologi dalam penyesuaian perubahan persekitaran secara makro. Keperluan perubahan yang drastik dalam sistem makanan global tidak dapat dielakkan untuk mencapai pertanian yang lebih lestari. Pihak berkepentingan industri pertanian, terutamanya industri kelapa sawit berpendapat mengekalkan kelestarian adalah penting atas sebab daya saing dalam industri tersebut. Selain itu, penguatkuasaan peraturan yang lebih ketat oleh organisasi dan pihak berkuasa telah memeransangkan pihak industri untuk mencari penyelesaian yang lebih baik untuk mengurangkan jumlah kos operasi. Namun, senario ini telah memerangsangkan pasaran untuk meneroka penyelidikan dalam teknologi ketepatan. Penggunaan teknologi ketepatan masih kurang dalam industri kelapa sawit di Malaysia. Penyelidikan ini bertujuan untuk membangunkan sistem pengurusan pertanian ketepatan yang lestari untuk industri kelapa sawit. Melalui sesi termuduga separa-struktur, pihak berkepentingan industri mendedahkan persepsi mereka mengenai teknologi pertanian ketepatan. Mereka juga berkongsi pengalaman dan masalah yang dihadapi semasa perlaksanaan teknologi pertanian ketepatan dalam organisasi mereka. Penyelidikan ini kemudiannya bergerak ke arah pembangunan Sistem Pengurusan Kelapa Sawit (OPAMS) yang berfungsi sebagai sistem pemantauan dan pengurusan data untuk mewajarkan penentuan keputusan dalam proses operasi perladangan kelapa sawit demi pencapaian matlamat yang lestari. Sistem ini membantu mereka dalam pemantauan, pengawalan dan pengurusan sumber dengan betul termasuklah baja, bahan kimia, racun perosak, tenaga pekerja dan sumber air dengan kecekapan yang lebih baik. Penyelidikan ini meningkatkan kesedaran mengenai amalan pertanian ketepatan dan membenarkan pihak berkepentingan industri mengambil kira ciri kelestarian semasa membuat keputusan pelaburan dan pengurusan operasi.

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LIST OF ABBREVIATIONS

AFCS	Autonomous Flight Control System
AP	Aerial Photography
API	Application Program Interface
CO_2	Carbon Dioxide
CNN	Convolutional Neural Network
CPU	Central Processing Unit
CSI	Camera Serial Interface
CV	Computer Vision
DBMS	Database Management System
DSS	Decision Support System
DSSAT	Decision Support System for Agro Technology Transfer
EPF	Entomopathogenic Fungus
ERP	Enterprise Resource Planning
FELCRA	Federal Land Consolidation and Rehabilitation Authority
FELDA	Federal Land Development Authority
FFB	Fresh Fruit Bunch
g	Gram
GAP	Good Agriculture Practice
GHG	Greenhouse Gases
GHz	Gigahertz
GIS	Geographic Information System
GNI	Gross National Income
GPIO	General Purpose Input/Output
GPS	Global Positioning System
GUI	Graphical User Interface

HDMI	High-Definition Multimedia Interface
HTML	Hypertext Markup Language
ICM	Integrated Crop Management
ICT	Information and Communication Technologies
ID	Identification
ILSVRC	ImageNet Large Scale Visual Recognition Competition
IoT	Internet of Things
IPM	Integrated Pest Management
LDR	Light Dependent Resistor
LED	Light-Emitting Diode
LPS	Leica Photogrammetry Suite
mA	Milliampere
MIT	Massachusetts Institute of Technology
MMC	Multimedia Card
MPOB	Malaysian Palm Oil Board
MYR	Malaysian Ringgit
NDVI	Normalized Difference Vegetation Index
NLP	Natural Language Processing
OBIA	Object-Based Image Analysis
OECD	Organization for Economic Cooperation and Development
OPAMS	Oil Palm Management System
OS	Operating System
PA	Precision Agriculture
R&D	Research and Development
RFID	Radio-Frequency Identification
RGB	Red Green Blue
RISDA	Rubber Industry Smallholders Development Authority
RS	Remote Sensing
RSPO	Roundtable on Sustainable Palm Oil
SD	Secure Digital
SDIO	Secure Digital Input Output
SDLC	System Development Life Cycle

SFS	Sustainable Farming Systems
SLM	Sustainable Land Management
SOP	Standard of Procedures
SSCM	Site-Specific Crop Management
UAV	Unmanned Aerial Vehicle
USB	Universal Serial Bus
UPM	Universiti Putra Malaysia
VLAI	Vertical Leaf Area Index
VRT	Variable Rate Technology
WLAN	Wireless Local Area Network
WSN	Wireless Sensor Network
YM	Yield Monitoring

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CHAPTER 1

INTRODUCTION

1.1 Research background

According to department of Statistics Malaysia (2014), palm oil industry accounted for 10% of Malaysia's exports in 2012, the third most important source of export income. The oil palm planted area in Malaysia reached 5 million hectares in 2011, an increase of 3% over 2010. Sabah is the largest producer with 1.43 million hectares or 29% of the total. Neighbouring Sarawak, also on Borneo, is the region where the oil palm cultivated area is growing most rapidly, by 8% between December 2012 and December 2013, and by 5% in the previous year, in contrast to the growth rate in the rest of Malaysia which was under 1% per annum (Grágeda *et al.*, 2016). In terms of category of ownership, 62% of the total oil palm area was dominated by sizeable plantation companies which owned by private investors and government linked companies. However, independent smallholders still accounted for 38% of the total oil palm planting area as shown in Figure 1.1 (MPOB, 2014)

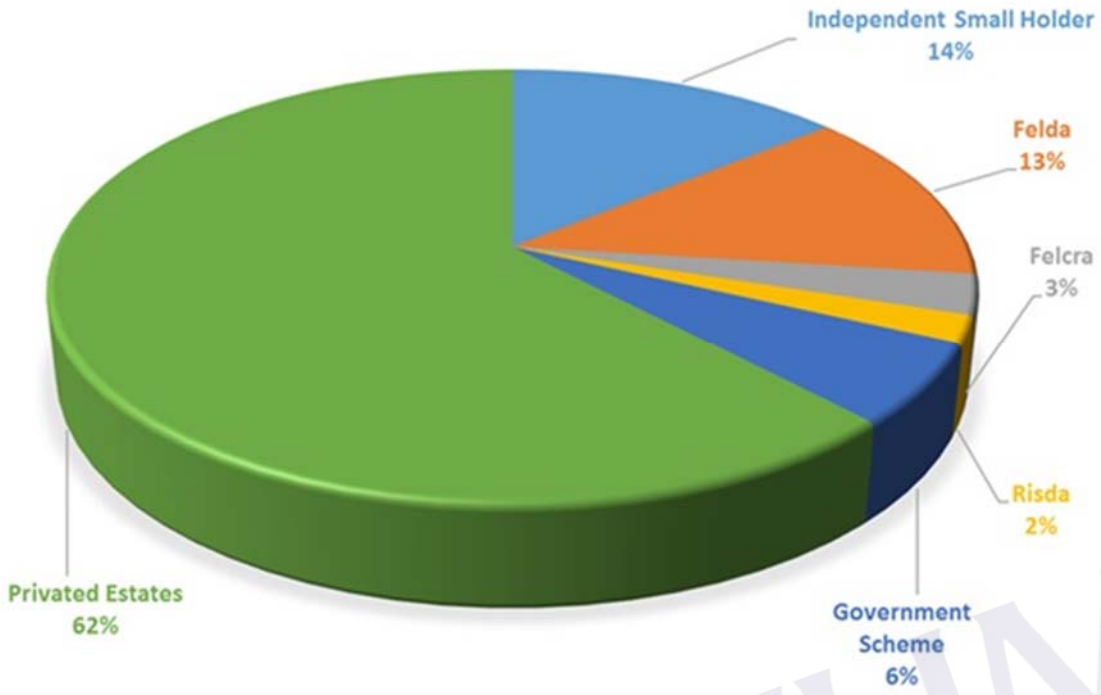

Figure 1.1: Oil palm area by category (MPOB, 2014)

Malaysian crude palm oil production in 2011 was second only to Indonesia, with Thailand 3rd, but way behind. Malaysia, on the other hand, only ranks 7th for growth of the industry, compared to 10% for Thailand and 8% for Indonesia (Martin, Rieple, Chang, Boniface, & Ahmed, 2015). Malaysia exports almost all of its palm oil to countries such as China (22.1%), the European Union (11.2%), Pakistan (10.1%), India (9.3%), and the USA (5.8%) (Economic & Industry Development Division, 2013). Palm oil is only producible in the tropics, and typically in lesser developed countries. Palm oil has very high yields per hectare, and a very wide range of applications from food processing to detergents, biodiesel and oleo-chemicals (Pirker *et al*., 2016).

Palm oil provides one of the leading vegetable oils produced globally, accounting for one-quarter of global consumption and approximately 60% of international trade in vegetable oils. Due to the increased in global population and oil consumption, the capacity of oil palm production in total has been jumped by 128% growing strongly as 58 m tons per year over the last decade (Pirker et al., 2016). In order to meet the global demand, a minimum of 78 million tonnes of palm oil will be required with the projection in 2020 (Mielke, 2013). In Figure 1.2 indicates that

Malaysia and Indonesia exported 42.9 million tonnes of palm oil which accounted for 58% of the world's total export of oils and fats in year 2013 (MPOB, 2014).

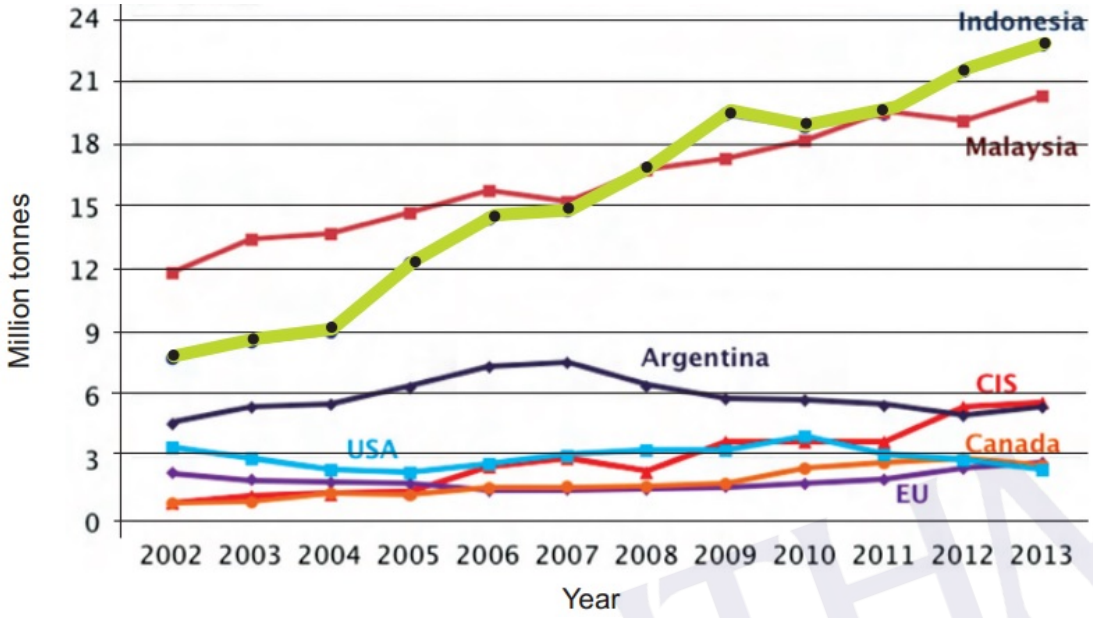

Figure 1.2: Export of oils and fats from major countries (MPOB, 2014)

1.1.1 Sustainable oil palm management system in Malaysia

The increasing worldwide demand of sustainable palm oil product has encouraged the industry to develop a sustainability strategy on the unintended social, environmental, and economic consequences of rapid population growth, economic growth, and consumption of natural resources (Abdullah *et al.*, 2015). Sustainability as a concept is more comprehensive and systemic to maximize the welfare of the environment, economy, and society (Vallance *et al.*, 2011). Procedural countermeasures have been taken in controlling the usage amount of chemical fertilizers and pesticides in the agriculture industry, with the existing guidelines such as Good Agriculture Practice (GAP) and Pesticides Act 1974. According to the control union for Roundtable on Sustainable Palm Oil (RSPO), pesticides are in conjunction with the Standard of Procedures (SOP) in the workplaces as well as the trainings given by the suppliers for the integrated pest management (IPM) system (Control Union, 2015).

A study by Ferdous Alam, Er, & Begum (2015) indicated a number of mechanisms have been developed to make palm plantation and the industry sustainable as the existing use of enormous amount of fertilizers and pesticides indicate impending

danger for further growth of the industry. Appropriate land use, land-use change and forestry (LULUCF) activities, good agricultural practice (GAP) for example that assists in recycling the nutrients through returning mill residues. Moreover, compared to other vegetable oil crops, efficient use of nutrients can be ensured in oil palm cultivation by using empty fruit bunches and by frond spreading. Besides, newly developed integrated pest management (IPM) methods infused with GAP is likely to usher in better sustainability in the palm plantations through bio pesticides like Metarhizzium fungi, Bt virus and Trichoderma to control Rhinocerous beetle grubs, bagworms and Ganoderma respectively. Barn owl has also proven to control rat in the plantations successfully (Ferdous *et al.*, 2015).

In Malaysia's (GAP) for oil palm, several things are mentioned such as crop management which is the crop protection system, basic elements of crop protection, the minimizing usage of pesticides, application of Integrated Pest Management (IPM) techniques, and preferences of non-chemical control measures (Federation of Malaysia, 2006). There are needs to improve the law terms whereby for example as compared to Thailand, the requirements and inspection for the good agriculture practice (GAP) in regards to fertilizers and pesticides were clearly stated. It mentions the requirements and inspection methods which satisfy the Thailand's standard for GAP (Thorp et al., 2008).

Presently, the industry is confronting new challenges of differing nature and dimensions in terms of regulatory requirements, trade obligations, technological advancement and new industrial and consumer demands (Sheil et al., 2009). Even though there are many things to be concerned over such as the social development, food safety and product quality, however one of the most important element that is emphasized over and over again is the sustainability of the agriculture in a whole to the social, economic and environmental aspect. Over the past few years, globally, the oil palm industry has been increasingly pressured by environmentalists, who have created a powerful lobby against oil palm, claiming that the crop contributes to rainforest destruction with its attendant elimination of wildlife and biodiversity and the alienation of indigenous people from their land (Mahat, 2012). One major challenge in the palm oil business is environment sustainability issues which is of global concern and is fast turning into a key trade issue. If palm oil is to stay dominant in the global trade, it is imperative that producers and exporters to develop appropriate production and marketing strategies not only to address these concerns but also to

enhance the acceptance of palm oil among consumers worldwide. However, agronomic practices of oil palm are environmentally pollution plantation, uncontrolled use of pesticides, poor attention to worker health and safety and it shows other negative impact as well.

So far the best practice in Malaysia oil palm industry is the usage of IPM system and zero burning technique. Two knowledge gaps and uncertainties were highlighted in one of the reports in RSPO as well, which are the information on the social and economic effects of oil palm development is scarce and contradictory, and there is a major need for alternative production scenarios that allow ecologically and socially sustainable oil palm development and give the highest yields with the lowest social and environmental impacts (Schrier-Uijl et al., 2013).

Historically, the focus of research and advice regarding to agriculture was to increase production, productivity and profits, whereas now the emphasis is on achieving those aims in a sustainable way, which often implies changing farm practices and using different technologies (OECD, 2012). The purpose of sustainable agriculture is also to produce more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services (Ibrahim, 2016).

Agriculture faces many challenges, annually worries over whether the produced crops are enough for the people on the earth. Population growth and changes in diet associated with rising incomes drive greater demand for food and other agricultural products, while global food systems are increasingly threatened by land degradation, climate change, and other stressors. Uncertainties exist in regional and local impacts of climate change, but the overall global pattern suggests that the stability of the food system will be at greater risk due to short-term variability in food supply (Nations, 2009).

1.1.2 Precision agriculture - a more sustainable way of agriculture

Drastic changes need to be made in the global food system in order to achieve a more sustainable agriculture that feeds people adequately, contributes to rural development and provides livelihoods to while sustaining the natural resource basis (Titus & Adefisayo, 2012). As the world become more aware, sustainable agriculture slowly

replaces the conventional agriculture practice (Omorogiuwa *et al*., 2014; Titus & Adefisayo, 2012). Agriculture industry shows several changes over the decades, as the vastly usage of Remote Sensing (RS) reduced the wastage of fertilizers and pesticides in the industry, it promotes sustainable development of the agriculture industry in a wider context. The application and development of the agriculture industry implies the path towards the sustainable agriculture, and one of the ways to achieve it is by the means of Precision Agriculture (PA). The planters which practice PA gain more productivity in terms of quality control and able to generate more income, while reducing the negative impact on the environment. In the year 2012, World Wide Fund organization made a study and state that the world need to produce more food in the coming 4 decades as compared to 8000 years ago (World Wide Fund , 2013). This is the crisis that the global society has to face, unlike the times before.

The purpose of PA in agriculture industry is to manage the crop production. PA promises a more sustainable form of agriculture that aims to produce food in a more environmental friendly and social way (Comparetti, 2015; Moura *et al.*, 2013; Robertson, 2007; Yadav, 2015). PA thus potentially provides means of addressing both human and environmental predicaments. There is a need to promote the sustainable agriculture, such as PA. One of the reasons is that recent trends in population and per-capita wealth continue, feeding a world population of about 9 billion people in 2050 would require raising aggregate global food production by at least 60-70%. With the benefits of the PA, the crop production can keep up with the growth of the world's population.

1.1.3 The role of PA technologies towards sustainable oil palm management system in Malaysia

PA method is related closely to crop management system, as it is a process of identifying the crops' health, and manage its productivity through the control amount of fertilizers, pesticides, and care. It may help the planters to save time and cost in the process while providing the knowledge of efficiently managing the crops. Crop management system is also related to risk management, resource management and technology management in agriculture. One of the technologies used in the agriculture

REFERENCES

AbdElHamid, A., Zong, P., & AbdElHamid, B. (2015). Advanced software ground station and UAV development for NLoS control using mobile communications. *Discrete Dynamics in Nature and Society*, *2015*. http://doi.org/10.1155/2015/285746

Abdullah, I., Wan Mahmood, W. H., Md Fauadi, M. H. F., Ab Rahman, M. N., & Ahmad, F. (2015). Sustainability in Malaysian Palm Oil: A Review on Manufacturing Perspective. *Polish Journal of Environmental Studies*, *24*(4), 1463–1475. http://doi.org/10.15244/pjoes/37888

Agtrans Research. (2007). *An economic analysis of the GRDC investment in precision agriculture variable rate technology (VRT). GRDC Impact Assessment Report Series*.

Albelwi, S., & Mahmood, A. (2017). A framework for designing the architectures of deep Convolutional Neural Networks. *Entropy*, *19*(6). http://doi.org/10.3390/e19060242

Alhojailan, M. I., & Ibrahim, M. (2012). Thematic Analysis : A Critical Review of Its Process and Evaluation. *WEI International European AcademicConference Proceedings*, *1*(2011), 8–21.

Alshenqeeti, H. (2014). Interviewing as a Data Collection Method: A Critical Review. *English Linguistics Research*, *3*(1), 39–45. http://doi.org/10.5430/elr.v3n1p39

Aubert, B. A., Schroeder, A., & Grimaudo, J. (2012). IT as enabler of sustainable farming: An empirical analysis of farmers' adoption decision of precision agriculture technology. *Decision Support Systems*, *54*(1), 510–520. http://doi.org/10.1016/j.dss.2012.07.002

Austin, O. C., & Baharuddin, A. H. (2012). Risk in Malaysian agriculture: The need for a strategic approach and a policy refocus. *Kajian Malaysia*, *30*(1), 21–50. Retrieved from http://ezproxy.um.edu.my:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=82578575&site=eds-live

Azman Ismail, Siti Mashani Ahmad, & Zuraihan Sharudin. (2015). Labour Productivity in the Malaysian Oil Palm Plantation Sector. *Oil Palm Industry Economic Journal*, *15*(2), 10.

B, L. Z., Louw, A., & Ndanga, L. Z. B. (2010). By Importance of Sustainability on Agriculture in Southern Africa. In *48th Agricultural Economists Association of South Africa (AEASA) Conference* (p. 29). Cape Town, South Africa.

Bello, O. M., & Aina, Y. A. (2014). Satellite Remote Sensing as a Tool in Disaster Management and Sustainable Development: Towards a Synergistic Approach. *Procedia - Social and Behavioral Sciences*, *120*, 365–373. http://doi.org/10.1016/j.sbspro.2014.02.114

Berends, P., & Romme, G. (1999). Simulation as a research tool in management studies. *European Management Journal*, *17*(6), 576–583. http://doi.org/10.1016/S0263-2373(99)00048-1

Bernardi, R., Cakici, R., Elliott, D., Erdem, A., Erdem, E., Ikizler-Cinbis, N., … Plank, B. (2016). Automatic description generation from images: A survey of models, datasets, and evaluation measures. *Journal of Artificial Intelligence Research*, *55*, 409–442. http://doi.org/10.1613/jair.4900

Bhandari, B., Oli, U., Pudasaini, U., & Panta, N. (2015). Generation of High Resolution Dsm Using UAV Images. *FIG Working Week*, (May), 1–28.

Bishwambher, P. (2009). *A Feasibility Study on the Application of GREEN TECHNOLOGY FOR SUSTAINABLE AGRICULTURE DEVELOPMENT : Assessing the policy impact in selected member countries of ESCAP-APCAEM*. *UNAPCAEM*.

Blaschke, T. (2010). Object based image analysis for remote sensing. *ISPRS Journal of Photogrammetry and Remote Sensing*, *65*(1), 2–16. http://doi.org/10.1016/j.isprsjprs.2009.06.004

Brown, E., & Jacobson, M. F. (2005, May). Cruel Oil: How Palm Oil Harms Health, Rainforest and Wildlife. *Center for Science in the Public Interest*, 45.

Cargill. (2014). Cargill Policy on Sustainable Palm Oil. Cargill, Incorporated.

Carlsson, R., & Björklund, F. (2010). Implicit stereotype content : Mixed stereotypes can be measured with the Implicit Association Test. *Social Psychology*, *41*(4), 213–222. http://doi.org/10.1027/1864-9335/a000029

Chang, P. (2007, November). Towards Sustainable Agriculture : Challenges and Opportunities, 1–7.

Chong, K. L., Kanniah, K. D., Pohl, C., & Tan, K. P. (2017). A review of remote sensing applications for oil palm studies. *Geo-Spatial Information Science*, *20*(2), 184–200. http://doi.org/10.1080/10095020.2017.1337317

Clifton, E. H. (2013). *Impacts of conventional and organic agriculture on soil-borne entomopathogenic fungi by*. Iowa State University.

Comparetti, A. (2015). Precision Agriculture : Past , Present and Future, (SEPTEMBER 2011).

Control Union. (2015). *RSPO PRINCIPLES & CRITERIA PUBLIC SUMMARY REPORT RE-ASSESSMENT: BORNION PALM OIL MILL Kuala Lumpur-Kepong (Sabah) Berhad*.

Daberkow, S. G., & McBride, W. D. (2003). Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the US. In *Precision Agriculture* (Vol. 4, pp. 163–177). http://doi.org/10.1023/A:1024557205871

DeLonge, M. S., Miles, A., & Carlisle, L. (2016). Investing in the transition to sustainable agriculture. *Environmental Science and Policy*, *55*, 266–273. http://doi.org/10.1016/j.envsci.2015.09.013

Edwards, R., & Holland, J. (2013). *What is Qualitative Interviewing? "What is?" Research Methods Series* (Vol. 7). http://doi.org/10.5040/9781472545244

Erickson, B. (2005). WORKSHOP HELPS FARMERS UTILIZE, 1–3.

Fadilah, N., Mohamad-Saleh, J., Halim, Z. A., Ibrahim, H., & Ali, S. S. S. (2012). Intelligent color vision system for ripeness classification of oil palm fresh fruit bunch. *Sensors (Switzerland)*, *12*(10), 14179–14195. http://doi.org/10.3390/s121014179

Federation of Malaysia. (2006). MS 1784-2 (2006) (English): GOOD AGRICULTURAL PRACTICE (GAP) - PART 2: OIL PALM (ELAEIS GUINEENSIS JACQ.). In *Malaysian Standard MS1784: 2006* (Vol. 2, p. 23).

Ferdous Alam, A. S. A., Er, A. C., & Begum, H. (2015). Malaysian oil palm industry: Prospect and problem. *Journal of Food, Agriculture and Environment*, *13*(2), 143–148.

Ferreyra, R. A., Jones, J. W., & Graham, W. D. (2006). Parameterizing spatial crop models with inverse modeling: Sources of error and unexpected results. *Transactions of the Asabe*, *49*(5), 1547–1561.

Fischer, G. (2008). Rethinking software design in participation cultures. *Automated Software Engineering*, *15*(3–4 SPEC. ISS.), 365–377. http://doi.org/10.1007/s10515-008-0030-z

Forouzani, M., & Karami, E. (2011). Agricultural water poverty index and sustainability. *Agronomy for Sustainable Development*, *31*(2), 415–431. http://doi.org/10.1051/agro/2010026

Fountas, S., Pedersen, S. M., & Blackmore, S. (2005). ICT in Precision Agriculture – diffusion of technology. *Sciences-New York*, (July 2015), 1–15. http://doi.org/10.13140/2.1.1586.5606

French, S. (2017). How DJI has crushed the consumer drone industry, and the rivals that could still take flight. Retrieved from https://www.marketwatch.com/story/how-dji-has-crushed-the-consumer-drone-industry-and-the-rivals-that-could-still-take-flight-2017-02-17?link=sfmw_tw

Garratt, M. P. D., Wright, D. J., & Leather, S. R. (2011). The effects of farming system and fertilisers on pests and natural enemies: A synthesis of current research. *Agriculture, Ecosystems and Environment*. http://doi.org/10.1016/j.agee.2011.03.014

Gebbers, R., & Adamchuk, V. (2010). *Precision Agriculture and Food Security. Science327(5967), 828-831*. *Science (New York, N.Y.)* (Vol. 327). http://doi.org/10.1126/science.1183899

Gomiero, T., Pimentel, D., & Paoletti, M. G. (2011). Environmental impact of different agricultural management practices: Conventional vs. Organic agriculture. *Critical Reviews in Plant Sciences*, *30*(1–2), 95–124. http://doi.org/10.1080/07352689.2011.554355

Grágeda, M., Escudero, M., Alavia, W., Ushak, S., & Fthenakis, V. (2016). Review and multi-criteria assessment of solar energy projects in Chile. *Renewable and Sustainable Energy Reviews*, *59*, 583–596. http://doi.org/10.1016/j.rser.2015.12.149

Grisso, R. B., Mark, A., & Gordon, G. (2009). Precision Farming Tools : GPS Navigation. *Virginia Cooperative Extension Precision Farming Series*. Virginia Cooperative Extension.

Guest, G., MacQueen, K., & Namey, E. (2012). Introduction to applied thematic analysis. *Applied Thematic Analysis*, 3–20. http://doi.org/http://dx.doi.org/10.4135/9781483384436

Guirado, E., Tabik, S., Alcaraz-Segura, D., Cabello, J., & Herrera, F. (2017). Deep-Learning Convolutional Neural Networks for scattered shrub detection with Google Earth Imagery. *ArXiv*, 1706.00917.

Gunasekaran, A., & Ngai, E. W. T. (2003). The successful management of a small logistics company. *International Journal of Physical Distribution & Logistics Management*, *33*(9), 825–842. http://doi.org/10.1108/09600030310503352

Hafez, L., & Elzarka, S. (2015). The Investigation of Purchasing Process and Supplier Development Practices in Manufacturing Companies : Multiple Case Studies on Food Processing Sector in. In *Proceedings of the International Conference on Operations Excellence and Service Engineering* (pp. 727–735). Orlando, Florida.

Hakojärvi, M., Hautala, M., Ahokas, J., Oksanen, T., & Maksimow, T. (2010). Platform for simulation of automated crop production. *Agronomy Research*, *8*(1), 797–806.

Hall, A., & Dorai, K. (2011). *THE GREENING OF AGRICULTURE: AGRICULTURAL INNOVATION AND SUSTAINABLE GROWTH*.

Hansen, W. J. (1971). User engineering principles for interactive systems. In *Fall Joint Computer Conference* (pp. 523–532). http://doi.org/10.1145/1479064.1479159

Harun, N. H., Halim, Z. A., & Ibrahim, H. (2016). Artificial Lighting System in Outdoor Image Analysis Application for Oil Palm Fresh Fruit Bunches. In *6th International Conference on Advances in Engineering Sciences and Applied Mathematics* (pp. 86–90).

Harun, N. H., Misron, N., Sidek, R. M., Aris, I., Wakiwaka, H., & Tashiro, K. (2014). Dual resonant frequencies effects on an induction-based oil palm fruit sensor. *Sensors*, *14*(11), 21923–21940. http://doi.org/10.3390/s141121923

Hossein Motlagh, N., Taleb, T., & Arouk, O. (2016). Low-Altitude Unmanned Aerial Vehicles-Based Internet of Things Services: Comprehensive Survey and Future Perspectives. *IEEE Internet of Things Journal*, *3*(6), 899–922. http://doi.org/10.1109/JIOT.2016.2612119

Huang, Y., Hoffmann, W. C., Lan, Y., Wu, W., & Fritz, B. K. (2009). Development of a Spray System for an Unmanned Aerial Vehicle Platform. *American Society of Agricultural and Biological Engineers*, *25*(6), 803–810.

Huth, N. I., Banabas, M., Nelson, P. N., & Webb, M. (2014). Development of an oil palm cropping systems model: Lessons learned and future directions. *Environmental Modelling & Software*, *62*, 411–419. http://doi.org/10.1016/j.envsoft.2014.06.021

Ibrahim, Y. A. (2016). Health and environmental impacts of pesticides: A responsibility principle and two novel systems for hazard classification and external cost determination. *Journal of Toxicology and Health*, *3*(1). http://doi.org/10.7243/2056-3779-3-1

Irizarry, J., Gheisari, M., & Walker, B. N. (2012). Usability assessment of drone technology as safety inspection tools. *Electronic Journal of Information Technology in Construction*, *17*(September), 194–212.

Isaias, P., & Issa, T. (2015a). *High level models and methodologies for information systems*. *High Level Models and Methodologies for Information Systems*. http://doi.org/10.1007/978-1-4614-9254-2

Isaias, P., & Issa, T. (2015b). High level models and methodologies for information systems. *High Level Models and Methodologies for Information Systems*, 1–145. http://doi.org/10.1007/978-1-4614-9254-2

Ismail, W. I. W., & Razali, M. H. (2010). Outdoor Colour Recognition System for Oil Palm Fresh Fruit Bunches (Ffb). *International Journal of Machine Intelligence*, *2*(1), 1–10. http://doi.org/10.9735/0975-2927.2.1.1-10

Jamil, N., Mohamed, A., & Abdullah, S. (2009). Automated grading of palm oil Fresh Fruit Bunches (FFB) using neuro-fuzzy technique. In *SoCPaR 2009 - Soft Computing and Pattern Recognition* (pp. 245–249). http://doi.org/10.1109/SoCPaR.2009.57

Joachims, T., Granka, L., & Pan, B. (2005). Accurately interpreting clickthrough data as implicit feedback. *Proceedings SIGIR 2005*, 154–161. http://doi.org/10.1145/1076034.1076063

Judkoff, R., & Neymark, J. (2006). Model validation and testing: The methodological foundation of ASHRAE Standard 140. *ASHRAE Transactions*, *112 (2)*, 367–376.

Jusoff, K. (2009). Sustainable Management of a Matured Oil Palm Plantation in UPM Campus , Malaysia Using Airborne Remote Sensing. *Journal of Sustainable Development*, *2*(1995), 196–200.

Kamalrudin, M. S., & Ramli, A. (2014). Malaysian palm oil – Moving ahead to sustainable production growth. *Oil Palm Industry Economic Journal*, *14*(1), 24–33.

Kharb, L. (2015). Moving Ahead in Future with Drones : The UAV ' s (Unmanned Aerial Vehicle). *Journal of Network Communications and Emerging Technologies*, *4*(3), 21–23.

Khorramnia, K., Shariff, A. R. M., Rahim, A. A., & Mansor, S. (2014). Toward malaysian sustainable agriculture in 21st century. *IOP Conference Series: Earth and Environmental Science*, *18*(1). http://doi.org/10.1088/1755-1315/18/1/012142

King, N. (2004). Using Interviews in Qualitative Research. In *Essential Guide to Qualitative Methods in Organizational Research* (pp. 11–23). http://doi.org/10.4135/9781446280119.n2

KINIRY, J. R., MACDONALD, J. D., KEMANIAN, A. R., WATSON, B., PUTZ, G., & PREPAS, E. E. (2008). Plant growth simulation for landscape-scale hydrological modelling. *Hydrological Sciences Journal*, *53*(5), 1030–1042. http://doi.org/10.1623/hysj.53.5.1030

Koch, B., & Khosla, R. (2003). The Role of Precision Agriculture in Cropping Systems. *Journal of Crop Production*, *9*(1–2), 361–381. http://doi.org/10.1300/J144v09n01_02

Koleva, N. G., Schneider, U. A., Mccarl, B. A., Change, G., & Science, A. (2009). *Climate change and external cost from US pesticides impacts on agricultural sector surplus*. Hamburg, Germany.

Kummer, S., Aigelsperger, L., Milestad, R., Chowdhury, A. H., & Christian, R. (2010). Knowledge systems , innovations and social learning in organic farming – An overview Agricultural Knowledge and Information System (AKIS). In *9th European IFSA Symposium* (pp. 664–669). Vienna, Austria.

Le Blanc, L. A., & Tawfik Jelassi, M. (1989). DSS software selection: A multiple criteria decision methodology. *Information and Management*, *17*(1), 49–65. http://doi.org/10.1016/0378-7206(89)90054-2

Levin, N. (1999). *Fundamentals of remote sensing*. *Tel Aviv University*. Tel Aviv University.

Li, S., Peng, S., Chen, W., & Lu, X. (2013). INCOME: Practical land monitoring in precision agriculture with sensor networks. *Computer Communications*, *36*(4), 459–467. http://doi.org/10.1016/j.comcom.2012.10.011

Luong, P. (2013). Securing Embedded Systems for Autonomous Aerial Vehicles. Retrieved from https://www.wpi.edu/Pubs/E-project/Available/E-project-042413-153504/unrestricted/Securing_Embedded_Systems_for_Unmanned_Aerial_Vehicles.pdf

Makky, M. (2016). A Portable Low-cost Non-destructive Ripeness Inspection for Oil Palm FFB. *Agriculture and Agricultural Science Procedia*, *9*, 230–240. http://doi.org/10.1016/j.aaspro.2016.02.139

Malézieux, E. (2012). Designing cropping systems from nature. *Agronomy for Sustainable Development*, *32*(1), 15–29. http://doi.org/10.1007/s13593-011-0027-z

Malhan, I. V, & Rao, S. (2007). Agricultural knowledge transfer in India: a study of prevailing communication channels. *Library Philosophy and Practice*.

Marcelino, J. P., & Diaz, E. V. (2016). Frond pruning enhanced the growth and yield of eight-year-old oil palm (Elaeis guineensis Jacq.). *Annals of Tropical Research*, *38*(2), 96–105. Retrieved from http://atr.vsu.edu.ph/resources/pdf file/Vol. 38 No. 2 Full Paper/7.pdf

Martin, S., Rieple, A., Chang, J., Boniface, B., & Ahmed, A. (2015). Small farmers and sustainability: Institutional barriers to investment and innovation in the Malaysian palm oil industry in Sabah. *Journal of Rural Studies*, *40*, 46–58. http://doi.org/10.1016/j.jrurstud.2015.06.002

Mielke, T. (2013). Palm oil, the leader in global oils and fats supply. *Malaysia/Myanmar Palm Oil Trade Fair & Seminar*, (June), 1–21. Retrieved from http://www.mpoc.org.my/upload/Plenary_Paper-Thomas-Mielke.pdf

Mishra, A. (2013). A Comparative Study of Different Software Development Life Cycle Models in Different Scenarios. *International Journal of Advance Research in Computer Science and Management Studies*, *1*(5), 2321–7782.

Mishra, A., & Dubey, D. (2013). A comparative study of different software development life cycle models in different scenarios. *International Journal of Advance Research in Computer Science and Management Studies*, *1*(5), 64–69.

Mondal, P., Basu, M., & Bhadoria, P. B. S. (2011). Critical Review of Precision Agriculture Technologies and Its Scope of Adoption in India. *American Journal of Experimental Agriculture*, *1*(3), 49–68.

Moura, E. G., Sena, V. G. L., Corrêa, M. S., & Aguiar, A. D. C. F. (2013). The importance of an alternative for sustainability of agriculture around the periphery of the Amazon rainforest. *Recent Patents on Food, Nutrition & Agriculture*, *5*(1), 70–78. http://doi.org/10.2174/2212798411305010011

MPOB. (2014). *Malaysian Oil Palm Statistics 2013 - 33th Edition*.

Naderinejad, M., Jafar Tarokh, M., & Poorebrahimi, A. (2014). Recognition and Ranking Critical Success Factors of Business Intelligence in Hospitals - Case Study: Hasheminejad Hospital. *International Journal of Computer Science and Information Technology*, *6*(2), 121–129. http://doi.org/10.5121/ijcsit.2014.6208

Nations, F. and A. O. of the U. (2009). *The State of Food and Agriculture*. *Livestock in the Balance*. http://doi.org/ISBN: 978-92-5-107671-2 I

OECD. (2001). Adoption of Technologies for Sustainable Farming Systems. In *Wageningen Workshop Proceedings* (p. 149). OECD Publications.

OECD. (2012). *Identification and Quantification of the Proceeds of Bribery*. http://doi.org/10.1787/9789264121652-en

Olsen, Jr., D. R. (2007). Evaluating User Interface Systems Research. *ACM Symposium on User Interface Software and Technology (UIST 2007)*, 251–258. http://doi.org/10.1145/1294211.1294256

Omorogiuwa, O., Zivkovic, J., & Ademoh, F. (2014). the Role of Agriculture in the Economic Development of Nigeria. *European Scientific Journal*, *10*(4), 1857–7881.

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan N., & Hoagwood, K. (2013). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Springer Science Business Media*, (November 2013), 1–13. http://doi.org/DOI 10.1007/s10488-013-0528-y

Patil, V. C., Al-Gaadi, K. A., Biradar, D. P., & Rangaswamy, M. (2012). Internet of Things (Iot) and Cloud Computing for Agriculture: an Overview. *Agro-Informatics and Precision Agriculture*, (i), 292–296.

Pemandu. (2013). Annual report 2012. *EPPO Bulletin*, *43*(3), 534–545. http://doi.org/10.1111/epp.12066

Peterson, D. K., & Kim, C. S. (2000). Journal of Information Technology Management A Publication of the Association of Management INFORMATION SYSTEMS OBJECTIVES : EFFECTS OF EXPERIENCE , POSITION LEVEL , AND EDUCATION ON DEVELOPERS SOUTHWEST MISSOURI STATE UNIVERSITY SOUTHWEST MISSOURI STATE . *Journal of Information Technology*, *XI*, 29–42.

Pirker, J., Mosnier, A., Kraxner, F., Havlík, P., & Obersteiner, M. (2016). What are the limits to oil palm expansion? *Global Environmental Change*, *40*, 73–81. http://doi.org/10.1016/j.gloenvcha.2016.06.007

Powers, L. A., Building, C. E. B., & Dillon, C. R. (2003). *Risk Management in Precision Agriculture Authors :* Alabama.

Prasad, B. D. (2008a). Content Analysis. *Research Methods for Social Work*, (2008), 173–193. Retrieved from http://repository.upenn.edu/cgi/viewcontent.cgi?article=1232&context=asc_papers&sei-redir=1&referer=http://scholar.google.com.my/scholar_url?hl=en&q=http://repository.upenn.edu/cgi/viewcontent.cgi?article=1232&context=asc_papers&sa=X&scisig=AAGBfm23DWDQYw

Prasad, B. D. (2008b). Content Analysis A method in Social Science Research. *Research Methods for Social Work*, (2008), 173–193.

Pretty, J. N., Brett, C., Gee, D., Hine, R. E., Mason, C. F., Morison, J. I. L., … Van Der Bijl, G. (2000). An assessment of the total external costs of UK agriculture. *Agricultural Systems*, *65*(2), 113–136. http://doi.org/10.1016/S0308-521X(00)00031-7

Primicerio, J., Di Gennaro, S. F., Fiorillo, E., Genesio, L., Lugato, E., Matese, A., & Vaccari, F. P. (2012). A flexible unmanned aerial vehicle for precision agriculture. *Precision Agriculture*, *13*(4), 517–523. http://doi.org/10.1007/s11119-012-9257-6

Priyanga, M., & Raja, V. (2014). Unmanned-Aerial-Vehicle-for-Videosurveillance-Using-Raspberry-Pi. *International Journal of Innovative Research in Science, Engineering and Technology*, *3*(3), 1715–1720.

R, A. K., & Rajpurohit, V. S. (2014). Research Avenues in Fruit Characterization using Machine Vision : A Review. *International Journal of Emerging Technology and Advanced Engineering*, *4*(12), 617–623.

Ramin Shamshiri. (2006). Development of a low-cost smart UAV imagery with robust machine vision system for Oil Palm plantation Management, (2004), 1–4.

Rango, A., Laliberte, A., Herrick, J. E., Winters, C., Havstad, K., Steele, C., & Browning, D. (2009). Unmanned aerial vehicle-based remote sensing for rangeland assessment, monitoring, and management. *Journal of Applied Remote Sensing*, *3*(1), 33542. http://doi.org/10.1117/1.3216822

Ranstam, J. (2009). Sampling uncertainty in medical research. *Osteoarthritis and Cartilage*, *17*(11), 1416–1419. http://doi.org/10.1016/j.joca.2009.04.007

Rao, N. H. (2002). Sustainable Agriculture: Critical Challenges Facing the Structure and Function of Agricultural Research and Education in India, 1–9.

Rashid, A., & Shariff, M. (2012). NDVI OF OIL PALM TREES BY LANDSAT-5 Imagery. In *The 33rd Conference on Remote Sensing* (pp. 5–8). Pattaya, Thailand.

Rastogi, V. (2015). Software Development Life Cycle Models- Comparison , Consequences. *International Journal of Computer Science and Information Technologies*, *6*(1), 168–172.

Rendana, M., Rahim, S. A., Idris, W. M. R., Lihan, T., & Rahman, Z. A. (2016). Mapping nutrient status in oil palm plantation using geographic information system. *Asian Journal of Agricultural Research*, *10*(3–4), 144–153. http://doi.org/10.3923/ajar.2016.144.153

Rider, T. W., Vogel, J. W., Dille, J. A., Dhuyvetter, K. C., & Kastens, T. L. (2006). An economic evaluation of site-specific herbicide application. *Precision Agriculture*, *7*(6), 379–392. http://doi.org/10.1007/s11119-006-9012-y

Robertson, M. (2007). *The economic benefits of precision agriculture : case studies from Australian grain farms*.

Sadler, E. J., Jones, J. W., Sudduth, K. A., & Stafford, J. V. (2007). Modeling for precision agriculture : how good is good enough , and how can we tell ? *Precision agriculture'07*, 241–248.

Sahin, I. (2006). Detailed Review of Rogers ' Diffusion of Innovations Theory and Educational Technology-Related Studies Based on Rogers ', *5*(2), 14–23.

Samad, R., & Zawawi, F. (2013). Oil Palm Fruit Maturity Grading System using Computer Vision Technique. *Malaysian Technical Universities Conference on Engineering & Technology (MUCET)*, 1–2.

Sargent, R. (2009). Verification and validation of simulation models. *Proceedings of the 2009 Winter Simulation Conference*, *37*, 162–176. http://doi.org/10.1109/EMR.2009.5235461

Saunders, M., Lewis, P., & Thornhill, A. (2008). *Research Methods for Business Students*. *Research methods for business students*. http://doi.org/10.1007/s13398-014-0173-7.2

Sawalha, I. H. S. (2015). Managing adversity: understanding some dimensions of organizational resilience. *Management Research Review*, *38*(4), 346–366. http://doi.org/10.1108/MRR-01-2014-0010

Schimmelpfennig, D., & Ebel, R. (2011). On the doorstep of the information age : recent adoption of precision agriculture / David Schimmelpfennig, Robert Ebel. *USDA*, (80), 31.

Schrier-Uijl, a P., Silvius, M., Parish, F., Lim, K. H., Rosediana, S., & Anshari, G. (2013). *Environmental and social impacts of oil palm cultivation on tropical peat- a scientific review*. *Roundtable on Sustainable Palm Oil*.

Shafri, H., & Hamdan, N. (2009). Hyperspectral Imagery for Mapping Disease Infection in Oil Palm Plantation Using Vegetation Indices and Red Edge Techniques Helmi Zulhaidi Mohd Shafri and Nasrulhapiza Hamdan Department of Civil Engineering , Faculty of Engineering ,. *American Journal of Applied Sciences*, *6*(6), 1031–1035. http://doi.org/10.3844/ajassp.2009.1031.1035

Shanwad, U. K., Patil, V. C., & Gowda, H. H. (2004). Precision Farming : Dreams and Realities for Indian Agriculture. In *Map India Conference* (p. 15).

Sheil, D., Casson, a, Meijaard, E., Van Noordwijk, M., Gaskell, J., Sunderland-Groves, J., … Kanninen, M. (2009). *The impacts and opportunities of oil palm in Southeast Asia*. *Africa*. http://doi.org/10.17528/cifor/002792

Shen, B. Y., & Mukai, S. (2017). A Portable, Inexpensive, Nonmydriatic Fundus Camera Based on the Raspberry Pi Computer. *Journal of Ophthalmology*, *2017*. http://doi.org/10.1155/2017/4526243

Shibusawa, S., & Haché, C. (2005). Data Collection and Analysis Methods for Data from Field Experiments. *Encyclopedia of Life Support System*, 29.

Shruti, N., Nisha, P. N., S.Kandolkar, S., & Mandrekar, R. L. (2011). Settlement of a Structure – a Case Study. In *Proceedings of Indian Geotechnical Conference* (pp. 1031–1034).

Spyros, F., Søren, M. P., & Simon, B. (2005). ICT in Precision Agriculture–diffusion of technology. Greece: University of Thessaly.

Srivastava, P., Ninawe, T., Puthran, C., & Nirgude, V. (2017). Quadcopter for Rescue Missions and Surveillance. In *International conference on computing and virtualization* (pp. 48–52).

Strickland, R. M., Ess, D. R., & Parsons, S. D. (2006). Precision farming and precision pest management: the power of new crop production technologies., (IV), 165–174.

Strydom, S. (2013). *Benefits of Centralized Materials Management : A Case Study in the Direct Selling Industry*. Royal Institute of Technology, Stockholm.

Suhaila Binti Alang Mahat. (2012). *The Palm Oil Industry From The Perspective of Sustainable Development : A Case Study of Malaysian Palm Oil Industry*. Ritsumeikan Asia Pacific University Japan.

Swinton, S., & Lowenberg-Deboer, J. (2001). Global adoption of precision agriculture technologies: Who, when and why? *Third European Conference on Precision Agriculture*, 557–562.

Tan, C. (2013, October 5). MPOB to assist in erradicating bagworm problem. Retrieved from https://www.thestar.com.my/news/community/2013/10/05/mpob-to-assist-in-erradicating-bagworm-problem/

Tan, Y. A., Low, K. W., Lee, C. K., & Low, K. S. (2010). Imaging technique for quantification of oil palm fruit ripeness and oil content. *European Journal of Lipid Science and Technology*, *112*(8), 838–843. http://doi.org/10.1002/ejlt.201000020

Teo, L., Shukri, R. M., Ong, K. P., & Zainuriah, a. (2010). Alternative oil palm fertilizer sources and management. *Oil Palm Bulletin*.

Terrón, J. M., da Silva, J. R. M., Moral, F. J., & García-Ferrer, A. (2011). Soil apparent electrical conductivity and geographically weighted regression for mapping soil. *Precision Agriculture*, *12*(5), 750–761. http://doi.org/10.1007/s11119-011-9218-5

Thenkabail, P. S., Stucky, N., Griscom, B. W., Ashton, M. S., Diels, J., van der Meer, B., & Enclona, E. (2004). Biomass estimations and carbon stock calculations in the oil palm plantations of African derived savannas using IKONOS data. *International Journal of Remote Sensing*, *25*(October 2012), 5447–5472. http://doi.org/10.1080/01431160412331291279

Thorp, K. R., DeJonge, K. C., Kaleita, A. L., Batchelor, W. D., & Paz, J. O. (2008). Methodology for the use of DSSAT models for precision agriculture decision support. *Computers and Electronics in Agriculture*, *64*(2), 276–285. http://doi.org/10.1016/j.compag.2008.05.022

Tisseyre, B., & Taylor, J. (2006). An overview of methodologies and technologies for implementing precision agriculture in viticulture. *XII Congresso Brasileiro de Viticultura E Enologia*, 45–54.

Titus, O. B., & Adefisayo, B. A. (2012). Institutional and Technical Factors Influencing Sustainable Agricultural Practices in Nigeria. *International Journal of Science and Technology*, *1*(11), 609–621.

Tran, D. ., & Nguyen, N. V. (2006). The concept and implementation of precision farming and rice integrated crop management systems for sustainable production in the twenty-first century. *International Rice Commission Newsletter*, *55*, 103–113.

Vallance, S., Perkins, H. C., & Dixon, J. E. (2011). What is social sustainability? A clarification of concepts. *Geoforum*, *42*(3), 342–348. http://doi.org/10.1016/j.geoforum.2011.01.002

Varkkey, H. (2012). The Growth and Prospects for the Oil Palm Plantation Industry in Indonesia. *Oil Palm Industry Economic Journal*, *Vol 12*(No.2), 1–13.

World Wide Fund (UK). (2013). *A 2020 vision for the global food system*.

Yadav, R. (2015). Big Data Meets Small Sensors in Precision Agriculture. *International Journal of Computer Applications*, 1–4.

Yahaya, M. F., & Choong, S. L. (2011). *Modeling Precision Agriculture Device for Palm Oil Industry*. *Advances in Ergonomics Modeling and Usability Evaluation*.

Yanez, M., & France, A. (2010). Effects of fungicides on the development of the entomopathogenic fungus Metarhizium anisopliae var. Anisopliae. *Chilean Journal of Agricultural Research*, *70*(3), 390–398. http://doi.org/10.4067/S0718-58392010000300006

Yin, Z., Seto, C., & Mao, Y. (2015). *Develop a UAV Platform for Automated Bridge Inspection*.

Zhang, Y., & Wildemuth, B. M. (2009). Qualitative Analysis of Content. *Applications of Social Research Methods to Questions in Information and Library Science*, 421. http://doi.org/10.1002/hbm.20661

Zimmerman, D. (2000). Model validation and verification of large and complex space structures. *Inverse Problems in Science and Engineering*, *8*(2), 93–118. http://doi.org/10.1080/174159700088027722

," *Iranian Journal of Reproductive Medicine,* vol. 10, pp. 409-412, 2012.