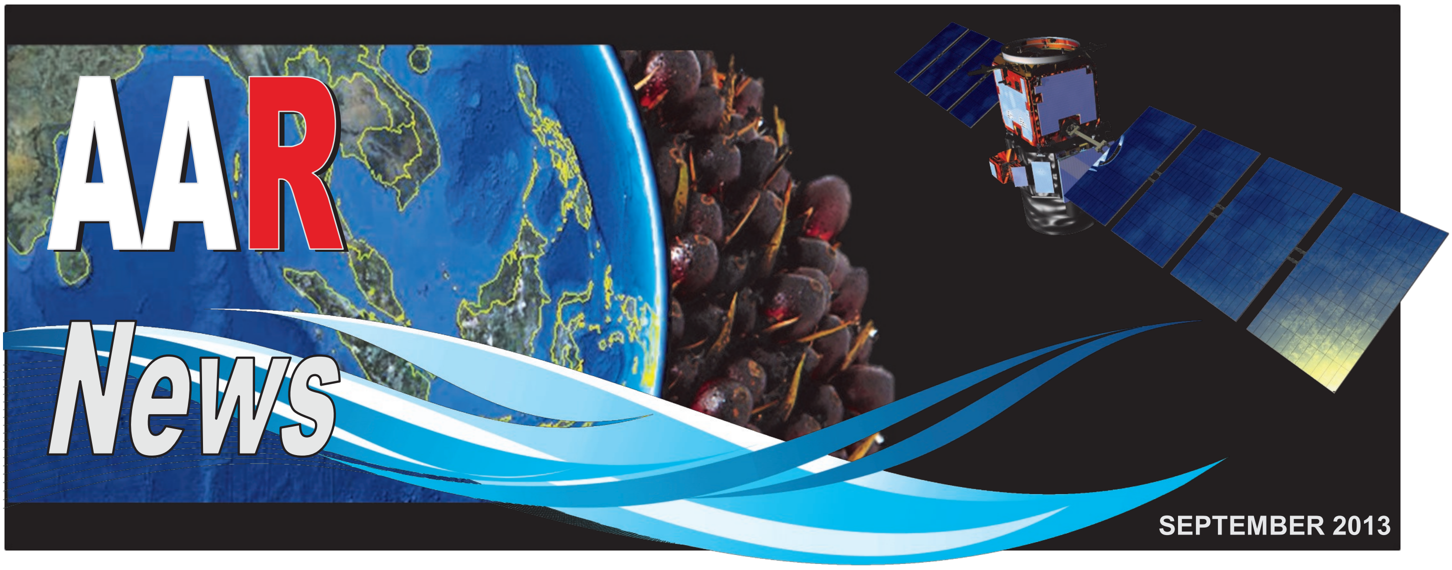

“AGRICULTURE NOT ONLY GIVES RICHES TO A NATION, BUT THE ONLY RICHES SHE CAN CALL HER OWN”

SAMUEL JOHNSON (1709-1784)

Plantation Management aided by Remote Sensing Technology

Science and technology has often paved the way for improved productivity and better gains in economic returns. With vast expansion of land cultivated with oil palm, plantation managements are now embracing newer methods and technologies to help in managing their fields. One such area of research which continues to make headway via the advancement of available technologies include applications of GPS/GIS (Global Positioning System / Geographical Information System) technologies, remote sensing systems and digital technologies in agriculture management. At AAR, we have long acknowledged its benefits and our aspiring researchers are constantly testing newer technologies and systems to benefit the oil palm industry. In this issue, we have included a paper by Mr. Patrick Ng along with his colleagues from AAR’s GIS/GPS, TEM and Drainage Sections presented at the *XVII International Oil Palm Conference* held at Cartagena, Colombia in 2012 covering the various remote sensing technologies and their applications in plantation management.

Happy Reading!

AAR Editorial team

IN THIS ISSUE

WE OFFER INTERNSHIPS!

AA Research is pleased to announce that we have long been offering internships to University undergraduates. Through the program, students will be able to apply for full-time internships within one of the many divisions/sections of AA Research. Internships are available for both undergraduate and graduate students and all positions are paid. Applicants should submit a resume with details of their relevant work and educational experiences and a cover letter stating their interests, qualifications and the internship they are applying for addressed to our Human Resource Manager at Siti.Nuraqilah@aarsb.com.my/aarsb@aarsb.com.my. Terms and conditions apply.





REMOTE SENSING AND DIGITAL TECHNOLOGIES FOR PLANTATION MANAGEMENT

PATRICK H.C. NG, TOTOK. S, S.H. TEY AND K.J. GOH

XVII International Oil Palm Conference, Cartagena Colombia (26 -28 September 2012)

1.0 INTRODUCTION

Digital technologies have changed the way we live, work and play. Tools that used to be only for premium users have become "simple", everyday, can't-live-without gadgets. From the humble telephone to mobile phones with various functions and purposes to digital cameras, tablet computers and PDAs (personal digital assistants), these gadgets or equipment have made tremendous impact in the way we communicate, transect businesses, reporting, entertain, collect data etc. which was unimaginable in the past. Like many other industries, the oil palm industry has also benefited from advances in such technologies.

The oil palm industry must continue to exploit the advances in digital technologies to further improve the productivity and efficiency of palm plantations to remain profitable and sustainable. Average yields from many major plantation groups including those in Malaysia have stagnated since the mid-1980s at about 4 tons crude palm oil per ha per year, which is well below the site yield potentials as defined by Tinker (1984). Managerial constraints, made worst with continued labour shortage have frequently been raised as the main reason for the inability of plantations to implement desired planting practices, quick identification of nutritional deficiencies as well as react rapidly to pest and disease issues, hence not obtaining the desired yields and results.

To a certain degree, the inability of plantations to identify the above issues for swift implementation is also due to the increased responsibilities of the planters in terms of area, type and amount of work and high expectations of results but with reduced staff and worker resources compared with previously and therefore the need to review and examine current work systems, practices and tools has become important and urgent. The planter's role and responsibility has been defined by Ng *et al*. (2000) and Abdullah (2012) which not only includes managing of substantial land area, large amount assets and workforce but also to provide the relevant training to the planter's subordinates to implement best management practices.

With the rapid development of IT (information technology) in the past two to three decades along with affordable hardware, software and various applications, new impetus to carrying out site specific practices even in extensive agriculture like the oil palm industry has become possible. By embracing and adapting such technologies, planters would be able to make quick and informed decisions when evaluating the suitability of potential new land, aid in planning of a new plantation with regards to both agro-management and the environment, monitor day to day operations and reduce downtime, quick reporting and to identify problems for site specific solutions to name a few. If these can be efficiently implemented, higher worker and palm productivity could be realised and as Gray and Siggs (1994) predicted, profitability depends heavily on productivity, which in turn depends on management of technology. So, what are some of these digital technologies that can be usefully incorporated for useful implementation by planters in oil palm plantations?

2.0 DIGITAL TECHNOLOGIES FOR PLANTATION MANAGEMENT

The improvement in digital and information technologies have presented the oil palm industry with new opportunities and possibilities to exploit as agri-business owners now realise the wealth of valuable information that can be at their fingertips with a simple click of a button. In the past, most of these valuable information are lost after collection as they were mainly recorded on pen and paper. If the information is collected digitally, imagine the vast amount of information that can later be collated into useful knowledge which would then allow for the development of practical site-specific practices and systems that could then lead to significant impacts on management methods and results (Kok *et al*., 2000). Even more useful would be converting these useful information to appropriate action-orientated geo-referenced knowledge-maps where planters could interpret and follow up upon. For these to happen, a few key technologies need to be available:

a) GPS/GIS (Global Positioning System / Geographical Information System) technologies
b) PDAs (Personal Digital Assistants) or other digital device for collecting data
c) Computers and databases
d) Remote sensing images and systems
e) Digital communication tools

How these technologies should be used within the context of a plantation management would be addressed. A schematic diagram illustrating how they should also be integrated into an Integrated Information Management System is illustrated in Figure 25.

2.1 GPS/GIS Technologies for mapping purposes and plantation management

Usage of GPS and GIS technologies in oil palm plantations are considered a norm nowadays although the humble beginnings of this technology was first widely purported for use in oil palm plantations by both Sugih *et al*. (1996) and Tey and Chew

(1997). The GPS project which was developed as a space-based satellite navigation system by the United States Department of Defence in 1973 was originally run with 24 GPS satellites and the system became fully operational in 1994 (NRC 1995). With the removal of "Selective Availability" (OSTP, 2000) and the ability of newer GNSS (global navigation satellite system) equipment which can receive both the Russian's Global Navigation Satellite System (GLONASS) in addition to the GPS signals, accuracy of most receivers have improved tremendously to within a few meters. Sub-meter accuracy can also be achieved with RTK (Real-Time Kinematic) survey grade receivers.

With the use of GPS/GIS technologies, creating accurate maps and updating them have become a bliss and examples of estate maps created with GPS/GIS can be seen from Figure 1 to Figure 4. The advantages of having such maps as compared with the conventional are listed in Table 1.

Additional information that can be digitized, mapped or created for overlaying onto the GPS maps would include the following:

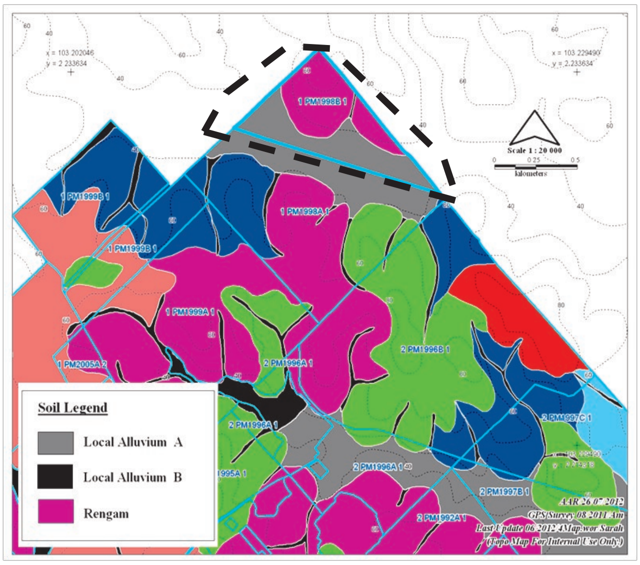

Figure 1: Topography and soils map of an oil palm plantation

a) Topography and soils map (example in Figure 1)
b) Relief map (example in Figure 2)
c) Pest and disease census map (Figure 3)
d) Planting material map (example in Figure 4)
e) Nutrition map (example in Figure 5)
f) Yield maps (example in Figure 6)

The use of topography and soils map superimposed on estate management maps (block maps) would enable planters and agronomist to have a more detailed assessment of the particular block. Take block 1PM1998B1 in Figure 1 for example. This particular block has two main soil types and two distinct topographic features. If it is practical or the area of this block is large enough, it should be split into 2 sublocks. Another way would be to maintain the same block but to manage the different soil types and topography rather differently. Estimation of site yield potential (Goh *et al*., 2000), fertilizer requirements (Kee *et al*., 1994), planning of management inputs (e.g. mechanized fertilizer application vs manual) to be carried out for this block needs to take into account the differences of both the soil and topography in order for more site specific recommendations (Goh *et al*., 2009) and actions to be achieved.

The relief map in Figure 2 can be mapped by GPS, digitized from available data including from remote sensing (refer Section 2.2) or even surveyed by levelling instruments (refer Section 2.3). With the availability of such a map, planters can estimate the overall drainage requirements for the area based on catchment analysis (Figure 15). Further refinement of internal drainage requirements and design can also be undertaken if more accurate height data obtained from high accuracy GPS or levelling survey is available as discussed in Section 2.3 and illustrated in Figure 20.

Tackling pest and disease problems in the estate should begin with proper identification of the pest (or disease), stages involved and the spread. This can be likened to say intelligence gathering in a military exercise. Gathering such data via census has been carried out by plantations classically but converting the data to useful information by displaying them onto a digital map would be more effective. In more advanced situations, plantations can also gather the data directly by GPS devices or PDAs with GPS capabilities which would then reduce the need

Table 1: Comparison of a conventional map vs digital map

Conventional Map	Digital Map
Normally hand drawn.	Either digitized in GIS or mapped with GPS.
Photocopy the most common way to reproduce.	Printed and controlled by software.
Difficult to produce in different scales.	Can be printed in many different scales or even only sections of map.
Difficult to add or remove features.	Modifying maps easily done - both by adding or reducing features.
Minimal investment in technology and skill.	Need investment in technology and skill.
Area (hectares etc.) occupied by certain sections of map can only be estimated.	Accurate area computation of certain sections of map (e.g. hectares occupied by a certain block). Computation of length of road or perimeter also can be done by software.
Less flexible to overlay other information.	Overlaying of other information (soil, topography, drainage etc.) easily done by software.

for double handling of the data. By studying the extent and stages of the pest (or disease) geospatially and in a time series, the planter can then decide whether it is necessary to carry out treatment or the appropriate time and location where treatment should be focused. In addition to prioritising the treatment of pest, planters can also determine if the treatment carried out is effective as illustrated in Figure 3. In Figure 3, the fresh damage caused by rats in a section of the plantation reduced where treatment was carried out (marked in dotted lines) but no real change was noted in other areas.

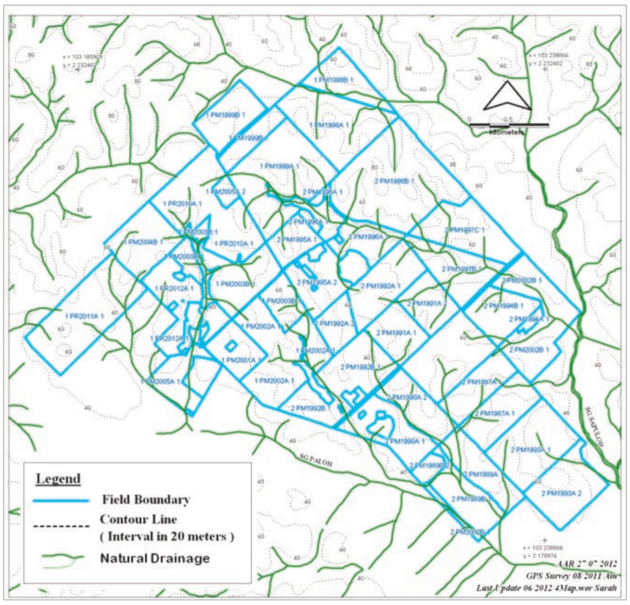

Figure 2: Relief map of an oil palm plantation

Other management data can also be summarized or displayed onto GIS maps easily such as the different planting materials the estates have planted (Figure 4). Such maps can help the planter to visualize the distribution of the various planting materials within the plantations which can then be used with GIS packages to correlate with other parameters such as yields, pest and disease occurrence, nutrition etc. This need has been made more important with plantations planting distinctively diverse materials such as the OxG hybrids which have very different characteristics compared with DxP (Cristancho *et al*., 2011) or even with clonal oil palms and they may have their own unique responses to nutrition and growth even on similar soils and growing conditions.

Most plantations would carry out periodic leaf analysis and classify them into various nutrient statuses for different agro-management practices. With digital mapping capability, these information can not only be displayed in a map for viewing purposes but could be used to study possible implications such as on yields. Figure 5 illustrates the distribution of leaf K% in a plantation in Indonesia whilst Figure 6 illustrates the yield gap of the same plantation. Yield gap here is defined as the difference between the site yield potential and the actual yield realised by the estate. Even without GIS analysis, it can be noted that the upper right corner of the estate had poorer leaf K nutrition and correspondingly, had larger yield gaps. More detailed work could be carried out if agronomic and management data of plantations are captured in a relational database and linking the data with digital maps using GIS (Fairhurst *et al*., 2000, Ooi *et al*., 2001 and Ng *et al*., 2002).

If yields were collected on a more detailed basis such as from each harvesting task, task yield can also be displayed to identify poorer yielding tasks for further checks and possibly remedial action. Harvesting tasks are normally allocated to each harvester (and/or carrier) and the size of harvesting tasks is normally 1 to 2 hectares in size. In a plantation in Malaysia, bunches are counted on a per task basis for payment purposes and the average bunch weight for the block is obtained when the total FFB weight for the area is divided by the total number of bunches of the same area. The bunch counting process is carried out by a bunch counter using a bar code scanning device.

At the end of the day, the data from the bar code device is then downloaded into the estate's computer that has a simple database to capture and store the information. Besides assisting the plantation in payment for each harvester (based on bunches harvested), the data can also be used to estimate the yield for each individual task by multiplying the number of bunches and the average bunch weight. This information can then be displayed in a digital map as illustrated in Figure 6. Although the task yield computed via this method is only an approximation, it can be used as a very handy tool to possibly locate problem tasks or tasks with potentially lower yields.

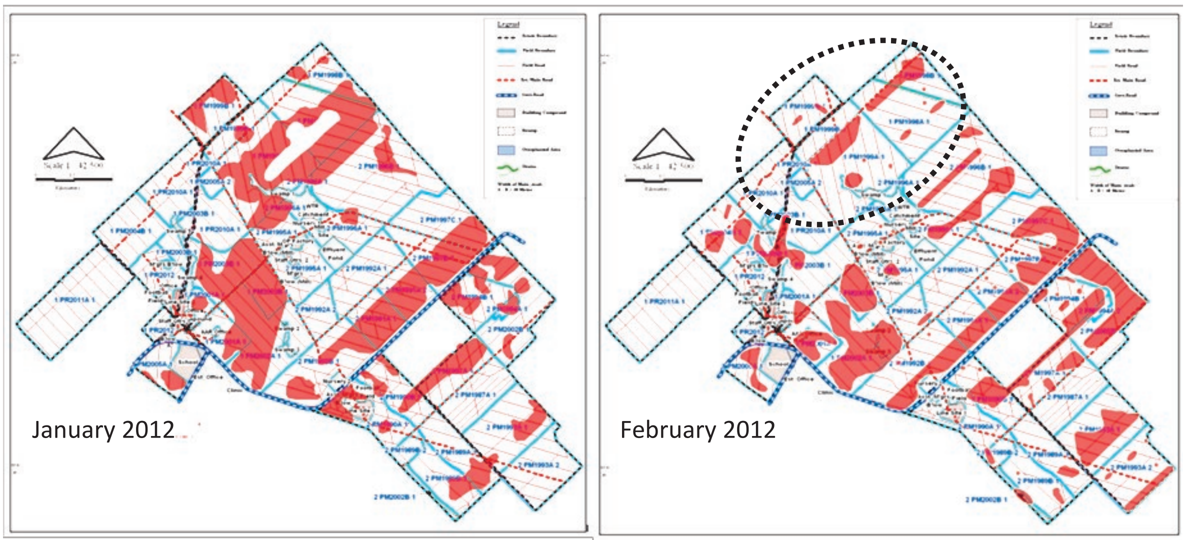

Figure 3: Pest and disease (rat) census map over two periods

With the availability of this system, planters should then be able to check on reasons why certain tasks are yielding poorer such as those coloured red in Figure 6.

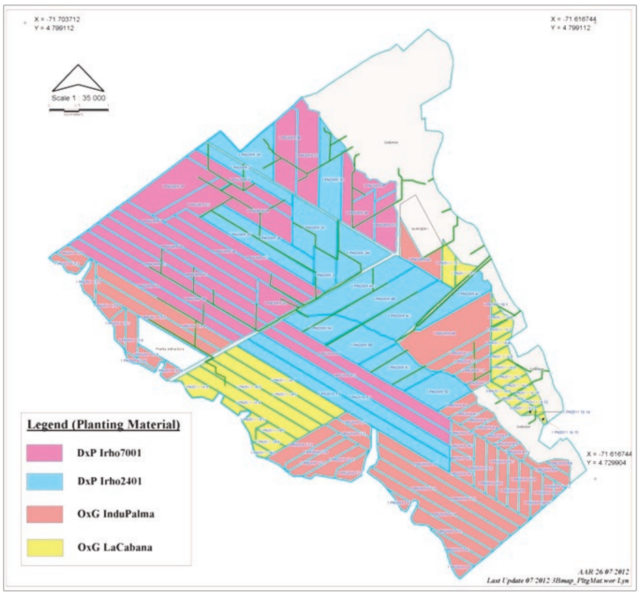

Figure 4: Planting material map of a plantation in Colombia

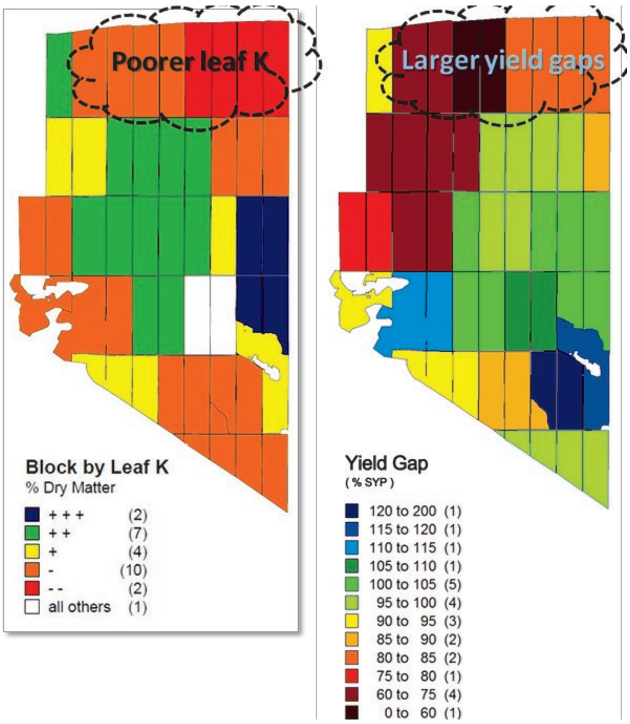

Figure 5: K nutrition and Yield Gap map of an oil palm plantation

Many plantations in Latin America in particular Colombia pay harvesters by the actual weight of FFB harvested using weighing mechanisms fixed to machines such as those in Figure 7. The weight of FFB harvested for each harvester or harvesting task could then be converted to yield/ha and would therefore be more accurate than the method describe earlier.

Even better, the task yield map could then be converted into a format which can be displayed by a GPS device or a PDA with GPS capability such as the 'smartphone' in Figure 8. Planters and supervisors can then when travelling in their plantations go to 'poorer tasks' and assess the situation on the ground for more site specific agro-management. Quite often, these 'poorer tasks' were due to harvesters not completing their harvesting operations (some palms left unharvested) due to accessibility issues or other agro-management constraints that could be identified for remedial action. By finding site-specific solutions to these constraints, yields in the 'poorer tasks' could be improved, hence higher overall yields achievable

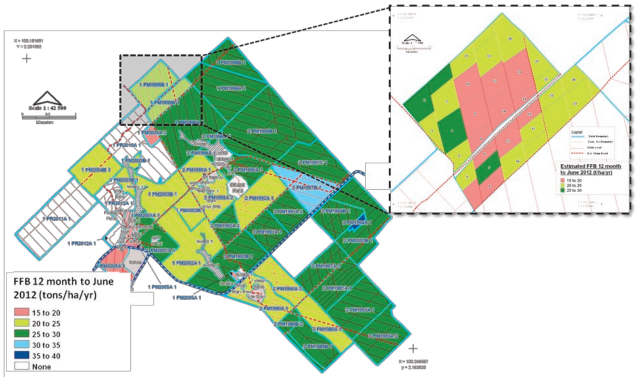

Figure 6: Yield Map and Task Yield Map (upper right) of a poorer yielding block within the same plantation (average yield of block is 21.6 tons/ha/yr)

Figure 7: Mechanized FFB weighing

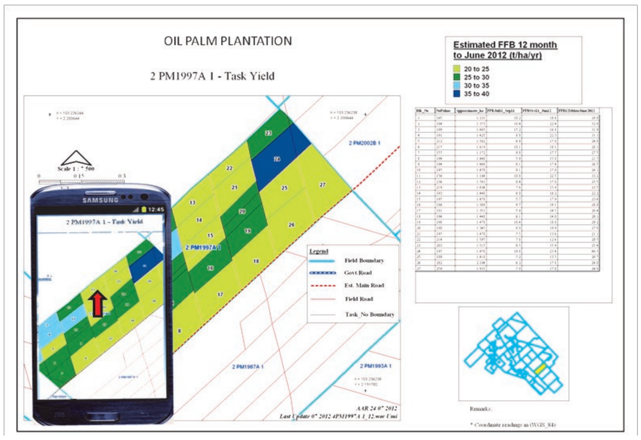

Figure 8: Yield map of a plantation – hardcopy and loaded onto a GPS enabled PDA. Each polygon represents the computed FFB yields for the task in a coloured defined range.

2.2 Remote Sensing for plantation management

The first report of remote sensing implemented in agricultural management, although indirectly used begun with the mapping of soil resources from aerial photography in 1929 by Kellogg. In the 1960s, attempts to understand light interactions with plant canopies were carried out as early studies of remote sensing followed by yield prediction and studies on relationship between plant leaf and temperature (Frazier *et al*., 1997). This was followed by using remote sensing in plantation crops with the production of Digital Elevation Models, DEMs (Tey *et al*., 2000) and usage of remotely sensed images for detecting various vegetative parameters (McMorrow and Tey, 2000, Ibrahim *et al*., 2000 and Koay *et al*., 2009) including biomass, loss of canopies due to pests, nutrient statuses and yield prediction. Later work with remote sensing also included using it to detect environmental parameters such as hot spots or open burning activities, change of ground vegetation or landuse such as from forest to agriculture or from one crop to another and even to identifying areas which are classified as High Conservation Value Forest – HCVF (Sulistioadi *et al*., 2004).

Work with remote sensing as described above was possible for oil palm plantations with the improvement in quality and availability of remote sensing data in the last ten years. Remotely sensed images could be obtained primarily from two sources i.e. space-borne or airborne and images from these can range from lower resolution (larger coverage per scene) to high resolution (smaller coverage per scene) and may or may not include images captured with multi-spectral sensors. Multi-spectral sensors are those that can simultaneously record multiple images (or bands), usually upto seven at different wavelengths of the electromagnetic spectrum. Different spectral images are more sensitive to different uses e.g. images captured at the near infrared spectrum is more sensitive to leaf area and plant structures (McMorrow and Tey, 2000) etc.

2.2.1 Space-borne Remote Sensing

Nowadays, estimations of vegetative parameters such as monitoring of palm growth and even for computing palm stand, leaf area and land use are normally carried out using high resolution optical images from space-borne satellites such as QuickBird, IKONOS, GeoEye and Worldview. Images from these high resolution satellites can have 1 m or submeter pixel resolutions and with archived images, option of obtaining them can be relatively less expensive. High resolution images on oil palm areas can also be procured from Google Earth as seen in Figure 9 and 10.

Examples of usage for these high resolution images in oil palm plantations can be seen in Figures 10 to 14. In newly planted oil palm areas, the images (Figure 10) can be used for desktop mapping by digitizing the required features off the images e.g. roads, block boundaries and unplanted or conservation areas. With these digitized, computation of planted area, length of roads etc. using desktop mapping software such as MapInfo Professional or other GIS software can be carried out. Counting palm points within each management block can also be an option as seen in Figure 11 and this can later be used to compute palm density as the planted area for that particular block is also known.

Figure 9: High resolution satellite imagery of oil palm plantation from Google Earth

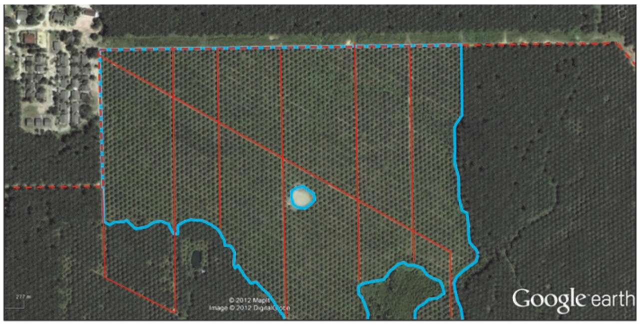

Figure 10: High resolution satellite imagery (Google Earth) that can be used for desktop digital mapping

For palms planted on terraces, the images can also be used to identify crowded areas as well as vacant areas as seen in Figure 12 and the plantation can then decide if it should remove or add new planting points in those areas. With images captured in the near-infrared spectrum (Figure 13), palms that are stressed or less normal can also be identified. Patches of poorer growing palms can also be identified with high resolution near infra-red and even with optical images (inset of Figure 13 and Figure 14). The nature of the stress or reasons why palm growth is poorer however needs to be ground-truth as they can be due to various reasons such as high water table (including flooding), poor nutrition, poorer soils etc. In large scale plantations, this preliminary indication via the use of satellite imagery can be extremely time-saving and useful for more site-specific actions to be then taken.

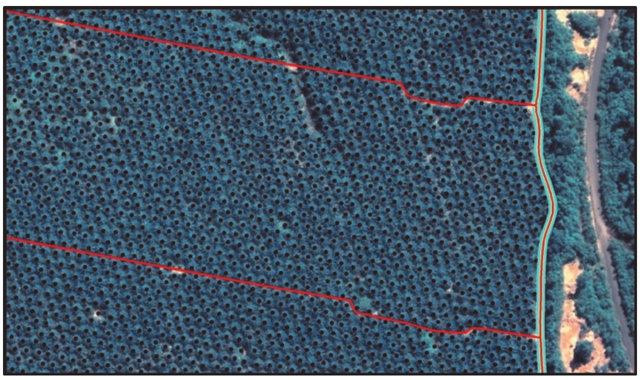

Figure 11: Each dot digitized for palm counting (Geoeye Image)

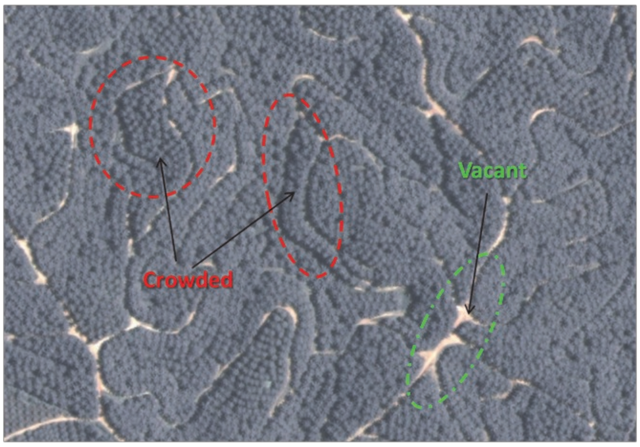

Figure 12: Image illustrating crowded and vacant palm areas (Quickbird Image)

Other usage of satellite imagery for plantation management would include the estimation of leaf area index using multi-spectral images (either the green band or the red band) as purported by McMorrow and Tey, 2000. The authors also produced a NDVI (normalized difference vegetation index) of their study area and although the NDVI did not show a good correlation with leaf area index, estimation of palm ages was possible. Work using a microwave scattering model for oil palm plantations has begun (Koay *et al*., 2009) and there is a potential of using such a model for detecting pest and disease incidences.

The use of satellite imagery for planning and designing of drainage requirements in plantations would also be very useful especially during the development stages of the plantation as seen in Figure 15. From this, water catchment studies, drainage flow, outlet points etc can be identified and designed prior to actual construction.

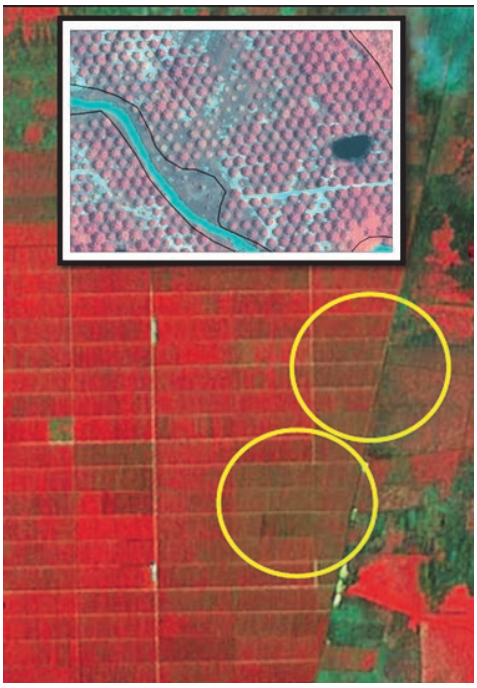

Figure 13: Near infra-red image of an oil palm plantation in Indonesia

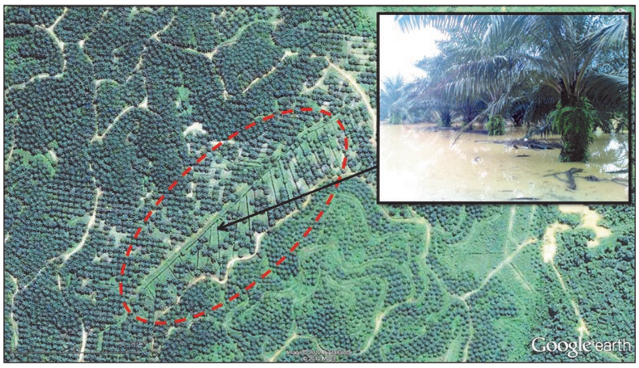

Figure 14: Google Earth image with patches of poorer growing oil palms

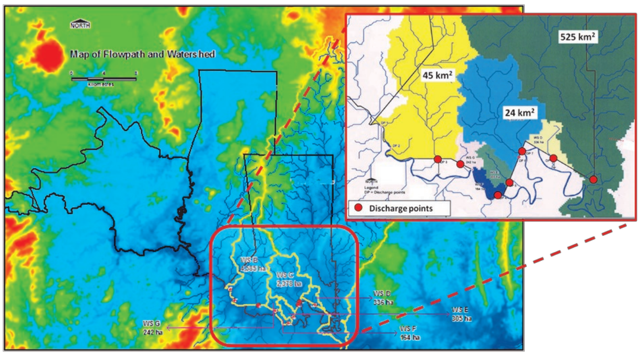

Figure 15: Watershed map of a plantation in Indonesia

2.2.2 Air-borne Remote Sensing

Despite the numerous exciting applications of space-borne remote sensing, acquiring timely, cloud-free images remain an issue in the tropics. Despite the significant improvement, acquisition of images can vary from days to even as long as six months depending on various factors including weather, cloud and satellite availability. This has sparked more effort in looking into using air-borne vehicles for image acquisition to counter problems with high cloud cover associated with satellite imagery as well as long lag period. Currently UAVs (unmanned aerial vehicles) holds the most promise in this category although sensors mounted on fixed-wing chartered planes continue to be commercially available. The latter is more suited for acquisition of images in a large tract of land in view of its relatively higher cost of operation (requires a licensed pilot and full scale aircraft). In addition to optical sensors, equipment with RADAR (Radio Detection and Ranging) and LiDAR (Light Detection and Ranging) capabilities can also be mounted on such aircraft.

UAVs for remote sensing have several key advantages over both space-borne and fixed-wing chartered plane remote sensing and this includes:

a) Cloud cover free
b) Able to acquire image over smaller study areas i.e. over a plantation or sections of plantation as and whenever required
c) Relatively simpler to operate and fast acquisition for specific purposes
d) Able to acquire image over pre-selected time periods e.g. to detect extent of flooding and how fast or slow flood waters are receding

e) Relatively cheaper
f) Very high resolution at lower altitudes

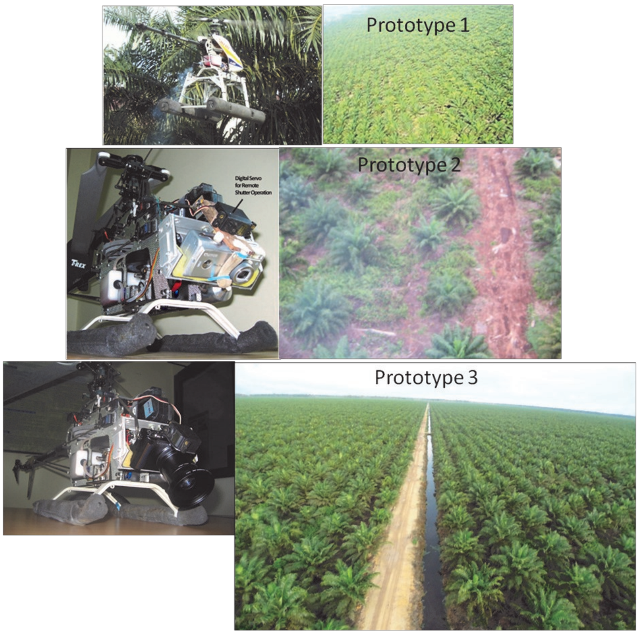

Figure 16: Prototype UAVs for small-scale airborne remote sensing

Remote sensing UAVs can be broadly categorised into two i.e. fixed-wing aircraft UAVs and helicopter UAVs. Work in AAR (Applied Agricultural Resources Sdn. Bhd.) has begun with the latter with several prototype UAVs as illustrated in Figure 16 along with the images captured by each prototype. As these prototypes were mainly small in nature, problem with wind especially at higher altitude and short flight time was an issue. In addition, they had limited flying altitude and range (about 200 m from the user) as they were manually flown (although remotely controlled) and flying them relied purely on visibility of the UAV. With low altitudes, extent of image cover was limited and many flying sequences are required to capture image for a particular sizeable block of area. Nevertheless, with Prototype 3, a much larger area at better image resolution can be captured.

With those limitations, AAR sought for alternative UAVs and is currently evaluating a bigger system (Figure 17) that has a 23 cc gasoline engine and this helicopter can be flown on autopilot with predefined coordinates and elevation. Problems with wind would still be anticipated although to a lesser extent due to its size and weight.

Other options would include Trimble's Gatewing X100 (Figure 18) which is a fixed-wing UAV with a one metre wing span. The X100 is able to fly at altitudes of 100 to 750 m, upto 45 minutes non-stop at a cruising speed of 75 km/hour on autopilot with predefined GPS-coordinated flight paths. At the default flight altitude of 150 m, images would be captured at 5 cm resolutions (XY plane) with height accuracy of 10 cm. Image acquisition for an average flight has been estimated to cover 100 to 300 ha with very high image overlaps. The X100 has also been designed to operate in light rain and wind speed of up to 60 km/hour.

Figure 17: A 23 cc gasoline engine UAV fitted with autopilot

The images in Figure 18 B and C were captured at an altitude of 600 m by the X100. In addition to normal optical images (RGB), the X100 can also acquire images in the NIR (near infra-red), red and in other parts of the spectrum and using different filters including CIR (coloured infra-red) with yellow filter. The images can also be used to produce a NDVI (NDVI = [NIR – Red] / [NIR + Red]) image where palms that have better canopies can be differentiated. The NDVI image of Figure 18C suggests that the area in the south (coloured reddish) had more vegetation (or denser palm canopies) compared with the north (coloured yellow).

2.3 Levelling Survey and Terrain Analysis

One of the major issues affecting growth of oil palms in flat alluvial soils is drainage or the lack of it. Whilst remote sensing can be used in the determination of the overall drainage design of the plantation, equipment such as the Total Station (could be used for more accurate determination of topography and water flow for plantations on extensive flat terrain. The total station is basically a computerized, waterproof electronic surveying equipment or an electronic theodolite incorporated with a high accuracy distance meter which can then read and determine slopes and distances automatically by using principles of trigonometry. With the total station, surveyed points are automatically stored in the onboard computer and every surveyed point's latitude, longitude and altitude can be computed to an accuracy of 3 mm with a known benchmark.

Figure 19 illustrates a plantation on flat coastal soils in the north of Peninsular Malaysia which has inherently poor drainage. In the previous cycle of oil palms (planted in the 1970s), the flow of water were aligned to the south (from N to S) as the plantation assumed that the terrain was totally flat and therefore water flow in all directions should be the same. Despite adequate drain density (a field drain in every 4 palm row), drainage continues to be an issue during heavy rainfall months. Just before replanting (replanting carried out from 2000 to 2002), a ground level survey was carried out as part of the plantation's drainage improvement. From the levelling survey, it appears that the general topography of the plantation although flat to the naked eye, had a natural gradient from the northeast flowing towards the southwest. A new

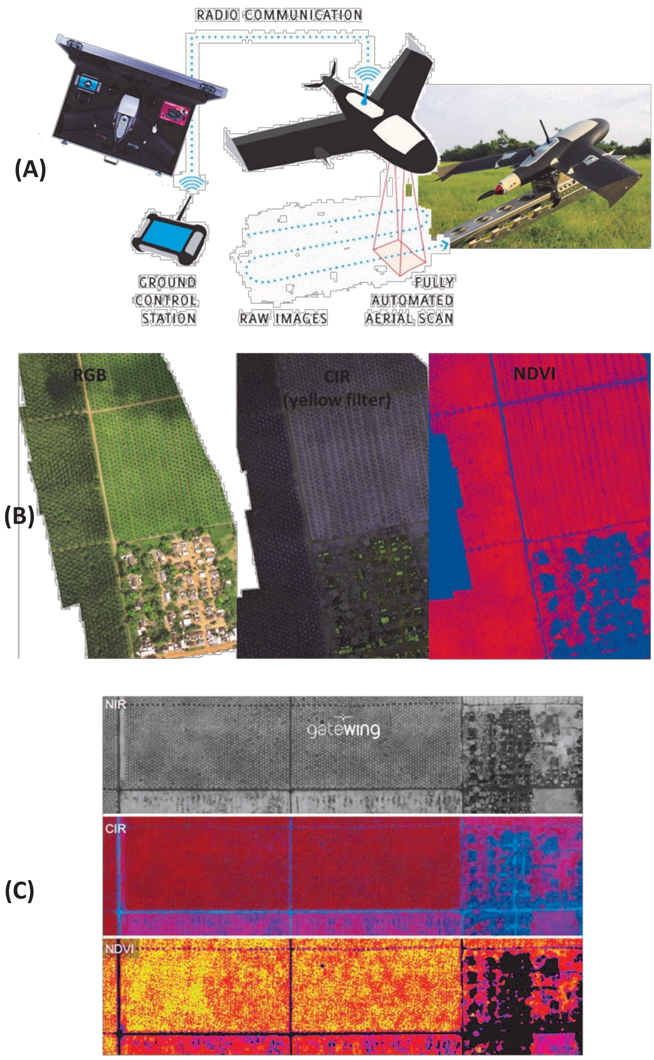

Figure 18: *Trimble's Gatewing X100 UAV used for remote sensing in oil palm plantations (Pictures and images from Gatewing)*

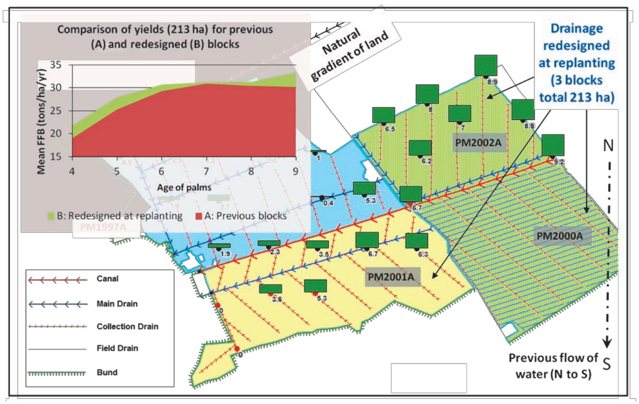

Figure 19: Drainage improvement project for an oil palm plantation in north Peninsular Malaysia. Inset chart illustrates the mean FFB yields (mean over 213 ha) for palms in previous plantings (1970s) compared with palms replanted (2000 to 2002) with drainage redesigned. Vertical columns (with numericals below) illustrate the relative ground height differences in feet.

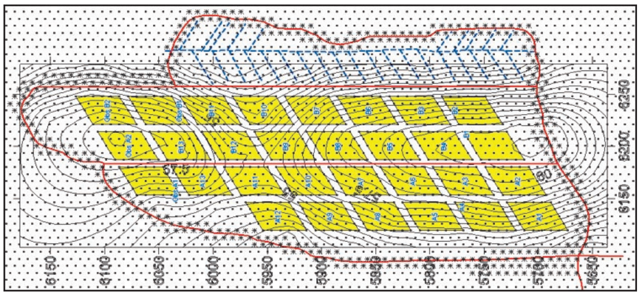

Figure 20: Topography (30 cm interval) map of surveyed experiment plot

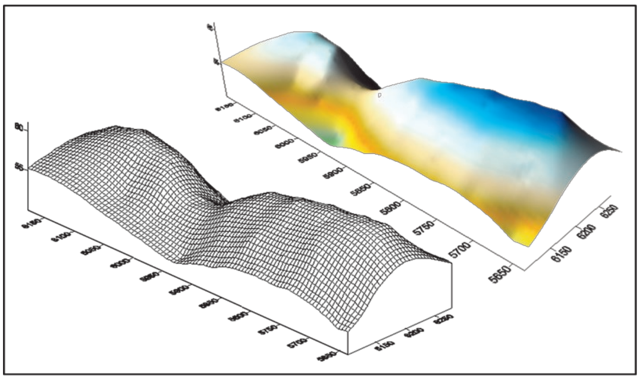

Figure 21: 3-dimension DEM of same study area in Figure 20

drainage scheme was then designed for the plantation minus the block at the top left corner as this area has since been replanted in 1997.

Palm growth and FFB yields for the redesigned areas (3 blocks totalling 213 ha, marked as B in inset chart of Figure 20) were monitored and compared with previous plantings (1970s plantings, marked as A in the same chart). As expected, higher early yields were obtained with the redesigned blocks (B) and this higher yield trend continued even till the 9th year after planting (data upto year 2011). 6-years cumulative yields for the improved drainage scheme (B) totalled 2302 tons of FFB over the 213 ha or 10.8 tons/ha higher.

The Total Station is also extremely useful in marking out plots such as for field research purposes and to carry out detailed topography survey because with these information, the effect of topography on treatments carried out can be better appreciated (Figure 20). To better visualise the terrain, the surveyed points can also be processed with GIS software such as Idrisi or Surfer to create a DEM as seen in Figure 21.

The effect of previous fertilizer applications in experiments carried out in plantations which have been replanted can also be studied if the old fertilizer plots were pre-surveyed with the Total Station and after the replanting exercise (felling, chipping, new lining, new planting distance etc.), the locations of these old plots were re-established using the 'stake-out' function (Figure 22). An example of this was recently carried out in a fertilizer trial in Sabah (East Malaysia) where oil palms which were planted in 1982 were felled in 2011 and replanted in 2012 and a new series of fertilizer trial was carried out in the same area. This new experiment would then attempt to assess how long previous fertilized plots (say at high N and K levels) would be able to sustain the growth of the new oil palms with available nutrient residues and vice versa, how much nutrients would be required to quickly improve palms on previous low (say at low N and K levels) or unfertilized (zero N and K) plots.

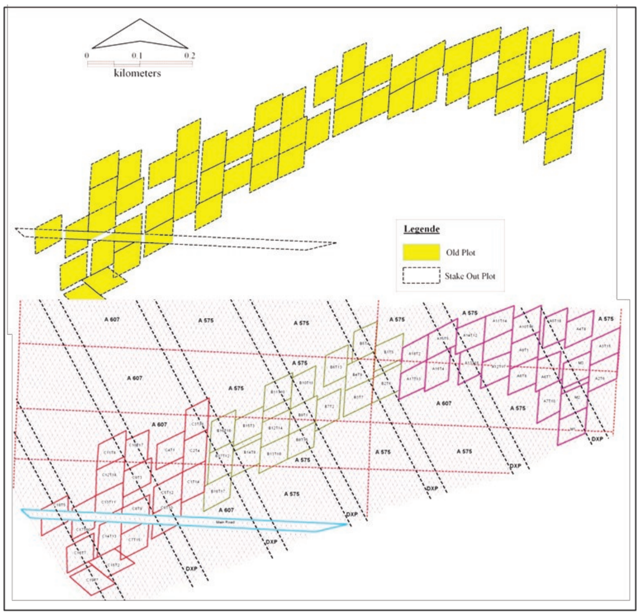

Figure 22.
Above: Comparison of pre-surveyed old plots and newly 'stake-out' plots using Total Station in a fertilizer trial in Sabah (accuracy obtained within 5 cm).

Below: Surveyed new planting rows, roads and superimposed with fertilizer trial plots made possible with high accuracy of Total Station survey.

Newer equipment such as a 3-D ground laser scanner (Figure 23) or airborne Laser Scanning with LiDAR (Light Detection and Ranging) can also be used to obtain terrain data and remotely sense images respectively.

Figure 23: 3D Laser Scanner in used in an oil palm plantation

2.4 Digital Information and Communication tools

The use of remote sensing and most digital devices for plantation management would need to be complemented with a robust database system and good data handling capability to manage the amount of data collected as well as to transform the information into useful practical knowledge. Figure 25 illustrates an example of a schematic flow of such a system that could be integrated, which basically centres on an Information Management System and well linked with necessary communication protocols.

Such a system would enable the plantations to obtain site specific information quickly, summarize it for quick reporting to both the head-office and/or research station for decisions to be made before being channelled down accurately to supporting field subordinates for further action and follow-up. This has become important nowadays with plantations being managed increasing in size with wide dispersal of workers, staff and resources. A quick, practical and site-specific means of communication between the supervisors and planters is a valuable 'time-saver' which could be turned into productive work and results.

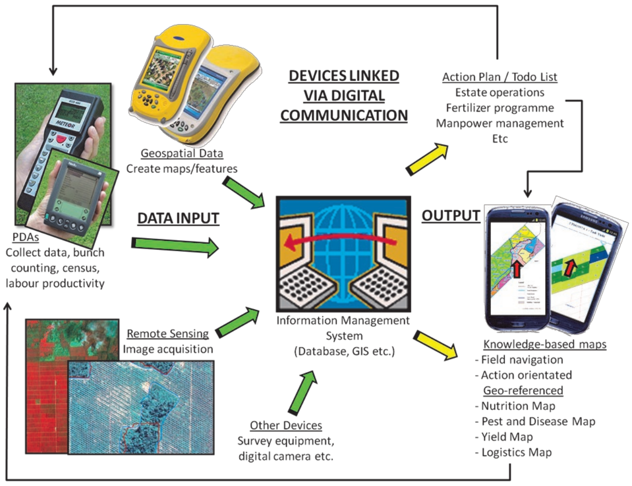

Figure 24: Schematic of Integrated Information Management System

With microcomputers and affordable navigational devices (using GPS), vehicle and resource tracking is also possible. These have long since been utilized by the police department (Cronk, 1996), fleet management companies (Diplomat, 2001) and even by oil palm plantations (Ooi *et al*., 2001). The latter reported that such systems can be used to track and monitor mechanical fertilizer spreaders in oil palm plantations. An 'as-applied fertilizer map' indicating which areas have been applied with fertilizers (via a mechanical fertilizer spreader) can be obtained. With sensors mounted on the spreader, the rate of application can also be known. By having such a map and information, plantations can then ensure that each palm received its designated fertilizer and areas where fertilizers were missed out by the mechanical spreader should then be corrected either by follow-up rounds or by manual means. An example of their fertilizer spreader's footprint has been reproduced in Figure 25. A similar system could also be set up to automatically collect real-time FFB yield information in the field.

3.0 DISCUSSIONS AND CONCLUSIONS

With ever increasing pressure on labour resources and larger areas of responsibilities, plantations need to continually ensure that their investments are effectively managed in order to achieve highest yields to remain profitable and sustainable (Ng *et al*., 1999). This can only be realised if plantations continue to be managed in a site-specific manner with necessary data and information being available for analysis sot that good

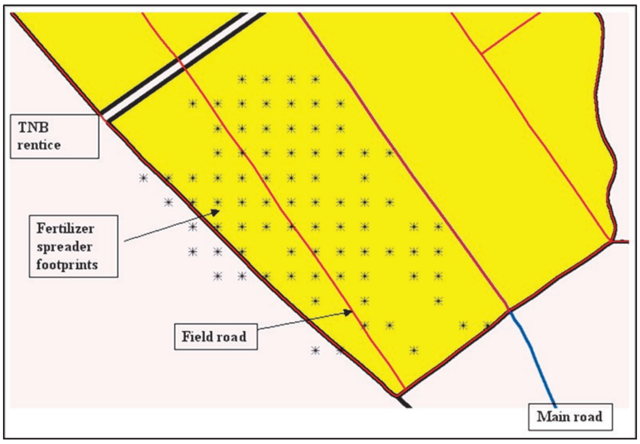

Figure 25: Footprint map of a fertilizer spreader (reproduced from Ooi et al., 2001)

agro-management decisions can be made in the shortest possible time for follow-up action and implementation to be carried out. Remote sensing and digital technologies have opened up these possibilities and can provide the quantum leap required in order to face these challenges. It should be noted that remote sensing and digital technologies does not provide the answers but are merely tools and means in achieving the ends.

In addition, with the use of an Integrated Information Management System vast amount of data that is currently being collected manually (on pen and paper) can be transformed into useful knowledge-based maps and action plans if these routine data are collected digitally. With these knowledge-based maps and action plans made available on modern day PDAs with GPS capabilities, planters and agronomists can then walk the fields with literally information and knowledge at their fingertips, even to every nook and cranny of the estate.

Even with the most useful systems available, whether the end results are achieved would highly depend on the planters themselves. Therefore, the plantation industry must be able to attract and retain the brightest and best talents available who not only can quickly adapt to changes and utilize new tools and technologies, but also have the right attitude in embracing challenges that comes with managing plantations in the 21st century.

Technologies both within plantations and other industries are now available and as Gray and Siggs (1994) emphasized, profitability which depends heavily on productivity, depends on management of technology. 18 years since, this statement still holds true in many ways and an industry that lags and does not exploit the uses of available technologies would have limited prospects. On the contrary, one that continues to exploit available technologies in the correct manner will have a more secure future. This should pose a strong incentive for palm oil producers to continue to embrace technologies in order to accomplish the task of maximizing returns in the light of changing economic situations that are generally well above their control.

ACKNOWLEDGEMENT

The authors wish to thank Applied Agricultural Resources Sdn. Bhd. (AAR) and our Principals, Messrs. Boustead Plantations Bhd. and Kuala Lumpur Kepong Bhd., for their permission to present and publish this paper. We also wish to thank the organizers of the conference for inviting us to present this paper. Thanks are also due to the Manager of Paloh estate for supplying the information for producing some of the digital maps. Last but not least, the contribution of AAR's Miss Lynda Anne and her team in preparing some of the digital maps is also acknowledged.

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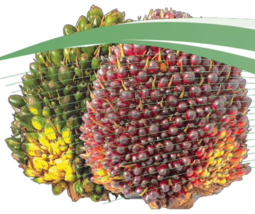

Sustainable oil palm industry revisited

By
Puspita Demitria

PT Applied Agricultural Resources Indonesia

Campaigns against the oil palm industry are heating up once again as it receives blind accusations following the recent Riau forest and land fires despite the major players in the industry adopting the zero-burn planting policy since the mid-1990s. However, what is less discussed and what the general public seems to have overlooked is how the production of sustainable palm oil could actually help conserve biodiversity and alleviate economic and social statuses of local people.

Deforestation is the most common subject of controversy facing the oil palm industry as studies claimed that large tracks of tropical rainforest are being converted to plantations, leading to the loss of natural habitats for many endangered species and, thus, to a reduction in biodiversity (Koh & Ghazoul 2008). Oil palm production, however, is not the sole contributor to deforestation in Southeast Asia. Others include logging, shifting agriculture, cattle ranching and mining, to name a few.

With oil palm, the loss of forest is minimised due to its relatively high oil yield per hectare, which is 4 to 10 times higher compared to the yields of other vegetable oil crops, and because palms could be replanted indefinitely on the same soil. The total oil palm area is less than 0.3% of the world total agricultural land or about 5.5% of vegetable oil crop area (Oil World in Sime Darby Plantation 2013), yet it contributes up to 33% and 45% of the world's vegetable and edible oil productions, respectively (Singh *et al.* 2013). Moreover, much of the present oil palm land was originally cleared for other agricultural commodities, such as rubber, cocoa and coconuts before being converted to oil palms (Corley & Tinker 2003), although the haphazard approach of some parties to opening up land for oil palm cultivation is very unfortunate and has been used to criticise the entire industry (Casson 2000), which highlights the needs for better business ethics and enforcement of government regulations.

Moreover, the claims of alarming levels of carbon emissions from deforestation in tropical regions have been unfounded, with new findings indicating that the figures only accounted for 25 to 50% of previously published estimates, or, in other words, that deforestation only accounted for 10% of greenhouse gas emissions sources (Harris *et al.* 2012). Also, between 1990 and 2010, 320 million hectares were deforested globally but oil palm cultivation accounted for less that 3% of it. The size of the oil palm industry also needs to be measured against the claimed rate of forest loss. Corley & Tinker (2003) estimated that the land area required by 2020 would only add to about 2.1-2.6% of expected forest loss. On the other hand, oil palm plantations could neutralise emissions caused by land conversion by acting as a site of sink for atmospheric carbon through the accumulation of soil organic matter and plantation biomass (Germer & Sauerborn 2008), and thereby leaving a lower carbon footprint than other oil crops (Yew *et al.* 2009).

The current belief that underlies biodiversity conservation is that ecosystems are more stable if they contain large rather than small biodiversity, although many studies have found that this was not true or not proven (Lawton & Brown 1993). Biodiversity within oil palm plantations will be less than under natural forest, as expected from newly established compared to old-growth lands. To maintain or create structural complexity within plantations, practices commonly undertaken by oil palm estates include enhancing understorey vegetation, leaving aside marginal land with steep slopes or unsuitable soil and creating forest 'islands' within plantations. Diversity in oil palm management approaches could include the 'land sharing' system, in which oil palm is planted with other species in mixed open forest stands to facilitate movement of species between natural habitats, and the 'land sparing' system, in which agroforestry zones are maintained between high conservation value (HCV) areas and intensive oil palm plantations. To compensate for reduced yields due to reduced sunlight and nutrients and land allocation to reserves, measures that can be taken encompass setting higher prices for palm oil, creating market incentives for biodiversity-friendly palm oil and producing improved varieties of oil palm that can perform well in mixed plantation matrix.

As a high-yielding and labour-intensive crop, oil palm can generate enough income to help satisfy economic needs of farmers, plantation owners and governments. Sufficient revenues mean greater degrees of conservation and rehabilitation of forests.

Oil palm is a naturally sustainable crop. Soil is protected to a considerable extent using field techniques so as to minimise erosion and land degradation. Pesticide use is less than in most tropical crops and integrated pest management (IPM) is extensively used. The yearly fertiliser demand of oil palm is also relatively lower compared to that of annual oilseed crops and is carefully computed using a 'nutrient balance' approach to avoid excessive application (Kee *et al.* 1994). To eliminate or greatly reduce the pollution of soil and water bodies, the techniques developed include the recycling of nutrients in effluents and by-products back onto the plantation, which also helps in reducing fertiliser usage. Further, palm oil can be converted into renewable biofuel to substitute for diesel fuel, which will be a major advantage in the future.

The pressing environmental and social issues surrounding oil palm industry have given rise to the Roundtable on Sustainable Palm Oil (RSPO), which comprises palm oil stakeholders and non-governmental organisation representatives. This voluntary scheme encourages planters to follow environmentally and socially sustainable management practices, such as zero-burning for land clearing, ecological conservation, IPM and waste minimisation and recycling. The HCV concept is used, as commonly employed by governments worldwide, and is considered a more flexible approach promoting sustainable use of natural resources, compared to land sparing and land sharing, which may seem unlikely for large commercial oil palm plantations. The Indonesian Sustainable Palm Oil (ISPO), RSPO's counterpart, was launched in 2011 by the Indonesian government and will be compulsory in the coming years for all oil palm growers – in 2014 for large companies and in later years for smallholders – in Indonesia.

In regards to environmental issues faced by the industry, Applied Agricultural Resources (AAR) Sdn Bhd and its subsidiary, PT AAR Indonesia, continue to provide technical support for the management of associated oil palm estates which follow RSPO and/or ISPO guidelines, and to perform research activities directed to improve oil palm planting materials and management practices that would better fit the local environment – contributing to promote a sustainable oil palm industry.

Investment in the agricultural sector is needed to boost increases in jobs, incomes and opportunities. In developing countries, if natural resource development is hindered or stopped, the rural populations would remain poor and would continue to illegally make use of natural resources to earn an income, thus worsening deforestation. Sustainable oil palm cultivation may, in fact, help conserve natural resources and ecological diversity and alleviate economic and social statuses of people in palm oil producing countries. It is therefore important for the industry to develop and identify ways to manage oil palm landscapes in recognition of biodiversity, economic and livelihood needs.

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ABOUT THE AUTHOR

Puspita Demitria, a graduate in Wildlife Management (B.Sc. Hons) from the University of Western Australia, is one of the many aspiring young researchers recruited by PT AARI. She has joined our ranks as an agronomist and advisory consultant. Her main research interests lie on the ecological structures of oil palm plantations and their surrounding environment and their interrelationships with various aspects of oil palm production.

PT AARI SOCIAL NEWS

NEW RECRUITS

Tri Padukan Purba who joined us as Agronomist (ARO 1) in November 2012 was recently confirmed. His current duties include oil palm advisory and conducting agronomy trials and has also been tasked to assist PT AARI's Drainage Improvement Section. Paduka holds a B.Sc. in Forest Product Technology / Forest Engineering obtained from Bogor Agriculture University (2006) and a M.Sc. in Wood Science & Technology obtained from Universiti Putra Malaysia (2012).

The torch has now been passed on to Ms. Ee Chea Chea and Ms. Masniwati as President and Vice-President of AAR's Sports Club (AARSC), respectively. So far, the young and dynamic duo are determined to add a punch to those carbs and flabs by organising several sports and outdoor activities such as a futsal and netball tournament and also a hike up Broga Hill, Semenyih…. and we have included some snippets capturing the many happy and perspiring moments.

NETBALL & FUTSAL TOURNAMENTS