

**THE FUTURE OF
MECHANIZATION IN OIL
PALM PLANTATIONS
(A MALAYSIAN
EXPERIENCE)**

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Outline of Presentation

Introduction to Malaysian Palm Oil Industry

MPOB's Field Mechanization Technologies

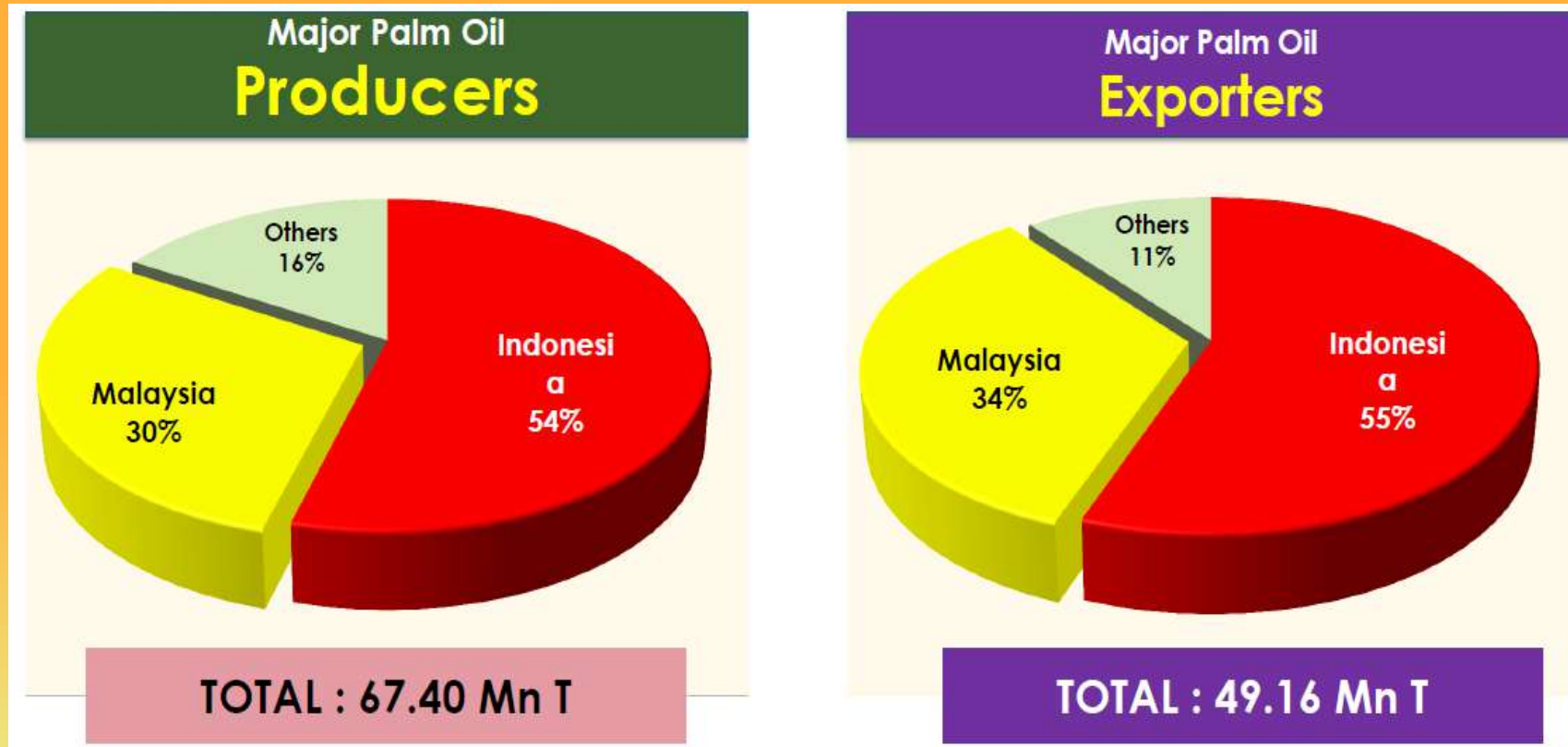
Current Mechanization Practices By Plantation

The Future in Oil Palm Mechanization

Concluding Remarks

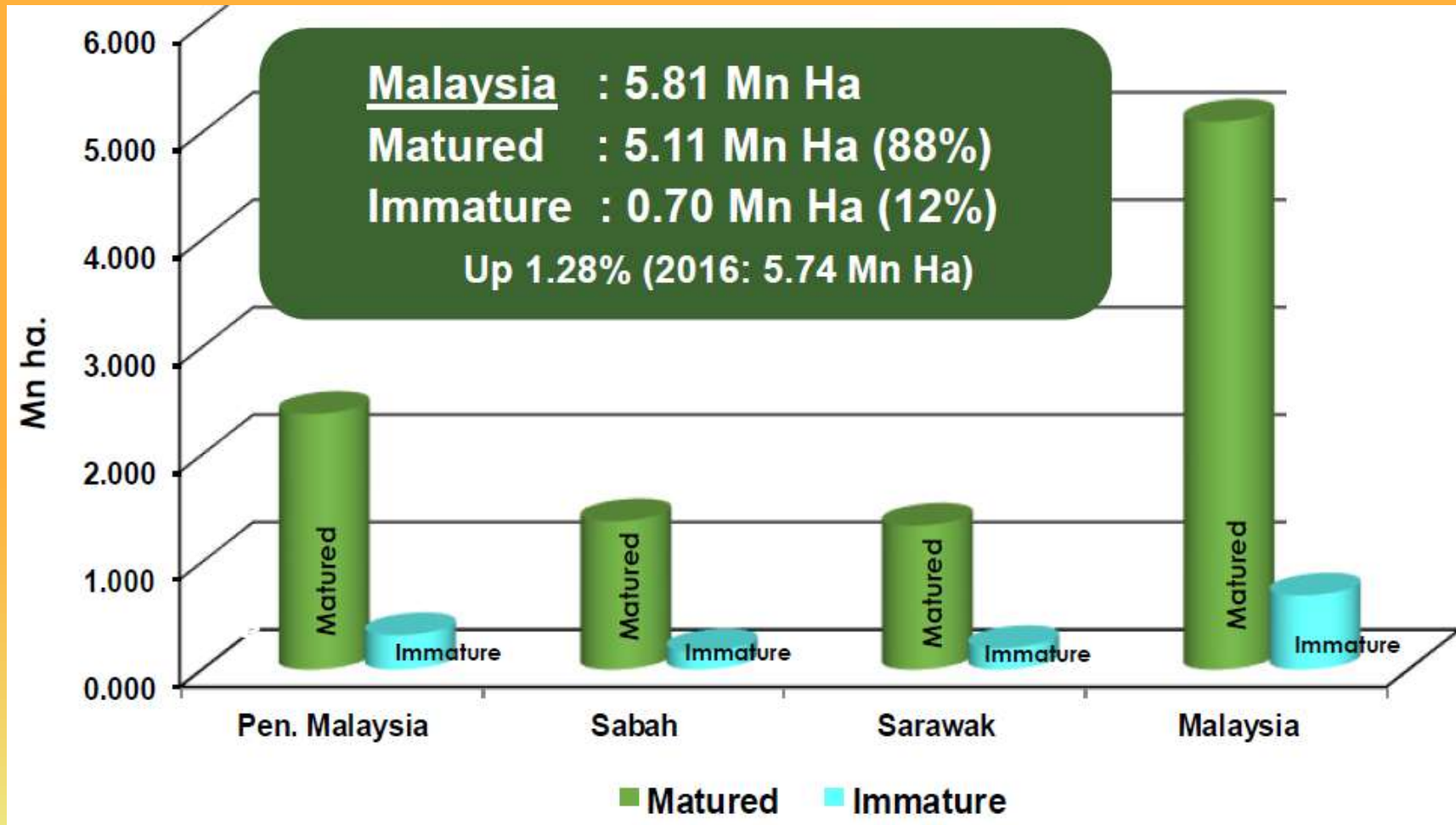
Introduction

Malaysia is 2nd largest producer & exporter of palm oil in the world. Indonesia is still the market leader



(Source: MPOB, 2018)

Oil Palm Planted Area in 2017



(Source: MPOB, 2018)

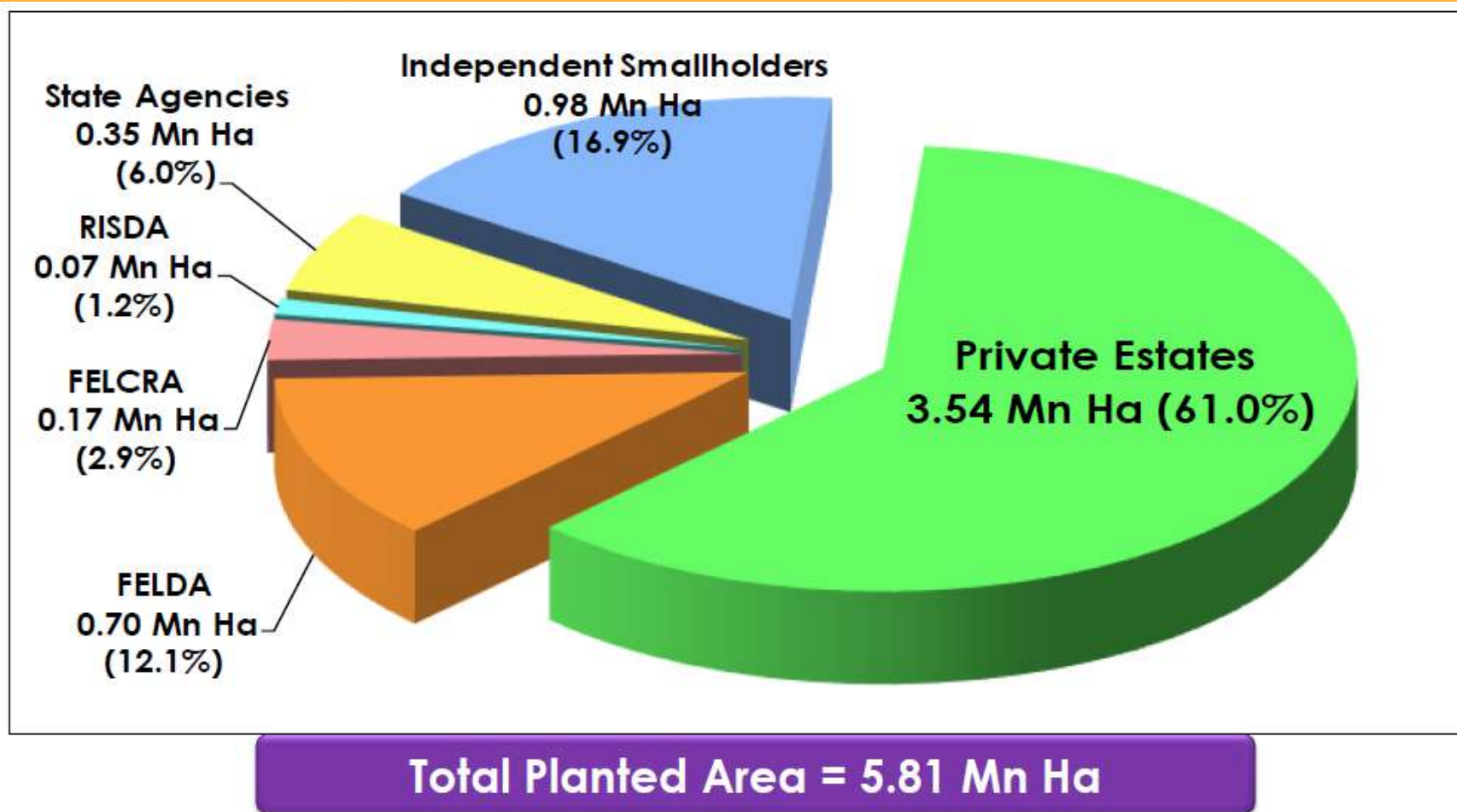
Performance of Palm Oil Industry

Indicator		2017	2016
• Planted Area	(Mn ha)	5.81	5.74
• CPO Production	(Mn T)	19.92	17.32
• FFB Yield	(T/ha)	17.89	15.91
• Oil Extraction Rate	(%)	19.72	20.18
• PO Imports	(Mn T)	0.56	0.42
• PO Exports	(Mn T)	16.56	16.05
• Closing Stocks	(Mn T)	2.73	1.67
• CPO Price	(RM/T)	2,783.00	2,653.00
• Export Revenue *	(RM Bn)	78.00 (p)	67.92 (r)

(Source: MPOB, 2018)

Note: p= preliminary ; r- revised

Oil Palm Planted Area by Category in 2017



(Source: MPOB, 2018)

Categories of Growers

Categories of Growers	Total Planted Area (Million ha)	Categories of Mills	Percent of Milling Capacity	Current Field Mechanization Technologies
Independent Smallholders	0.98	190 Independent mills	41%	Harvesting tools (Al. pole, knives & chisels), knapsack sprayer, wheelbarrow, trailer, motorized cutter
Organized Smallholders	0.94	105 government related mills	22%	Harvesting tools, Knapsack sprayer, wheelbarrow, motorized cutter, tractor mounted implements & trailer, mainline loading & transport
State Companies	0.35			
Private Companies	3.54	170 estate mills	37%	As above plus conducting R&D on potential technologies
Total	5.81	465 mills	100%	

**FIELD MECHANIZATION
TECHNOLOGIES
DEVELOPED BY MPOB**
*(An Introduction to
Improvements Made on
Conventional Systems)*

Harvesting Technologies (MPOB)

Motorized Cutter

(MPOB TT No.180)

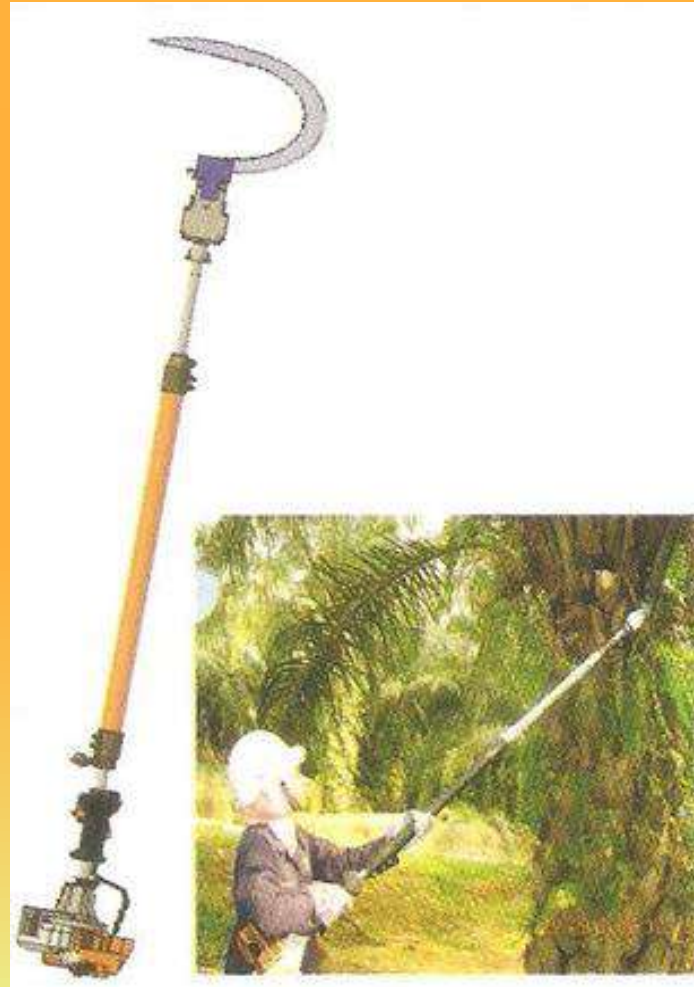
- For cutting FFB at 2-5 meters.

Specifications:

- Engine: 1.3 hp petrol, 2-3 strokes
- Weight: 7.2 kg
- Length of pole: 3.6 (telescopic)
- Petrol: 0.15 liter/hour
- Cutting edge: C-shaped crescent with safety casing

Productivity:

- 700-1000 bunches a day
- Labor reduction = 2-3 person.



Harvesting Technologies (MPOB)

Motorized Chisel

(MPOB TT No.409)

- It uses chisel tool to cut the palm oil bunches and prune the leaves of palm trees of <2 meters

Specifications:

- Engine: petrol (2 strokes)
- Displacement: 25.4cc
- Weight: 5.0 kg
- Length: 1.5m

Productivity:

- 80 bunches per hour / person



Harvesting Technologies (MPOB)

Mechanical Harvester

(MPOB TT No.217)

- Harvests FFB at height 6-10 m
- Cuts, carries and unloads FFB to the roadside.

Specifications:

- Engine: 31.5 hp water cooled
- Moving speed: 4km/hour
- Slope ability: 30° or less
- Cutting height: 6m-10m
- Maximum load: 500kg

Productivity:

4–6 ton FFB/day and 80-100 hectares/machine



In-field Transportation (MPOB)

Compact Transporter

(MPOB TT No.316)

- It transports bunches along narrow terrain areas

Specifications:

- Dimension: 1.8m X1.2 M
- Tyre size: 2.25-17
- Weight: 40kg
- Maximum load: 250kg
- Motorcycle capacity: 70 cc

Productivity:

- 3-5 ton FFB/day



In-field Transportation (MPOB)

The Grabber

(MPOB TT No.3)

- The arm is mounted on the tractor and it uses a three-blade clamp to grab/hold the bunch.

Specifications:

- Mini tractor 25-35 hp
- 3-blades clamp on mechanical sleeve.

Productivity:

- 20-30 ton FFB/day



Loose Fruitlets Collection (MPOB)

Loose Fruitlets Collector

(MPOB TT No.57)

- The suction mechanism is installed on the three-wheeler to suck in the loose fruitlets

Specifications:

- Engine: 6hp diesel- air cooled
- Holding capacity: 30kg
- Dimensions: 2270 x1160 x750mm

Productivity:

- 1400kg-1700kg / day (3 labors)



Loose Fruitlets Collection (MPOB)

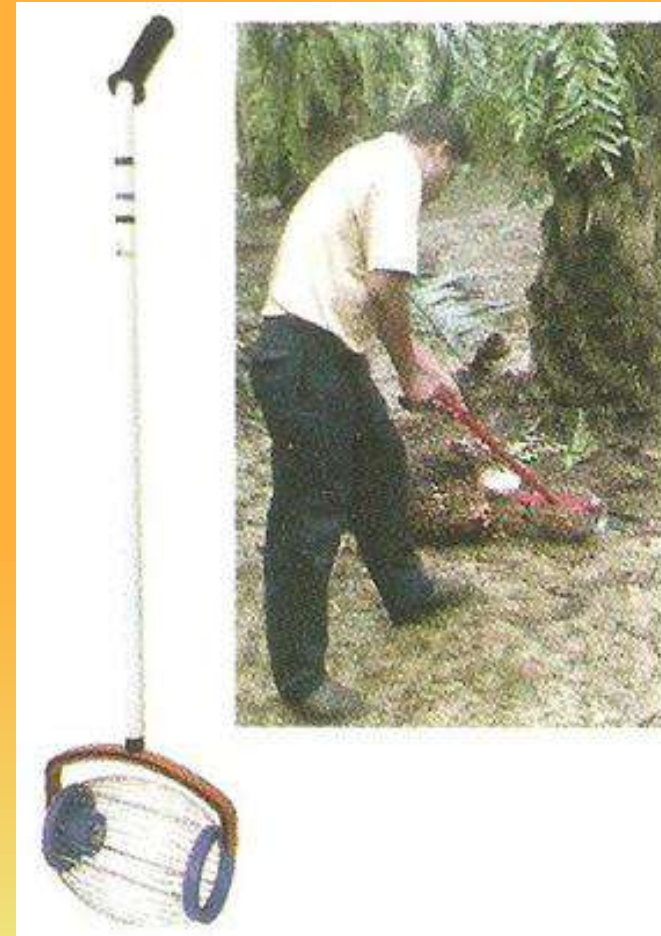
Loose Fruitlets Collector

(MPOB TT No.419)

- By pushing the collector wheel, the fruitlets enter through the flexible crevices of the rod.

Productivity:

- 30-60 kg of palm fruitlets collected per working hour depends on the soil surface



Loose Fruitlets Collection (MPOB)

Loose Fruitlets Separator

(MPOB TT No.257)

- It separates fruitlets from the garbage and can be operated as a moving or stationary unit.

Specifications:

- Engine: 6hp diesel- air cooled
- Dimension: 2800 X1100 X1600mm
- Fan: twin type 6 blades (1600rpm)
- Wind velocity: 10 m/s

Productivity:

- 1 ton /hour
- 97% clean



Motorized Injector (MPOB)

Motorized Injector.

(MPOB TT No.215)

- A tool for injecting liquids or chemicals into the palm stem e.g. to control Ganoderma

Specifications:

- Drill bit: 10 mm diameter
- Injector nozzle: 12 mm Diameter; 250mm Length
- Power: 1) hydraulic (tractor) and 2) petrol engine

Productivity:

- 40-50 trees/day



**CURRENT
MECHANISATION
PRACTICES IN
OIL PALM PLANTATIONS**

Mechanization in Oil Palm Plantations

- Usage of machines & implements (adapted to local terrain conditions) depends on:
 - Land size
 - Terrain conditions
 - Management preferences
 - Economic returns
- Approach varies from plantation to plantation
- Focus is on Infield transportation of FFB

(Source: Rahim et al.. MPOB, 2010)

Oil Palm Harvesting

The harvesting operations comprise:

- Cutting fronds and ripe bunches
- Rearrange & stacking fronds and trim bunch stalk
- Collecting harvested bunches and loose fruitlets
- Transport bunches to hopper or mill

(Source: Kulim (M) Berhad, 2012)

Harvesting Operations (Both Manual and Mechanized)



(Source: Kulim (M) Berhad, 2012)

Mechanized Cutting Operation



- Motorized cutters developed by MPOB are widely used

(Source: Kulim (M) Berhad, 2012)

Tall Palm Harvesting



- Machines evaluated so far were unsuitable

(Source: Kulim (M) Berhad, 2012)

Collection of Loose Fruitlets



- Machines developed were not adopted

(Source: Kulim (M) Berhad, 2012)

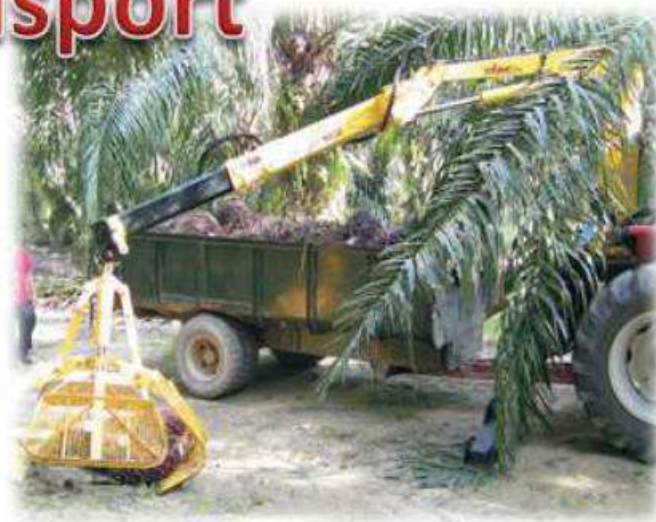
In Field Transportation



- Technologies are matured.
- Selection is based on:
 - a) Types of work,
 - b) Terrains,
 - c) Productivity,
 - d) Machine CapEx & OpEx

(Source: Kulim (M) Berhad, 2012)

Mechanization in Mainline Loading & Transport



tested and proven...

(Source: Kulim (M) Berhad, 2012)

United Plantations: Leader in Mechanization



Buffalo assisted method

United Plantations: Leader in Mechanization



Mechanization at Sime Darby Plantation

Harnessing skills and competency with technology



Harnessing skills and competency with technology



Skilled workers + Machines + System = Productivity & Less labor

(Source: Sime Darby 2012)

Mechanization at Sime Darby Plantation

Harnessing skills and competency with technology

Compost and fertilizer application

Local skill workers are operating these machines and systems



Harnessing skills and competency with technology

Herbicide/pesticide spraying



Productivity between 15–20 ha per day

(Source: Sime Darby 2012)

Mechanization at Sime Darby Plantation

Harnessing skills and competency with technology

• Field upkeep and maintenance



Harnessing skills and competency with technology

• Other mechanical equipment



Skilled workers + Machines + System = Productivity & Less labor

(Source: Sime Darby 2012)

THE FUTURE IN OIL PALM MECHANISATION

Objectives to Migrate from Conventional Mechanization to Modern / Robotic Assisted Mechanization System

- Overall reduction of labor usage and to break away labor dependent operations.
- To improve and enhance skills of labors in the industries to increase individual output and overall reduction of production cost
- To reduce number of equipment and mechanization tools (conventional) which will reduce upkeep cost and costly inventory in the long run.
- To reduce flood incidents within the plantation which reduces the effectiveness of mechanization system within the plantation.
- To increase effectiveness of fertilizer application and reduce wastage / application cost.
- To increase effectiveness of pest and disease control operations within the plantation

Objectives to Migrate from Conventional Mechanization to Modern / Robotic Assisted Mechanization System

- To increase quality of plantation produce delivered to processing plant in terms of freshness and ripeness
- To reduce dependency on fossil fuel run plantation machinery, in big numbers
- To reduce hard labor and improve skill level of labor force
- To standardize plantation activities and to produce constant desired results
- To create effective control over plantation activities
- Overall to improve production activities with minimized cost with the help of modern technology and break away from hard labor dependency
- To create good will among the plantation community and the environment

Advantages of Drone in Palm Oil Planting

1) Precision Planting

- Excellent opportunity for precision farming making full use of remote sensing and DEM.
- Auto-count palm oil plants
- Create density maps that (reveals uneven planting)
- Overlay with soil type maps
- Improve implementation mechanization system in the field
- Improves maintenance of infrastructure and upkeep cost of the facilities
- Provide value for plantations besides speeding up the processes of tree counting to forecasting yields
- Drone technologies can generate precise locations to eliminate empty spots.(More density, more yield result)

Advantages of Drone in Palm Oil Planting

- Provide precise terracing ; calculates accurately the volume of trees and estimates their heights.
- Designing plantation land :
 - i. able to create digital elevation models in 3D and clear view of slopes and contours before starting the earth works
 - ii. Company tablet equipped with GPS in bulldozers and easy terracing can be done (speeds up the process + 5% more trees can be planted on the hills)

RESULT:

- *Organized terrain for higher planting density for peat soil (162 palms per ha) and shallower soils (146 palms per ha). Thus it improves the total output of FFB from a particular planted area with reduce cost of operations.*

Advantages of Drone in Palm Oil Planting

2) Precision Irrigation

- Excellent opportunity for digital elevation maps (DEM)
- Determine the flow of water
- Identify areas prone to floods
- Map out the drainage area
- Redesign FFB harvesting and increase output

RESULT:

- *Conventional plantation design and upkeep can be drastically improved and made more productive with the use of modern technologies such as the drone usage.*
- *Redesign irrigation & drainage system to feed into areas most prone to dry spells and low FFB yield. Research has shown that yields can be increased by 20% by improving irrigation in areas prone to dry spells. Rainfall can be stored in basins for later use.*

Advantages of Drone in Palm Oil Planting

3) Track & Manage Diseases

- Ganoderma and Rhino Beetles affect large proportions of plantations and cause reduced FFB yields
- Aerial Normalized Difference Vegetation Index (NDVI)can be used to monitor:
 - State of plants
 - Plants in distress
- Timely identifying affected plants and managing diseased zones is crucial:
 - Isolation trenching, ploughing, clearing, burning and fallowing
- Determine exact locations of affected areas with a “click of a mouse”
- Deploy ground teams for closer inspection
- Infected tree detections, enable more targeted treatment instead of mass spraying

RESULT:

- *Disease spreading is under control, damage is reduced and yield is increased*

Advantages of Drone in Palm Oil Planting

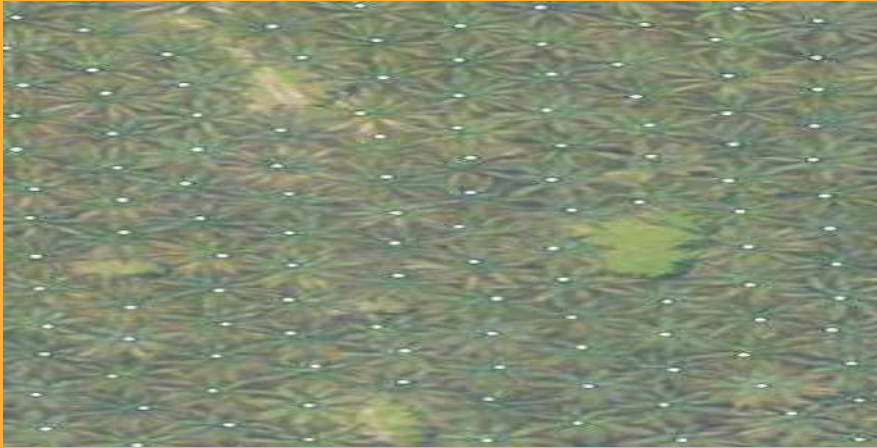
4) Precision Fertilization

- 60% to 70% of cost in growing Palm Oil FFB is related to fertilizers
- Aerial NDVI can be used to monitor:
 - State of plants
 - State of growth (size and healthy status)
 - Identify dry plants or plants in distress
- Focusing on area of reduced growth in order to maximize efficiency of fertilization
- Determine exact locations of fertilization areas using the web portal
- Pesticide/ fertilizer spraying - Spraying of 1 hectare can be done in 20 minutes, 100 times faster than trunk injections
- Improved application efficiency
- Redesign fertilizer application process
- Reduced manpower

RESULT:

- *Significant decrease in fertilizer/nutrient capital and application costs*

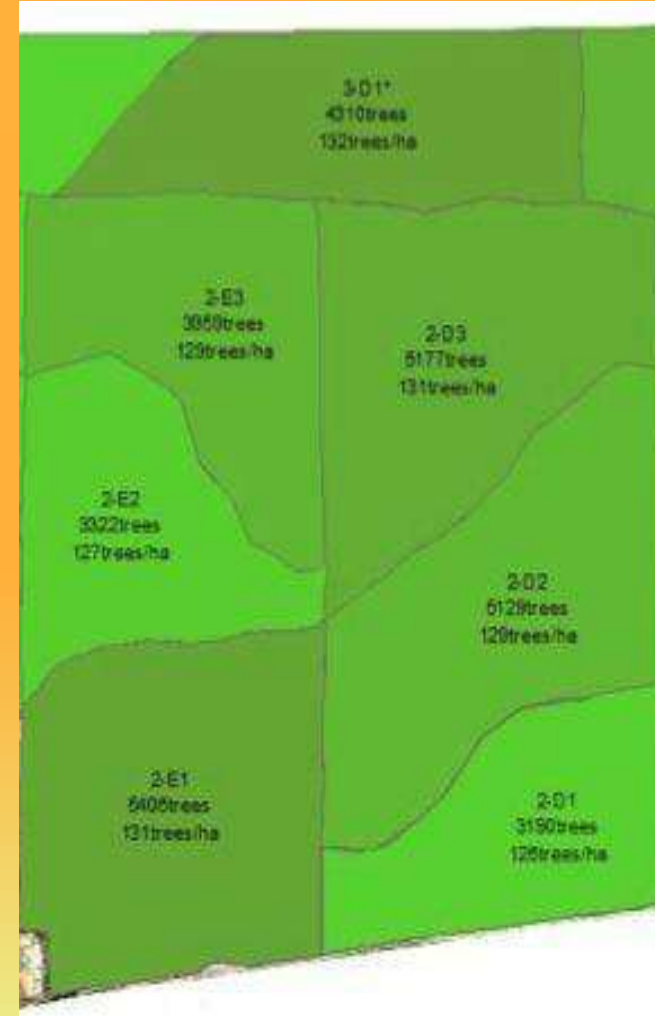
Tree Counting and Soil Types Segregation



Tree counting

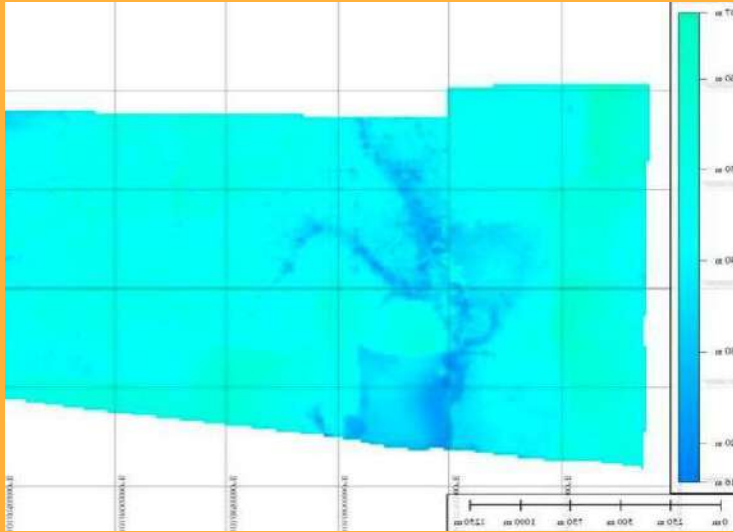


Plant according to soil types

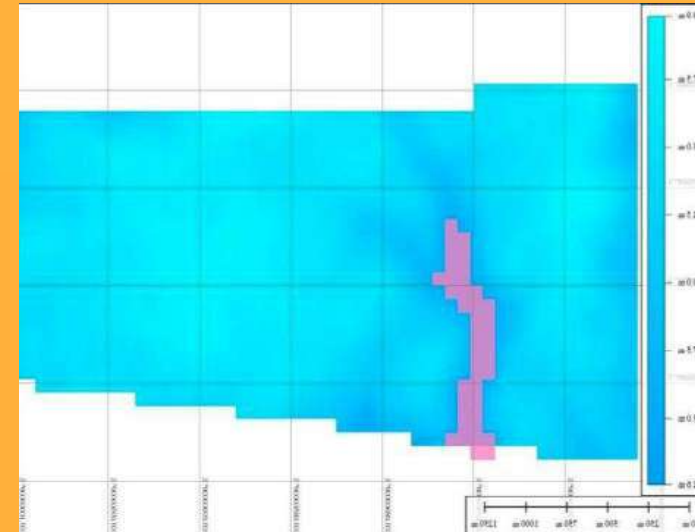


Create density map

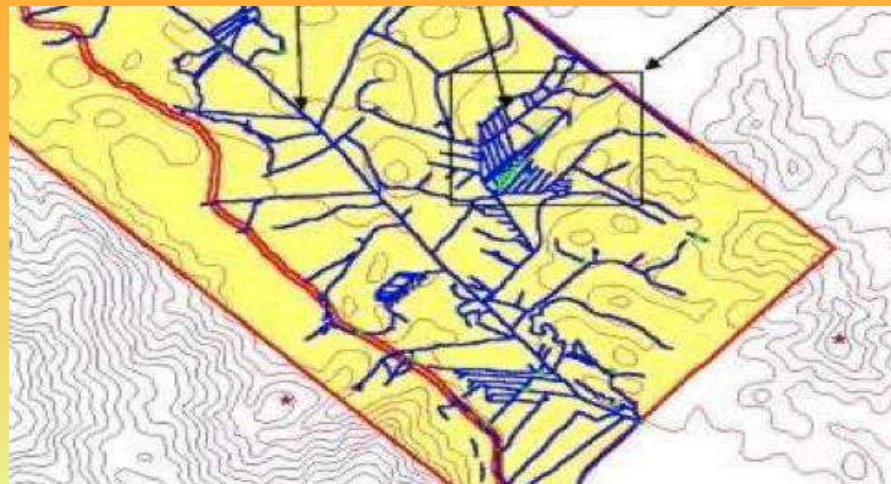
Advantages of Drone Usage in the Plantation



Digital elevation map



Identify flood prone area



Redesign irrigation activities

Instant Advantages of Using Drones in the Oil Palm Plantation



Fertilization spraying using drone

Frontier Mechanization by Sime Darby Plantation – Sharing Experience

- The world's biggest publicly listed palm-oil producer undertakes joint mechanization R&D with MPOB, UPM, etc.:
 - To improve productivity with less labor force
 - To ease field work,
 - To improve plantation activities efficiency
 - To improve labor performance
 - To harness skills & competency with technology
- **Sime Darby Plantation VISION 2025 - [Video](#)**

FFB Grabber-Loader (R&D with MPOB)



In-field machinery paths and engineering infrastructure are required

Loose Fruitlets Collector-Loader (R&D with MPOB)



In-field machinery paths and engineering infrastructure are required

Using Drone in Field Operations (R&D with Univ. Putra Malaysia)



GPS, GIS and IoT equipment / facilities are required

Auto Guided Oil Palm Planter by using multi-GNSS – R&D by UPM

The 5 steps in Multi-GNSS (Global Navigation Satellite System)

- Design planting pattern
- Determine boundary coordinate of planting area
- Geo-reference with ArcGIS
- Stakeout process with Tracy software
- Marking location with wooden spikes.

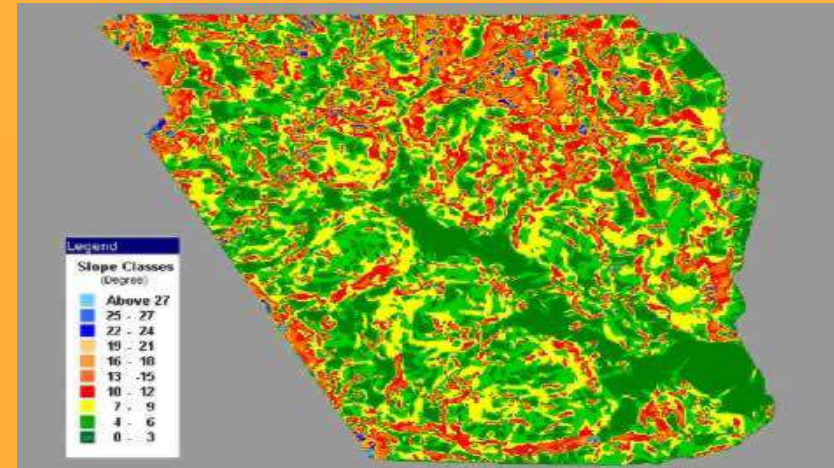
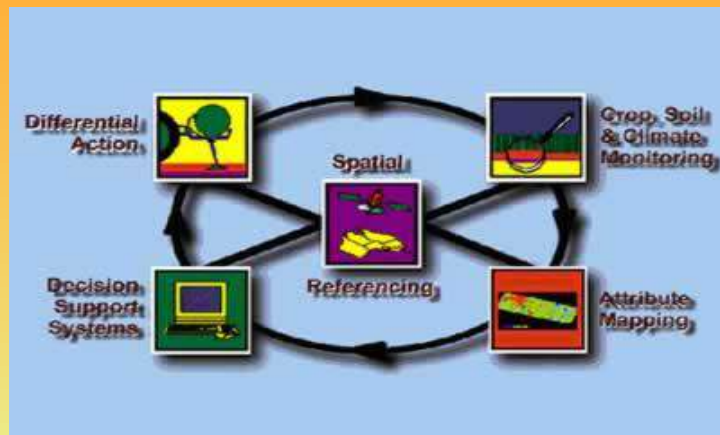


It took one person 290 minutes to complete 70m x 50m planting area –i.e. 25 minutes faster than using GPS

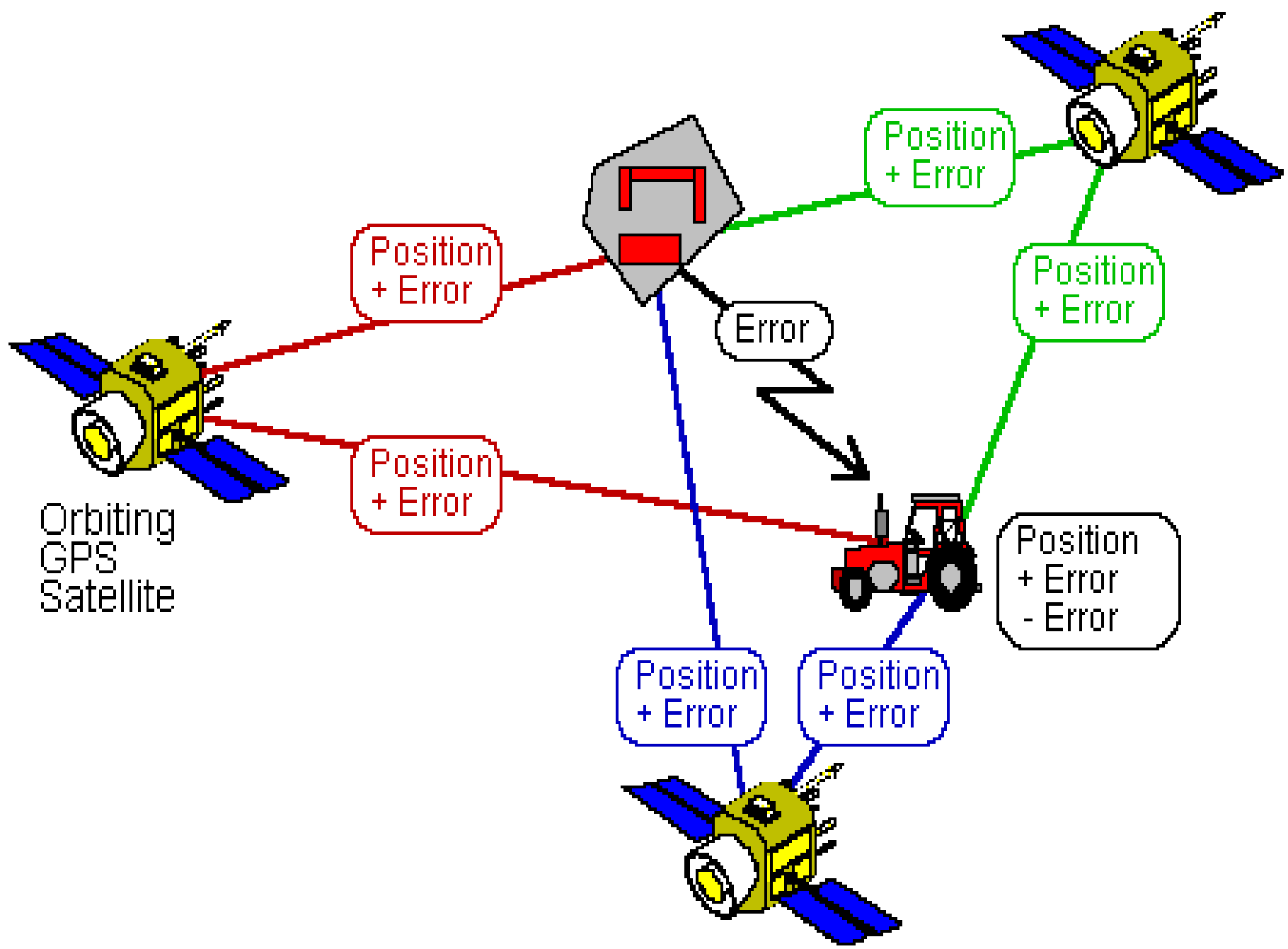
Oil Palm Precision Farming (R&D by AA Resources)

The 5 core activities of Precision Farming (PF):

- Measuring variability
- Analyzing variability
- Decision-making
- Differential actions
- Assessment of results



Tools & technologies associated with PF have been widely utilized. Data loggers, yield monitors, GPS, sensors etc. are fitted on the machines for data collection



Benefits of Precision Farming

ENSURES:

- Efficient & precise application of chemicals & inputs to fertilize the plant and to protect the crop from weeds and pests - i.e. right rates, right places, right timing of applications & done very efficiently

RESULTS IN:

- Improved productivity & product quality
- Reduced wastages due to efficient application of inputs
- Minimal environmental pollution
- Energy conservation

Oil Palm Precision Farming (Findings by AA Resources)



Applicability of PF depends on success of mechanization of field operations and on attitude & readiness of management to change

PF hinges on:

- Advent of information technology (A.I.)
- Affordability of GPS, sensors, yield monitors
- Agronomic knowledge of the crop
- Management strategy and system

Digitalization of Estate Operations (R&D by IJM Plantations)

- Connecting mobile phones with cloud data storage & Internet of Things (IoT)
- Managers obtain real-time data from workers regarding field & crop conditions... for decision making & timely action
- Data on the harvesters' FFB collection is uploaded to computer at estate's office for payment (using Near Field Communication technology)



Summary of Findings

- Application of robots and automation to a variety of field operations is possible. But ***cost effective technologies are yet to be made commercially viable.***
- **REASON** is that robots are unable to operate efficiently and cost-effectively in unstructured, continuously changing conditions & environments
- Need to design and construct **Weather Proof** infield engineering infrastructures & supporting systems to facilitate efficient mechanization, automation & robotic technologies to be applied

Realistic Future In Mechanization

- Develop Mechanization Packages based on Field Conditions & Infrastructures
- Design, construct and maintain weather-proof field Infrastructures to facilitate efficient mechanization
- Adopt and adapt appropriate automation & robotic technologies to replace the mechanization systems

**FUTURE MECHANISATION
OF
FFB HARVESTING**

Selection of Harvesting Systems

- H1, H2 or H3

SYSTEM	DESCRIPTION
H1	Infield FFB collection by wheelbarrows > 60% of the fields are inaccessible to infield machine i.e. narrow/hanging terraces, very hilly & large ravines.
H2	Infield FFB collection by Mechanical Buffalo (MB) > 60% of the fields are wide terraced & accessible by MB
H3	Infield FFB collection by MTG (Mini Tractor/Grabber) > 60% of the fields are flat/undulating & accessible by MTG

Note:-

One Harvesting System is applicable in

a) Contiguous block.

b) Economies of scale: minimum H2 = 500ha & H3 = 1000ha

Established Work Methods

Division of Labor (D.O.L) & Division of Earnings (D.O.E)

System	Function	Code	DOL (Duties)	Ratio/Cutter	DOE	TPA	
H1 (Manual – C1R2)	Cutter	C1	Cut FFB and subtending fronds	1.0	3.00	35%	50%
	Carrier 1	R1	Stack Fronds, trims bunch stalks, collects FFB & LF to platform	1.0		32.5%	25%
	Carrier 2	R2		1.0		32.5%	25%
H2 (Infield by Mechanical Buffalo)	Cutter	QC	Cut FFB and subtending fronds	1.0	3.00	35%	50%
	FronD Stacker	QF	Stack Fronds, trims bunch stalks & align FFB	0.5		14%	-
	LFPicker	QL	Collects LF in G-Bags & brings to platform	1.0		29%	50%
	Machine Operator	QM	Collects FFB & unload into 3 mt bins at roadside	0.5		20%	-
H3 (Mini tractor with or without Grabber)	Cutter	QC	Cut FFB and subtending fronds	1.0	2.75	35%	50%
	FronD Stacker	QF	Stacks Fronds, trims bunch stalks & align FFB	0.5		14%	-
	Picker	QL	Collects LF in G-Bags & brings to platform	1.0		29%	50%
	Machine Operator	QG	Collects FFB & unloads into 3mt or 10mt bins at roadside	0.25		12%	-

Targets

- **To complete** harvesting operations for each block in **10 days cycle**.
- To **maintain** harvesting intervals within 10 days and below throughout the year.
- To improve harvesting operations **efficiencies**.
- To reduce future harvesting interval to 7 days or less to reduce cost of loose fruitlets collection.
- **Comment:**
 - *Due to labor shortage, current practices in Malaysia is 15 days harvesting interval and harvesting about 24 ton FFB a year (0.5 ton FFB harvested in a hectare per round) which makes mechanization an important aspect in increasing output and quality.*

One Contiguous Harvesting Block, with sub-blocks.

Task allocation and movement of harvesters:-

- *Ownership*
- *Quality monitoring / Traceability*
- *Supervision – Structured Block Supervision System.*
- *Basis on payment of piece rate works. Eg: pruning, circle raking.*
- *Zero Balance concept.*

How it works ?

- 120 to 160 palms per task
- Coastal (Flat) = 4/6 rows per task
- Inland (terrace)= 6 rows per task
- Tasks is fixed to the cutter and roll-on to other categories
- All tasks must be numbered.
- If possible indicate task owner, number of palm and arrow for harvesting movement at the task marker.
- On flat area, one person can cut and carry up to 3.5 ha a day (i.e. up to 2.0 ton FFB a day). If he cuts only, he can cover up to 6 ha a day (i.e. up to 3.5 ton FFB a day).

Task No.

Harv.
Movement

Task Size.



What are the Benefits ??

- Enhance supervision – work and crop quality
- Saving in workers transportation – travelling between task nearer.
- Increase productivity – no waiting and wastage on travelling time.
- Better crop evacuation – crop evacuation more focus to the completed rows to facilitate delivery within 24 hours to the mill to maintain FFA levels at below 3% (for good quality CPO).

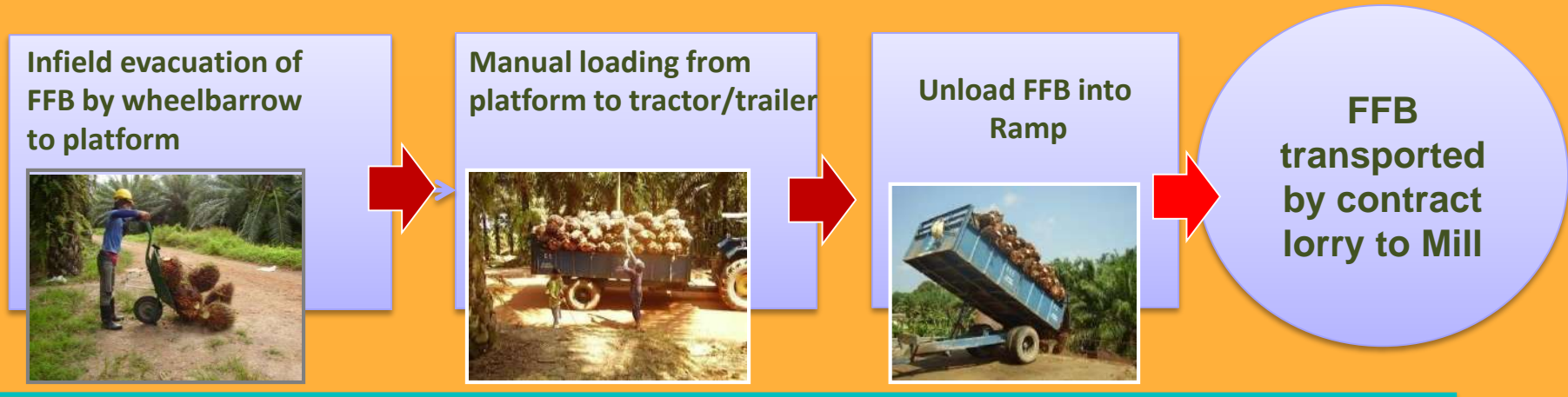
Tasking in Inland Area.

- In inland area, same concept can be applied.
- On terrace area, steepness of terrain and length of terrace need to be taken into consideration in the task allocation.
- Movement of harvesters must be properly organized to ensure better crop evacuation can be carried out.
- All broken terraces must be connected and high embankment (if any) from road to terraces must be leveled to avoid any issues in harvesting operations.

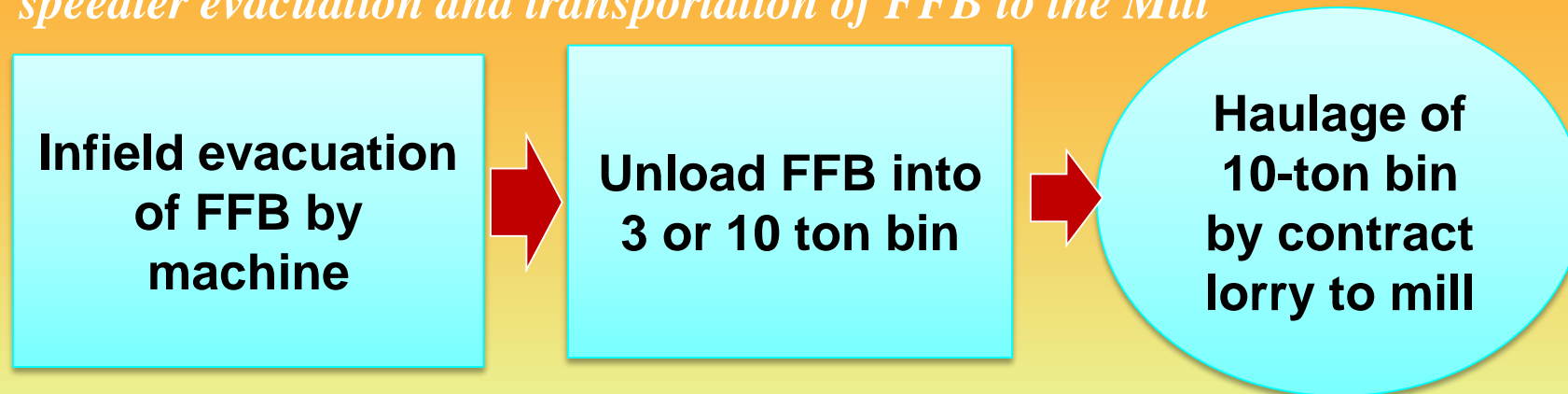
Harvesting Processes & Work Methods

- Migration from Conventional to H1, H2 & H3 Systems

Conventional Process for evacuation & transportation of FFB to Mill



Mechanized Process – integration of infield machine with mainline for speedier evacuation and transportation of FFB to the Mill



H1 System

Hilly & Terraced Mature Areas.



QC- Cut bunches



QC – Cut bunches (sickle)



R1 & R2 – Collect LF. / Stack fronds .trim stalk / bring bunches to platform using wheelbarrow



Platform loading manual / using 3.5m grabber-compact tractor



Unloading FFB into 10t bin



FFB lorry – cw hooklift will load the 10t bin from bin station



10t Bin – Weigh at estate weighbridge



POM

H2 System

Terraced / Undulating Mature Areas (Inland)



QC- Cut bunches



QF - stack the fronds / align FFB



QM - Collect the bunches.



QL - Collect and bag LF



QM-Unload FFB into 3t Bin



Compact Tr. Cw.4t hooklift / Scissor lift - from 3t bin staion



Compact Tr. - unload FFB into 10t bin



FFB lorry - cw hooklift will load the 10t bin from bin station



10t Bin - Weigh at estate weighbridge



POM

H3 System (Coastal)

Mini Tractor c/w 2.8m Grabber/1.0Ton Scissor Lift Trailer
Flat/Undulating Mature Areas (**Two-Tier**)



QC- Cut bunches



QF - stack the fronds / align FFB



QG - Collect the bunches.



QL - Collect and bag LF



QG – Unload FFB into 3t Bin



Compact Tr. Cw.4t hooklift / Scissor lift - from 3t bin staion



Compact Tr. – unload FFB into 10t bin



FFB lorry – cw hooklift will load the 10t bin from bin station



10t Bin – Weigh at estate weighbridge



POM

Pre-requisites of Bins station

- **Factors to be considered**

- Harvesting / Evacuation systems
- Crop Projection
- Bins requirement
- Bins ratio (Hooklift : 1 / Mini-Bins : 5)

- i. Mini bin**

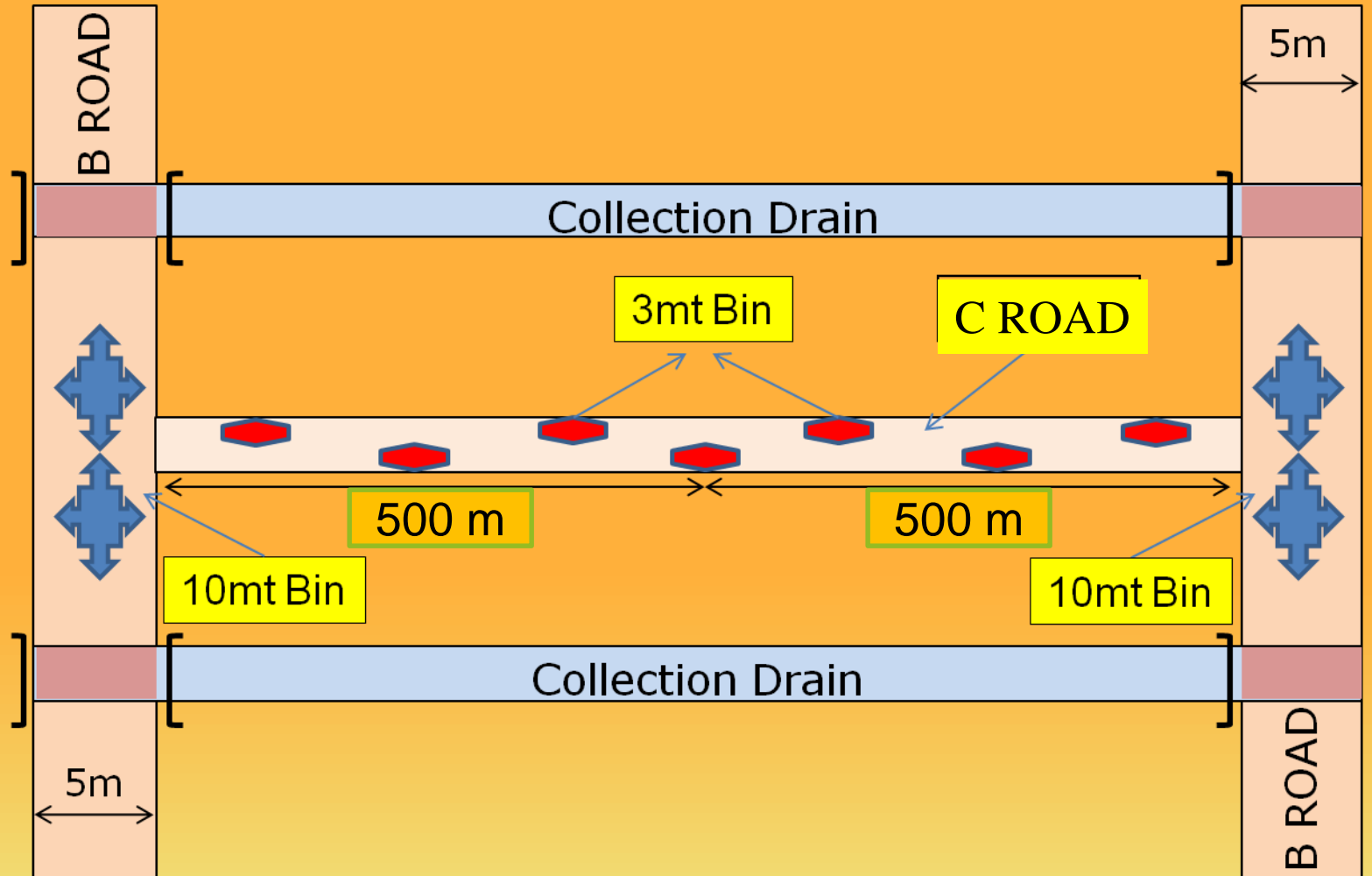
- 1) Marking (Approximately 5 ha/3mt bin) / 120-150m apart
- 2) Bin parking site preparation

- ii. 8/10 mt bin**

- 1) Marking (Approximately 10-15 ha/bin, depends on yield)
- 2) Bin parking site preparation
- 3) Upgrading A road, widening turning point, upgrade bridges/culvert
- 4) Traffic signage – fix additional/appropriate signage.



Roads and FFB Bin Placement Points



BIN PLACEMENT – 3 TON



BIN PLACEMENT – 3 TON



Example of Good / Bad Practices in the Estates



Unsafe and bad road upkeep



Good and effective upkeep

Unsafe Roads

Unproductive hours



Bad upkeep



Good Water Management Practices in the estate (coastal)

- Good Drainage – to prevent crop loss due to flooding.



Yard sticks to monitor water levels

- Irrigation.



Flood pumps to irrigate the fields

Management of Field Drainage is critical for Mechanization

Tractor with
twin tyres

And

Spacer



Dondi-ditcher

Operator's and workers Safety



Unsafe act..



Unsafe tractor



Safe tractor

Good 'A' road



Good 'B' road



All weather motorable roads

Conclusion

- Future in Mechanization is about the development of Mechanization Packages and machinery systems that are based on Field Conditions & Infrastructures as well as on **workers' productivity (income) and crop quality**
- It is about the design, construction and maintenance of weather-proof field Infrastructures for **safe and efficient mechanization**
- Option to create field conditions to suit mechanization usage from the start, could be just very costly in terms of terrain preparations.
- Dependency on hard labor and fossil fuel run machinery must be reduced to maintain sustainable plantations operations.

Conclusion

- Plantations operations must develop a good control over deteriorating weather conditions by utilizing robotic technologies.
- It is about the adoption & adaptation of automation & robotic technologies into the machinery systems to enhance the mechanization packages to increase output, improve quality, improve of safety operations, install food safety, reduce hard labor and reduce production cost.
- Future mechanization plans must also consider environmental issues to achieve sustainable growth and acceptance of the same technologies.

Last But Not Least..

- The drone usage and robotic infusion is also taking place in the palm oil mill construction with many added benefits.
- The details can be discussed in a another forum...



Last But Not Least..



Last But Not Least..



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THANK YOU