

(Invited Talk)

Is Precision Agriculture the Game Changer in Malaysia?

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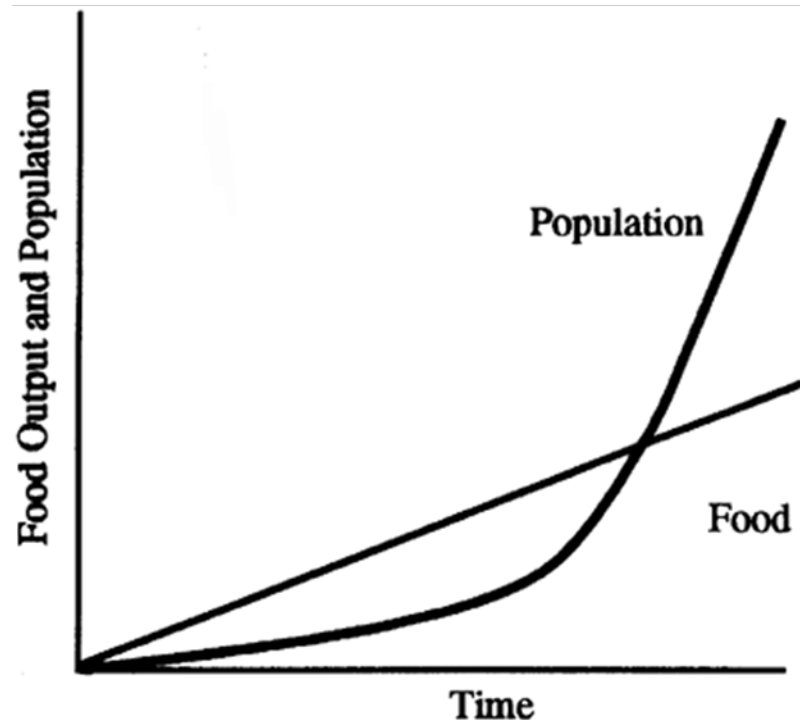
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Was Thomas Malthus correct?



Human population will increase in a geometric ratio (**exponential**) while food production (for human subsistence) will increase in an arithmetic ratio (**linear**)

- *Essay on the Principle of Population* (1798)

Today, after more than 200 years ...

Agriculture is being challenged on two fronts:

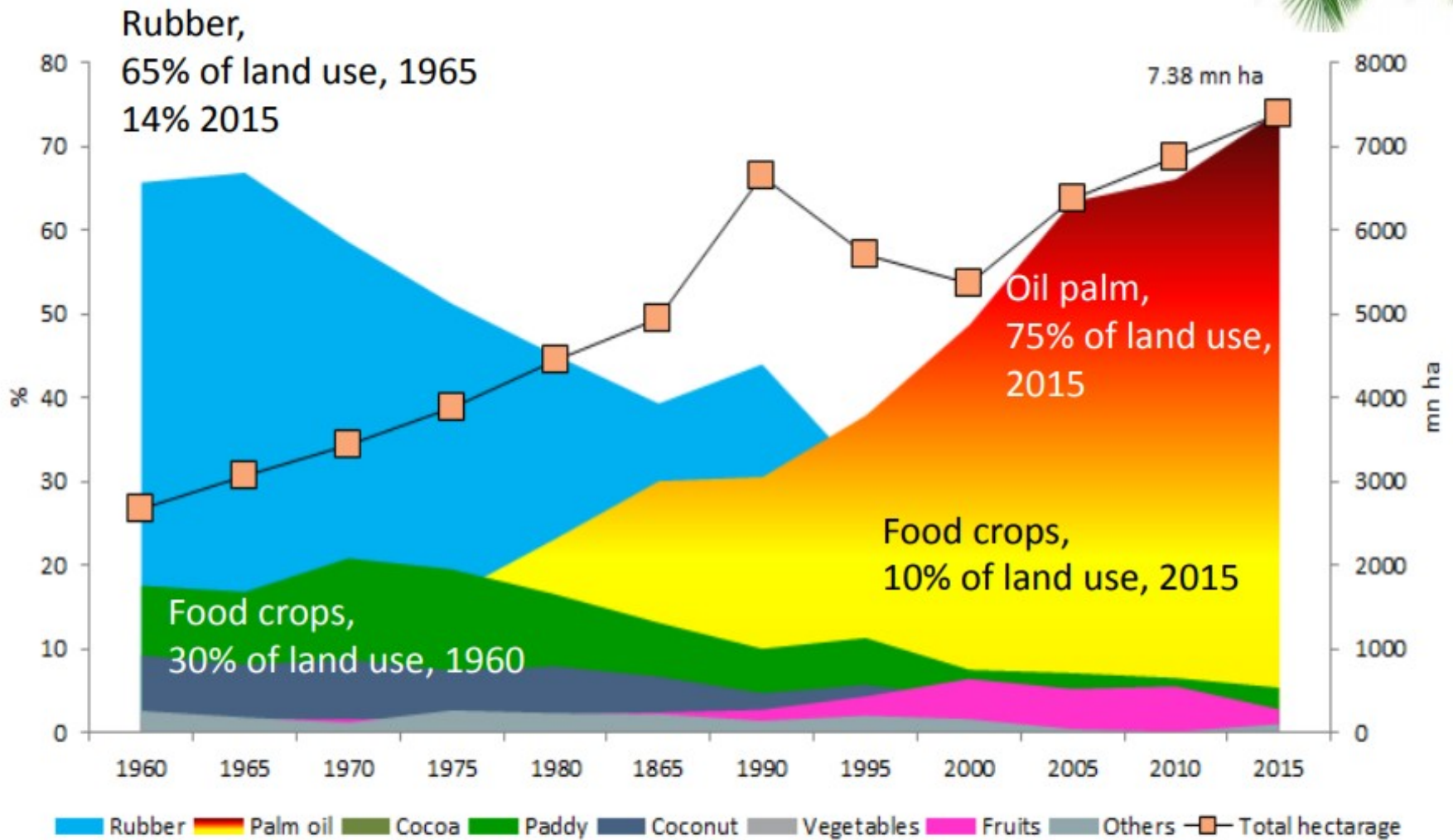
Demand

- Food security
- Population growth
- Growing pressure from biofuels
- Changing consumption patterns

Supply

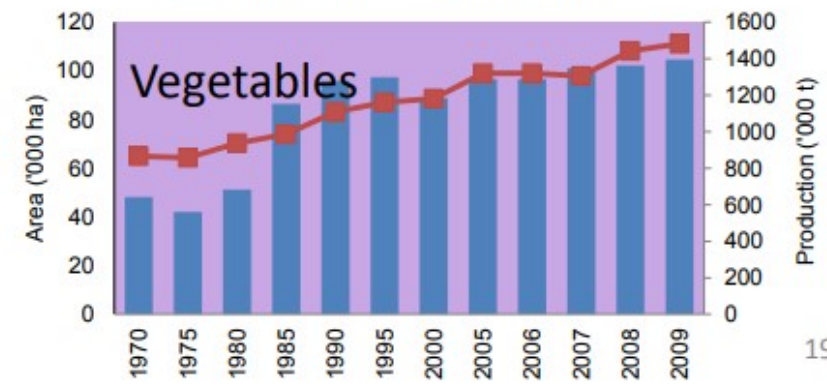
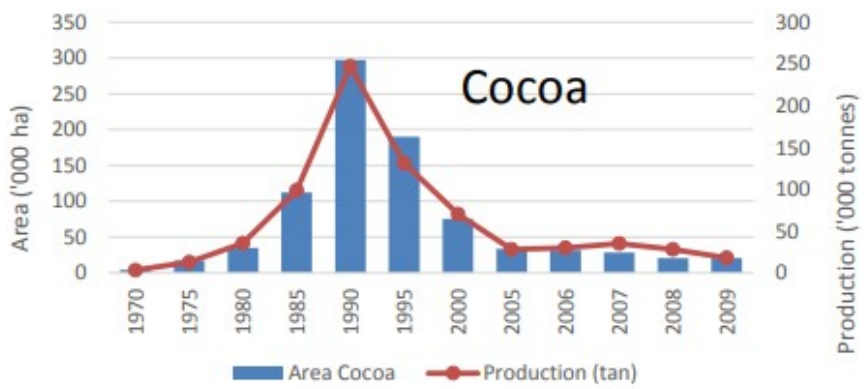
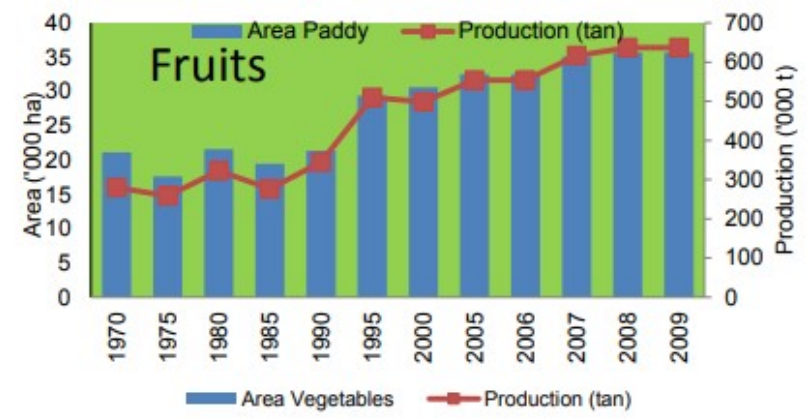
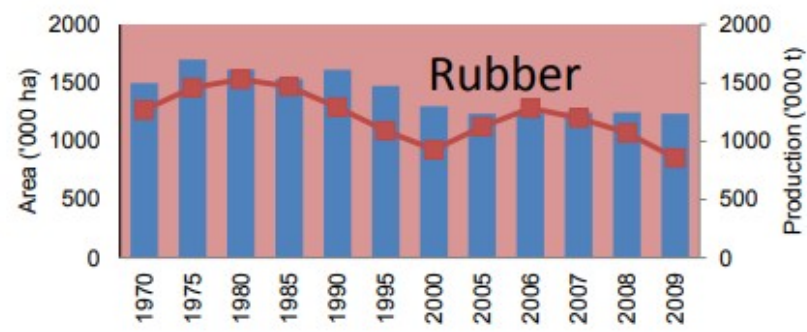
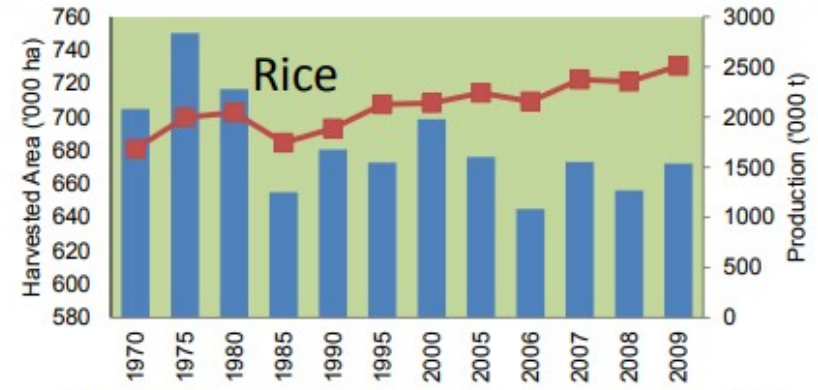
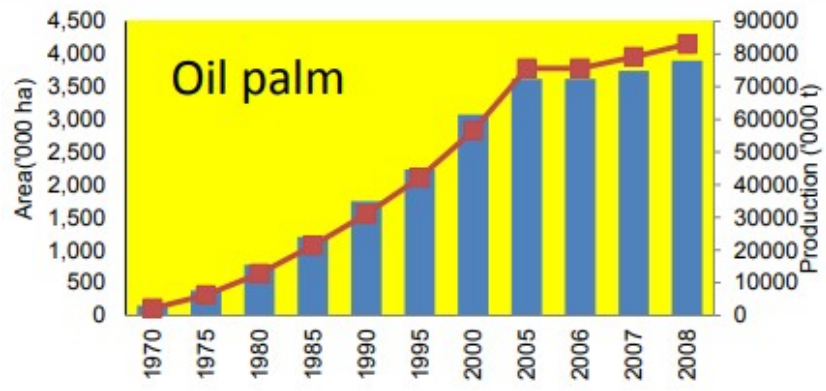
- Limited availability of land, water, mineral inputs and skilled labor
- Climate change
- Pre-harvest and post-harvest losses

Dominant shift towards monoculture (Fatimah, 2018)



Malaysia: Land use by crops (%) and total hectareage (mn ha), 1960-2015

Industrial crops are susceptible to cycles, demand for food is ever increasing (Fatimah, 2018)



Income potential ... (based on 2018 calculations)

A farmer's potential harvest from planting an acre of:-

rubber
RM 4,000



palm
RM 17,500



coconut
RM 37,500



pineapple
(MMD2)
RM 127,500



durian
(Musang King)
RM 156,000

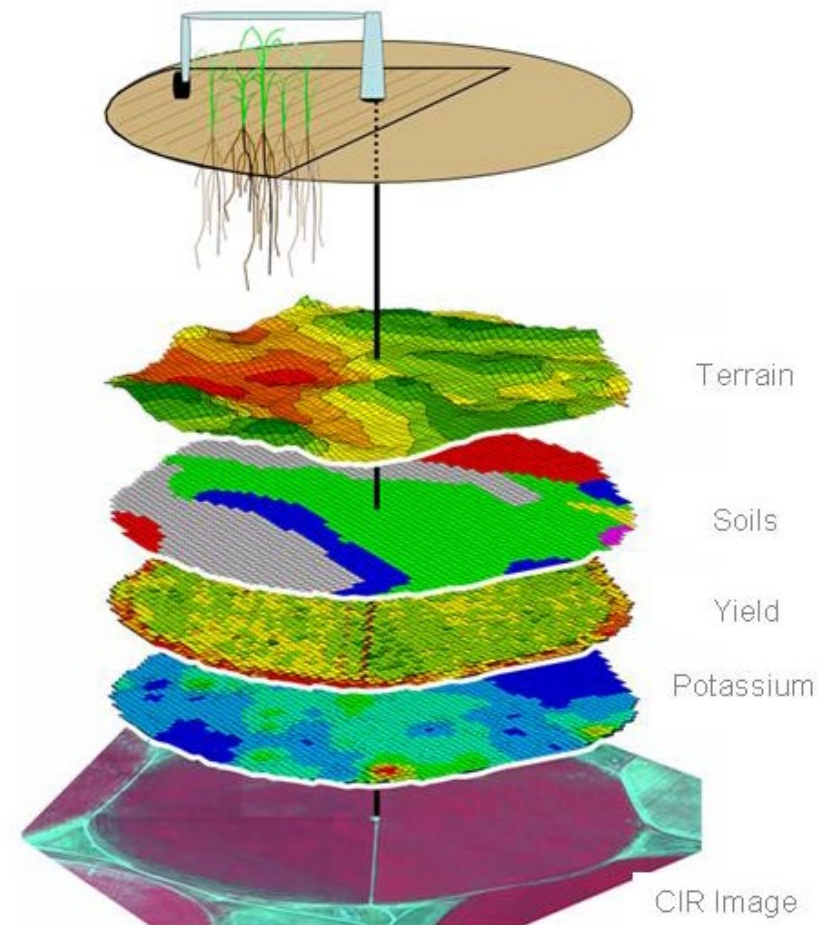


source: Ministry of Agriculture, Malaysia

Precision agriculture

- A management practice applied at the **right rate**, **right time** and the **right place**
- Field sub-region management
 - nutrients
 - drainage/irrigation
 - pests and diseases
 - tillage and seeding

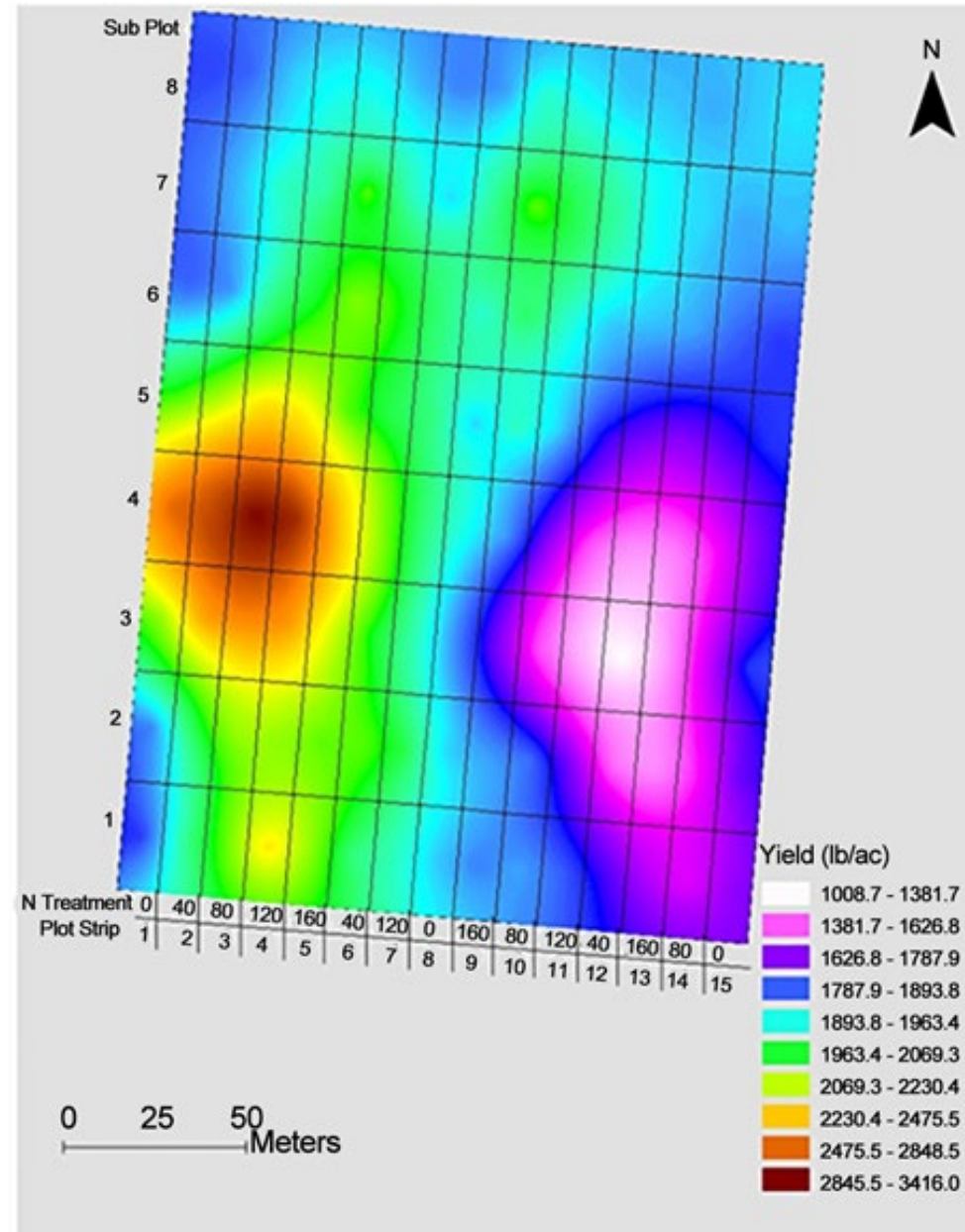
Individual field focus
➔ *spatial variability*
➔ *temporal variability*



Spatial variability

⇒ differences across space/distance

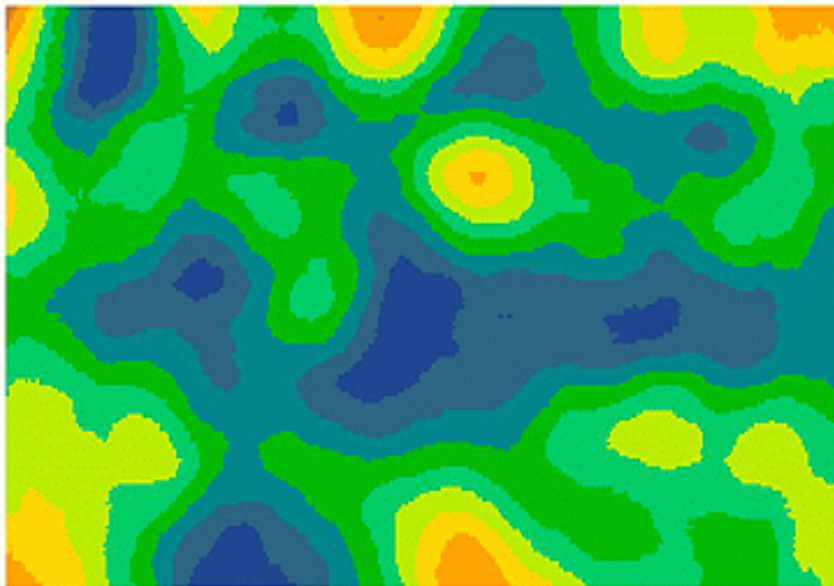
Yin, X. 2016. Geostatistical analyses of field spatial variability of cotton yield. *Journal of Geoscience and Environment Protection*, 4: 75-87



Temporal variability

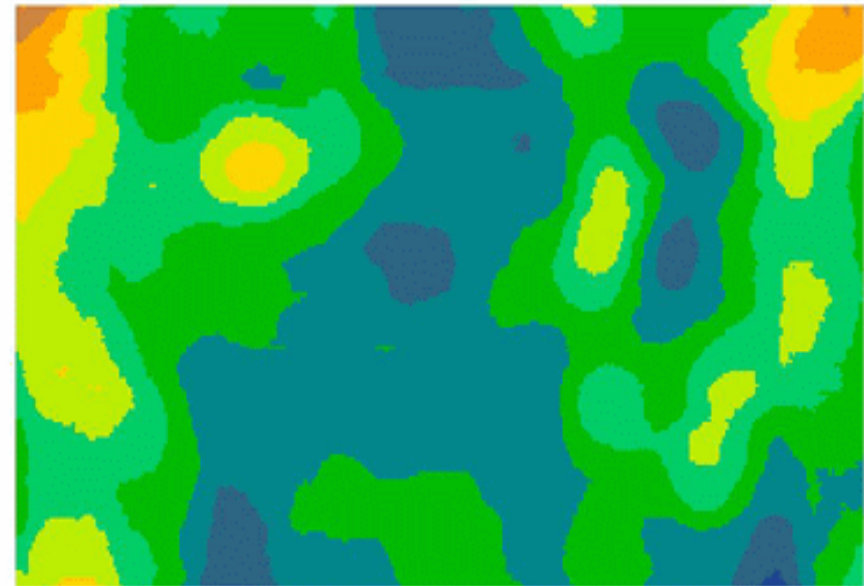
⇒ differences across time/season

Corn grain yield - 1997



Field M1 (30 ac.), Davis-Purdue Ag. Center

Corn grain yield - 1998



Field M1 (30 ac.), Davis-Purdue Ag. Center

High to low



Why is precision agriculture practical?

	Benefit Occurs	No Benefit Occurs
ACT	Correct action	Type II error: Loss caused
DON'T ACT	Type I error: Lost opportunity	Correct inaction

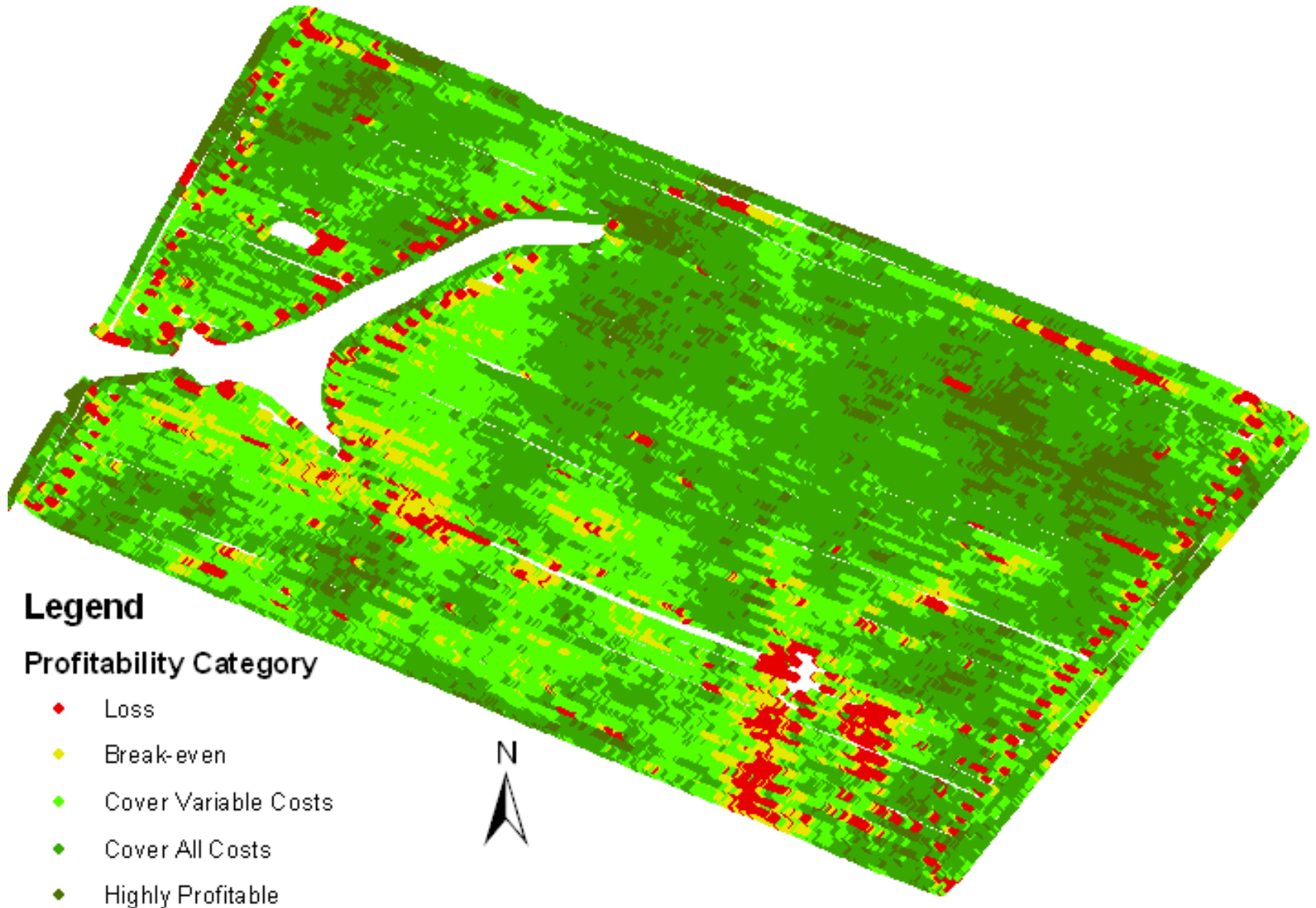
⇒ Precision agriculture minimizes **Type I & Type II errors**

Possible outcomes from using precision agriculture

- ⇒ Higher yield with the same level of inputs
- ⇒ The same yield with reduced inputs
- ⇒ Higher yield with reduced inputs



Mapping out the bottom line!



Key challenge for precision agriculture

□ Technology structure

- Precision agriculture is information-intensive and not embodied knowledge (e.g. hybrid seeds, GMO)
 - ⇒ need to transform precision agriculture into embodied knowledge so that end-users can understand better, without having to understand the complex science behind it

Balasundram, S.K. 2016. Selected precision agriculture studies in oil palm: A 10-year summary. *Revista Palmas*, 37(1): 243-266. (In Spanish)

Technological domain	Scope of investigation	Keywords
Geo-spatial modeling	FFB yields Leaf and soil nutrients Fertilizer trials Soil organic carbon	Spatial variability, management zones, nearest-neighbor analysis, operational zones
Decision support system	Oil yield Oil quality	FFB harvesting, image processing, surface color, degree of bleachability index
Remote and proximal sensing	FFB yields Disease detection Oil quality Stand density	Vegetation indices, spectral reflectance, sensor, geographical information system, Google Earth

Our recent outputs: Crop monitoring

The screenshot shows a web browser displaying a ScienceDirect article. The browser's address bar shows the URL: <https://www.sciencedirect.com/science/article/pii/S2214317317301774>. The page header includes the ScienceDirect logo, navigation options like 'Download PDF', 'Share', and 'Export', and a search bar. The article title is 'A review of neural networks in plant disease detection using hyperspectral data', published in 'Information Processing in Agriculture', Volume 5, Issue 3, September 2018, Pages 354-371. The authors listed are Kamlesh Golhani, Siva K. Balasundram, Ganesan Vadmalai, and Biswajeet Pradhan. The abstract states: 'This paper reviews advanced Neural Network (NN) techniques available to process hyperspectral data, with a special emphasis on plant disease'. The left sidebar contains an 'Outline' section with 11 items: 1. Introduction, 2. Mechanism of neural networks, 3. Major types of NNs, 4. NN models, 5. The NN classifiers, 6. Early disease detection, 7. An overview of two studies on rice (*Oryza sativa* L)..., 8. Challenges of NN, 9. SDi, 10. Future trends: deep learning of hyperspectral data, 11. Conclusion. The right sidebar features 'Recommended articles' and 'Citing articles (10)'. At the bottom, a 'Review Article' section is visible, titled 'Detecting and Monitoring Plant Nutrient Stress Using Remote Sensing Approaches: A Review' by Chong Yen Mee, Siva Kumar Balasundram, and Ahmad Husni Mohd Hanif. The Windows taskbar at the bottom shows the system tray with the date 7/23/2019 and time 1:05 AM.

CV_Siva K Balasundram_April, 2019 (1) [Compatibility Mode] - Word

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Outline

Abstract

Graphical abstract

Nomenclature

1. Introduction

2. Mechanism of neural networks

3. Major types of NNs

4. NN models

5. The NN classifiers

6. Early disease detection

7. An overview of two studies on rice (*Oryza sativa* L)...

8. Challenges of NN

9. SDi

10. Future trends: deep learning of hyperspectral data

11. Conclusion

KeAi CHINESE ROOTS GLOBAL IMPACT

Information Processing in Agriculture

Volume 5, Issue 3, September 2018, Pages 354-371

A review of neural networks in plant disease detection using hyperspectral data

Kamlesh Golhani^a, Siva K. Balasundram^a, Ganesan Vadmalai^b, Biswajeet Pradhan^c

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<https://doi.org/10.1016/j.inpa.2018.05.002> Get rights and content

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Abstract

This paper reviews advanced Neural Network (NN) techniques available to process hyperspectral data, with a special emphasis on plant disease

Recommended articles

A Comparison of Machine Learning Metho...
IFAC Proceedings Volumes, Volume 46, Issue 4, 2...
Download PDF View details

Detection of plant leaf diseases using imag...
Information Processing in Agriculture, Volume 4, ...
Download PDF View details

Smart Farming: Pomegranate Disease Dete...
Procedia Computer Science, Volume 58, 2015, pp...
Download PDF View details

1 2 Next

Citing articles (10)

Article Metrics

Feedback

Review Article

Detecting and Monitoring Plant Nutrient Stress Using Remote Sensing Approaches: A Review

Chong Yen Mee, Siva Kumar Balasundram and Ahmad Husni Mohd Hanif

WILEY

Our recent outputs: Landuse and hydrological modeling

Journal of Water Resource and Protection, 2012, 4, 870-876
<http://dx.doi.org/10.4236/jwarp.2012.410102> Published Online October 2012 (<http://www.SciRP.org/journal/jwarp>)



[Applied Spatial Analysis and Policy](#)

March 2016, Volume 9, [Issue 1](#), pp 1-19



[Environmental Earth Sciences](#)

February 2015, Volume 8, Issue 2, pp 1-19




Journal
[Hydrological Sciences Journal](#)

Volume 59, 2014 - Issue 10

Original Articles

SWAT-based hydrological land-use scenarios

Modélisation hydrologique d'utilisation des sols avec le modèle SWAT

Hadi Memarian, Siva K. Balasundram , Kari Sood

Pages 1808-1829 | Received 17 May 2012, Accepted 14 Aug 2013, Accepted 2014

[Journal of Applied Remote Sensing](#): [Journal Home](#) [Current Issue](#) [All Issues](#)

[Journal of Applied Remote Sensing](#) | [Volume 7](#) | [Issue 1](#) | [Research Papers](#) >

Computers and Electronics in Agriculture 93 (2013) 98-110

Contents lists available at [SciVerse ScienceDirect](#)



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Computers and Electronics in Agriculture

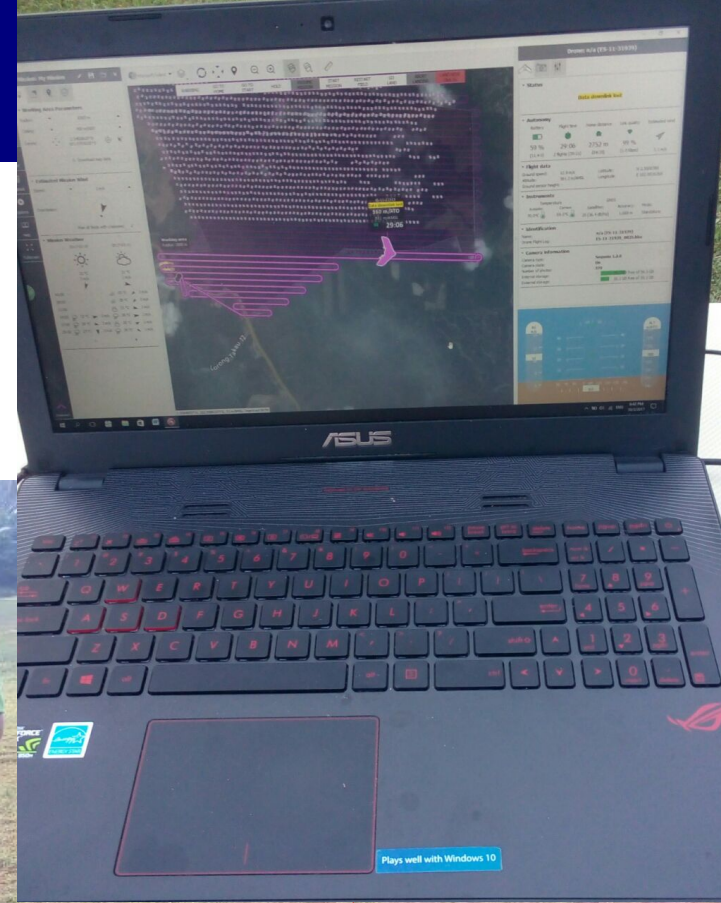
journal homepage: www.elsevier.com/locate/compag

Agriculture Land Suitability Evaluator (ALSE): A decision and planning support tool for tropical and subtropical crops

Ranya Elsheikh^a, Abdul Rashid B. Mohamed Shariff^a, Fazel Amiri^{a,b,*}, Noordin B. Ahmad^c, Siva Kumar Balasundram^d, Mohd Amin Mohd Soom^e

Our ongoing work

Monitoring of **oil palm stress** using drone technology (mounted with an **NDVI sensor**)

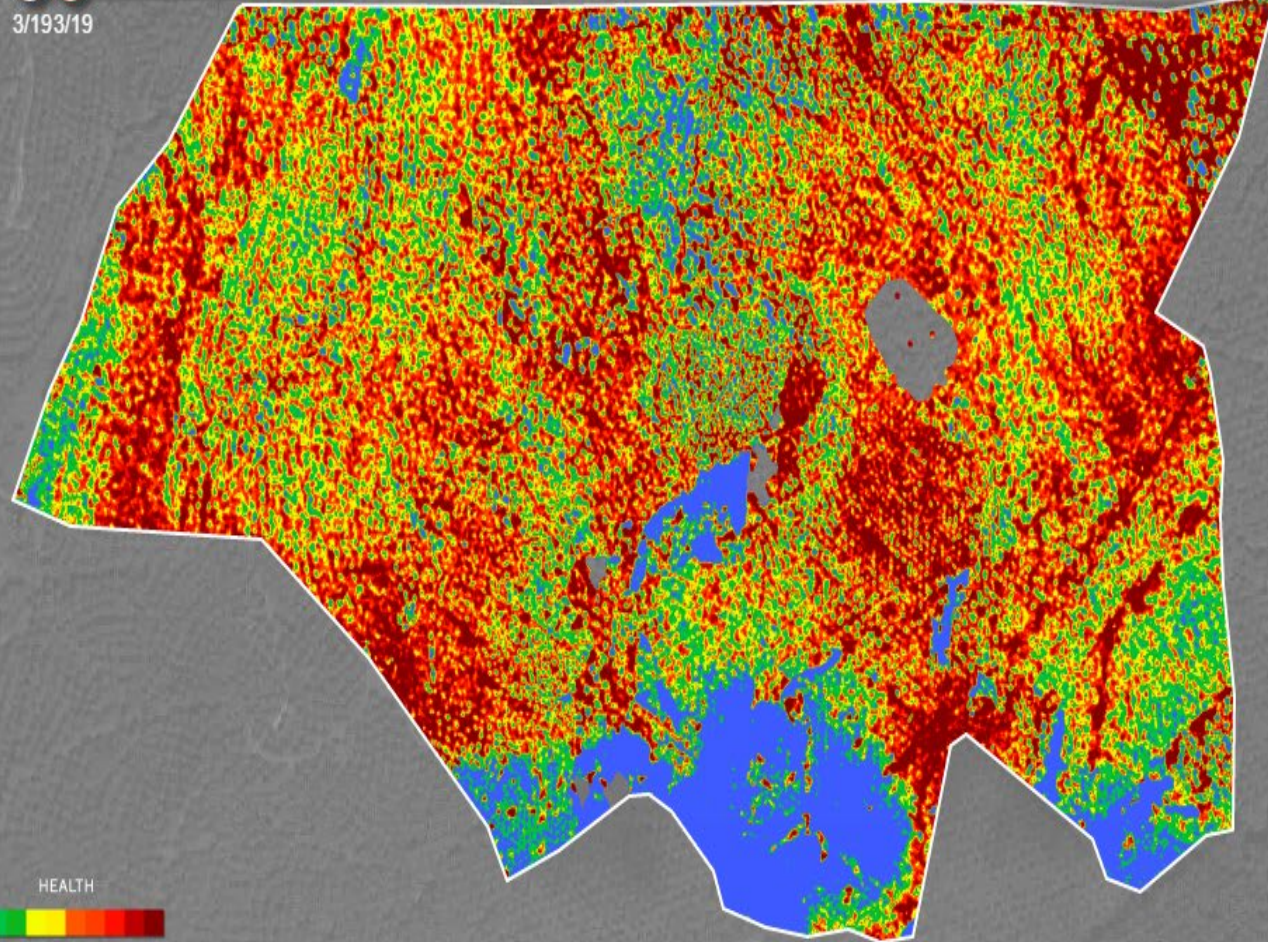


Send a scout Order service

Impact Report



3/193/19



HEALTH
MORE LESS

Flight data uploaded.
3/19/2017

Flight order accepted.
We will notify you when
to send a scout.
3/19/2017

Flight order submitted.
Please wait while we
process your order.
3/19/2017

Flight data uploaded.
3/19/2017

Flight order accepted.
We will notify you when
to send a scout.
3/19/2017

Stress factors under investigation:

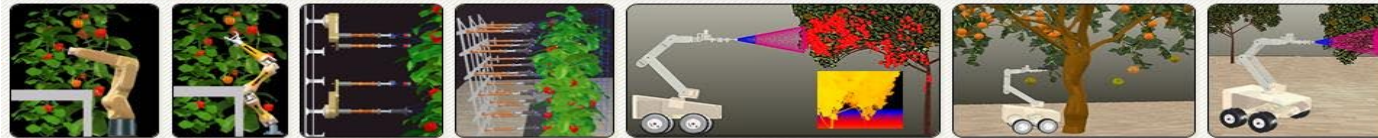
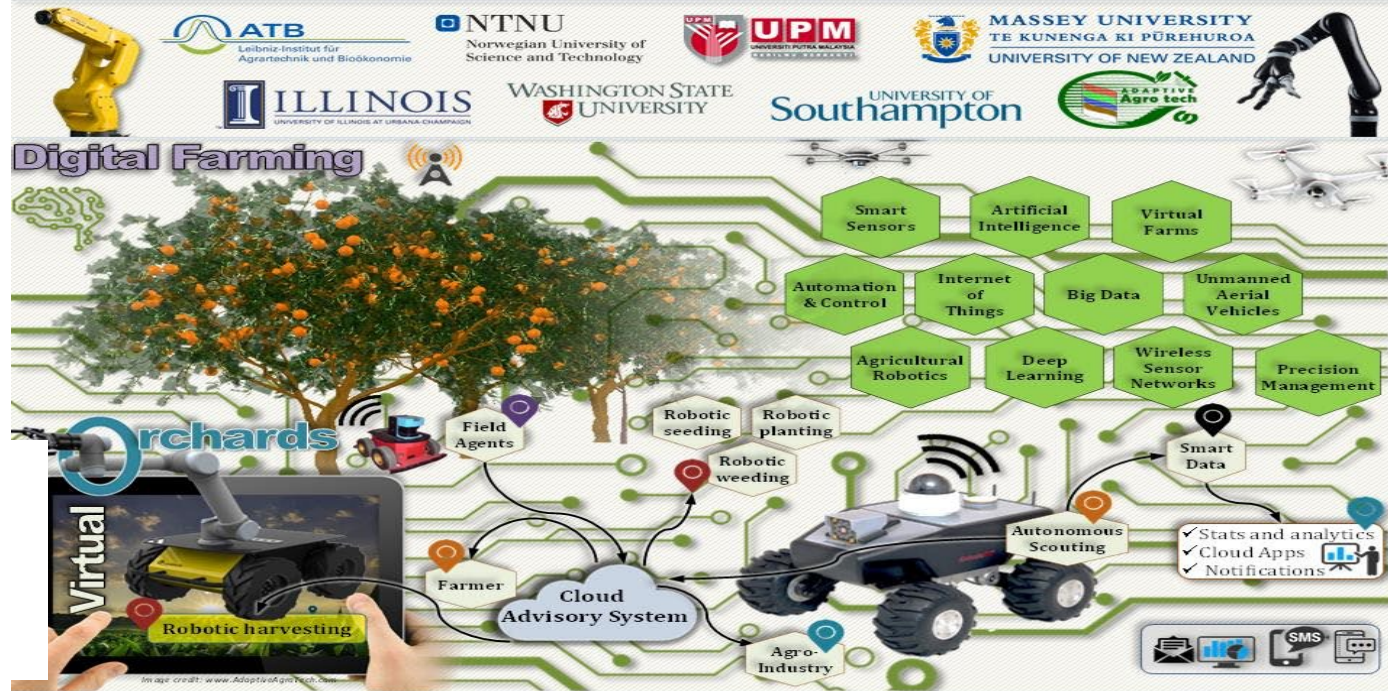
- ◆ nutrient imbalance
- ◆ pest infestation
- ◆ water flow

Robotics for Agriculture, Acceleration by simulation

An international collaborative research

Our ongoing international collaboration

Digital farming for citrus orchards



Selected publications

1. Shamshiri, R. R., Weltzien C, Hameed, I. A., Yule I. J., Grift T. E., Balasundram S. K., Pitonakova L., Desa A., and G. Chowdhary. 2018. Research and Development in Agricultural Robotics : A Perspective of Digital Farming. *Int. J. of Agric & Biol Eng.* 11 (4): 1–14. doi:10.25165/ijabe.20181104.4278. Q2. IF:1.267 (Invited) [PDF]
2. Shamshiri, R. R., Hameed I. A., Pitonakova L., Weltzien C, Balasundram S. K., Yule I. J., Grift T. E., and G. Chowdhary. 2018. Simulation Software and Virtual Environments for Acceleration of Agricultural Robotics : Features Highlights and Performance Comparison. *Int. J. of Agric & Biol Eng.* 11 (4): 15–31. doi:10.25165/ijabe.20181104.4032. Q2. IF:1.267 (Invited) [PDF]
3. Shamshiri, Redmond R., Ibrahim A. Hameed, Manoj Karkee, and Cornelia Weltzien. 2018. Robotic Harvesting of Fruiting Vegetables: A Simulation Approach in V-REP, ROS and MATLAB. INTECH: *Automation in Agriculture-Securing Food Supplies for Future Generations*. Page 81-105. ISBN: 978-953-51-3874-7. DOI: 10.5772/intechopen.73861 [PDF]

Talks and visits

- Robotic Harvesting of Fruiting Vegetables: "Acceleration by Simulation". [Acceleration workshop, Glas-40](#) (Invited as keynote speaker). 11-12 Sep, 2017. TU Delf, The Netherlands" [Video][Presentation]
- Leibniz Institute for Agricultural Engineering and Bioeconomy, Potsdam, Germany, Feb 2018-Aug 2018
- Wageningen UR, Plant Research International, The Netherlands, Aug 2015-Feb 2016
- 2nd live demo of sweet pepper harvesting robot, Proefstation voor de Groenteteelt in Sint-Katelijne-Waver, Belgium, September 12th, 2018

International Contributors



Redmond R. Sh.
AdaptiveAgroTech



Dr. Cornelia Weltzien
ATB, Germany



Dr. Siva K Balasundram
UPM, Malaysia



Dr. Ibrahim Hameed
NTNU, Norway



Dr. Ian Yule
Massey Univ, NZ



Dr. Tony E. Grift
UIUC



Dr. Girish Chowdhary
UIUC



Dr. Lenka Pitonakova
Univ of Southampton



Dr. Manoj Karkee
Washington State



Key areas for further work

1. Crop nutrition

- Nutrient balance index

2. Pest and disease control

- Early detection in a non-destructive way

3. Harvesting/Crop recovery

- Optimum ripeness detection protocol
- Optimized quality

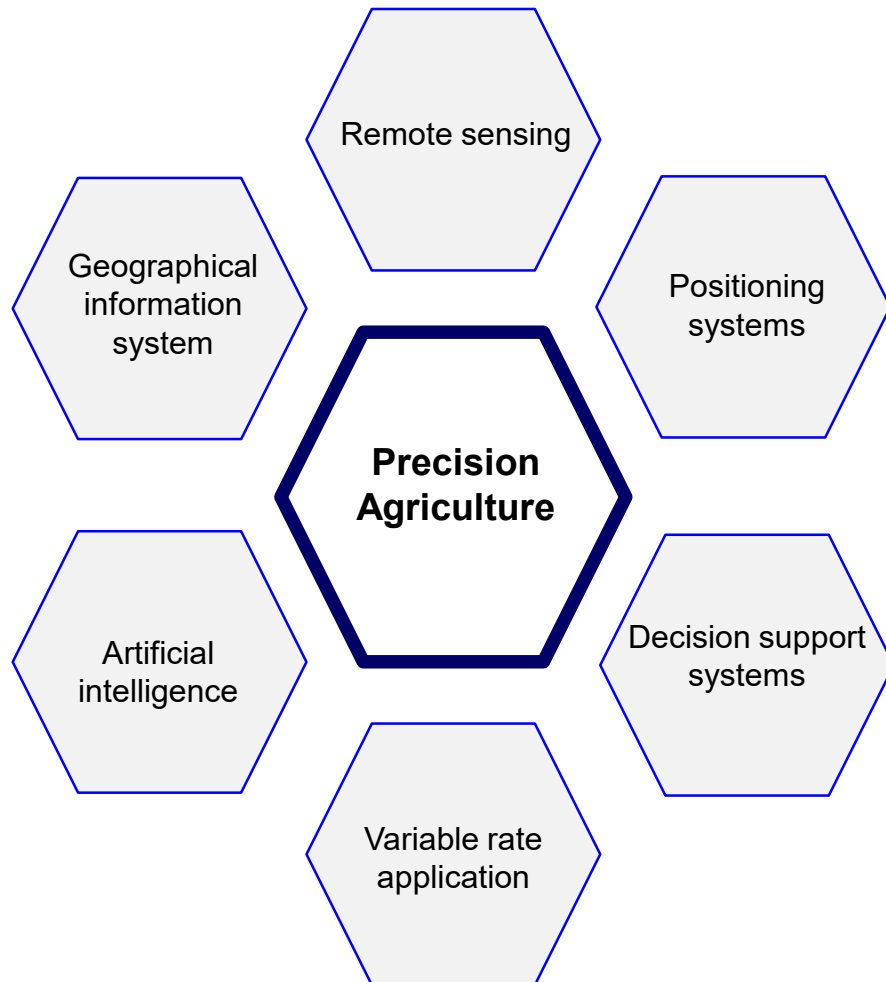


Other areas that require further work

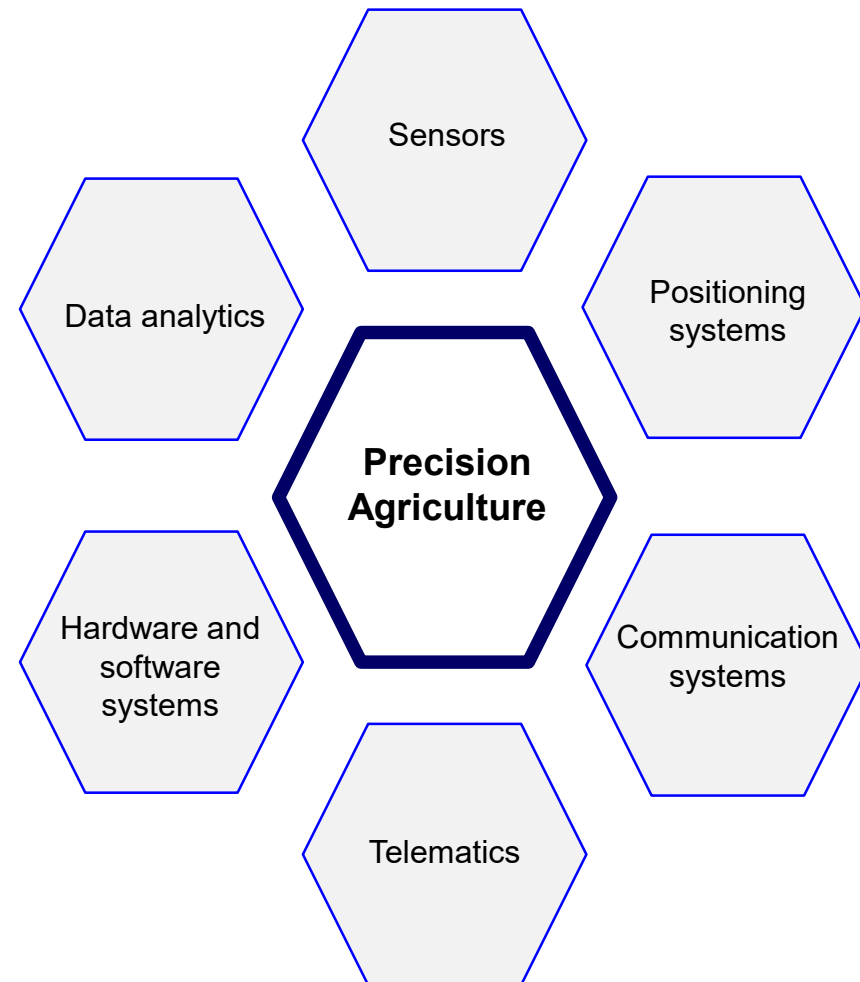
- Mapping of carbon sequestration potential in different oil palm ecosystems
- Development of sustainability indicators that include spatial and temporal variability
- Development of appropriate spatial scale to monitor shifts in yield maxima
- Geospatial modeling of water flow in sloping land
- Improvement of data processing methods, e.g. drone data should be in sync with spatio-temporal data

Evolution of precision agriculture

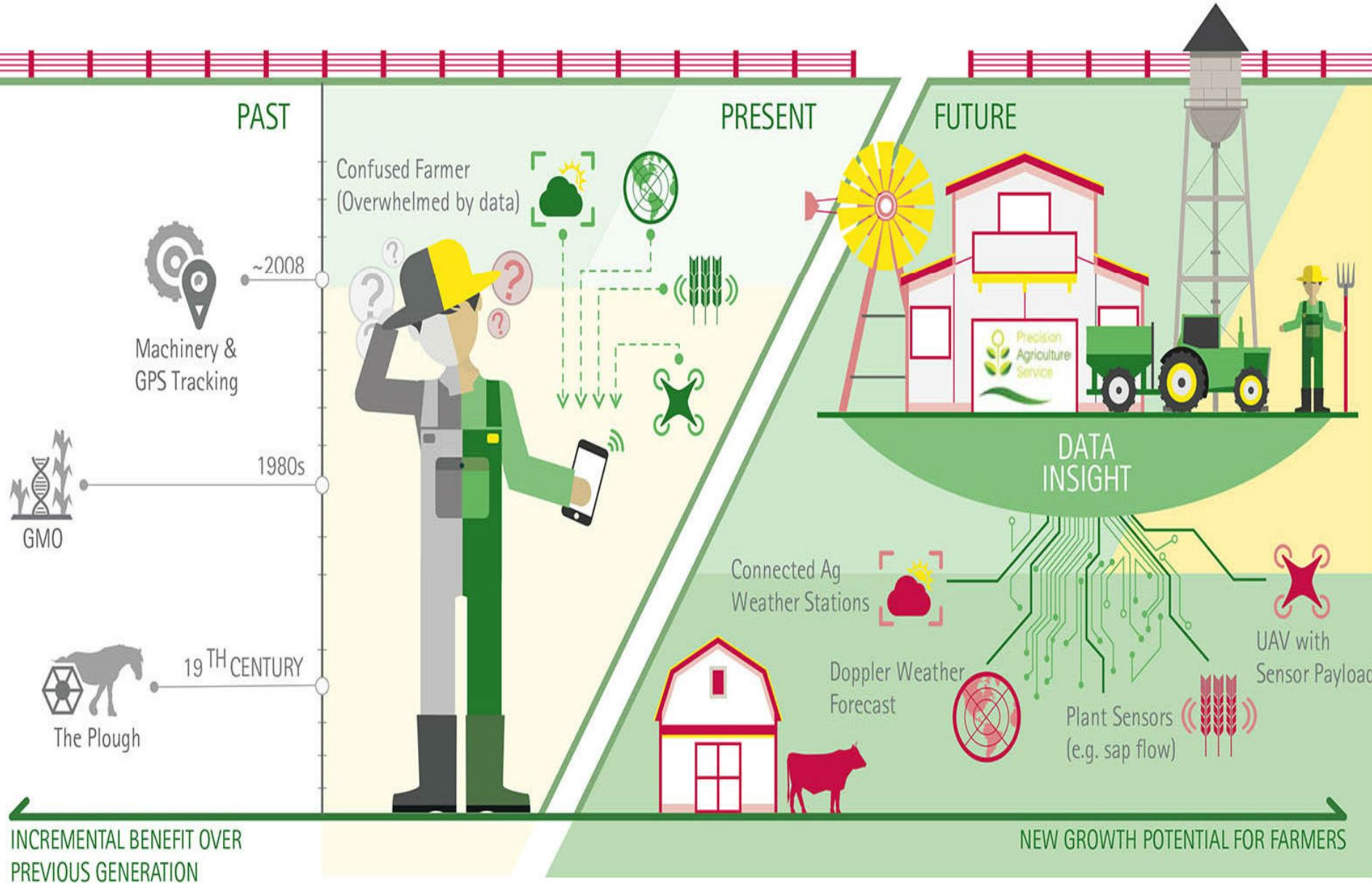
**The first 25 years (1990-2015):
Efficient farm**



**The next several years (2015-?):
Connected farm**



Towards a connected farm ...




Source: Accenture (2015)

Where are we going with all these?

Climate-smart agriculture

- Efficient
- Cost-effective
- Practical
- Pollution free



Making the crop fit the environment (always changing) → **resilience**

instead of the old way of changing the environment to fit the crop

Internet of Things (IoT) in Agriculture

- ➔ A means of connecting systems so as to allow an integrated, multidimensional view of farming activities, enabling deeper understanding on how the whole ecosystem works
 - Smart devices that can collect and send data in real time to increase speed for decision making
 - Big data

FUTURE FARMS

small and smart

SURVEY DRONES

- precise detection & quick intervention

FLEET OF AGRIBOTS

- microplot application of inputs

See you there!
Thanks for your attention

FARMING DATA

- rich & varied
- connected
- stored in 'cloud'

TEXTING COWS

- constant monitoring of animal wellbeing
- alerts & triggers

SMART TRACTORS

- reduces soil erosion

