POTENTIAL APPLICATIONS OF LOW-ALTITUDE REMOTE SENSING (LARS) WITH RADIO-CONTROLLED HELICOPTER PLATFORMS: CASE STUDIES ON NUTRIENT AND PEST MANAGEMENT UNDER AGRICULTURAL SYSTEMS IN DEVELOPING COUNTRIES.

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The small and medium farm holdings and limited accessibility to satellite-based remote sensing are found to be some of the major constraints for precision agriculture technology adoption in developing countries. An image acquisition system mounted on a radio-controlled helicopter platform can provide user-specified and near-real-time images for quick assessment of the crop and soil status giving enough time for preventive measures. The Low Altitude Remote Sensing (LARS) system can be made flexible in terms of system integration, specified applications and costs by choosing appropriate sensor combinations to acquire quality geo-referenced images of high spatial and temporal resolution. Reflectance indices and band ratios obtained by the LARS system can be analyzed for crop monitoring, crop status modeling and predictions.

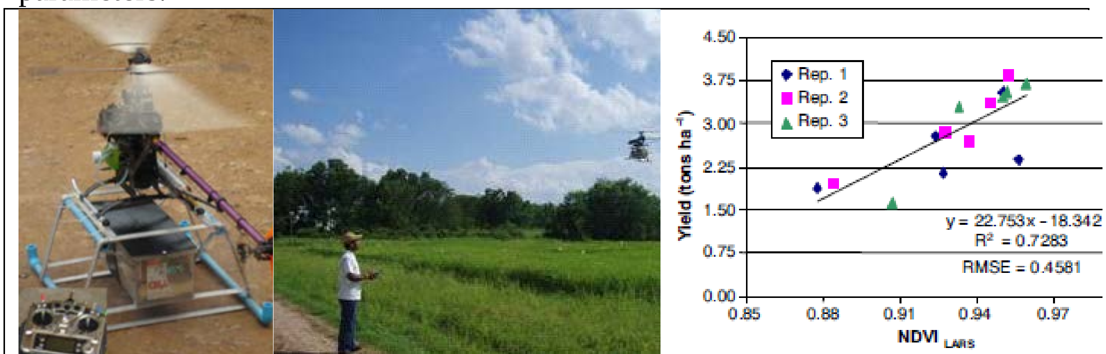
The developed LARS system consists of Digital and NIR image acquisition sensors, GPS receiver, altitude and orientation sensors, and an embedded CPU system mounted on the helicopter platform. The radio-control facility allows flying the helicopter over the targeted area at any selected elevation. The sensors mounted on the platform records data in the embedded CPU triggered by software. After retrieving data, the LARS system requires software algorithm set up to carry out image processing for modeling applications leading to making production decisions and recommendations. Experiments were conducted on nutrient and pest management applications following standard practices. Results obtained through image data were validated using ground truth data.

The case studies undertaken have justified the application potentials of the system under agricultural systems in developing countries. In the first study, LARS system acquired images were used to differentiate the rice yield and total biomass for different N treatments. Image results taken during panicle initiation stage were correlated with yield and total biomass with regression coefficients of 0.728 (RMSE = 0.458 ton/ha) and 0.760 (RMSE = 0.598 ton/ha) respectively, while leaf chlorophyll content correlated in terms of NDVI values at $r^2 = 0.897$, (RMSE = 0.012). In the second study, LARS images were processed to estimate vegetative-indices and thereby detected the infection levels of upper stem rot (Phellinus Noxius) disease in both young and mature oil palm plants. Good correlations and clear data clusters were obtained in characteristic plots of NDVI and GNDVI

against ground-truth data, hence infested plants could be discriminated from healthy plants in both young and mature crops. The regression coefficients (r^2) were in a reasonably acceptable range (0.62-0.88).

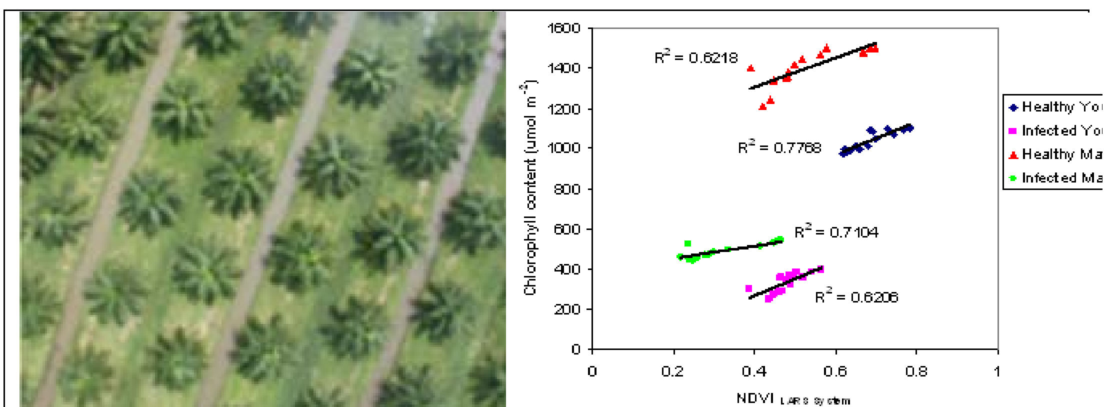
The developed LARS system justified its potential for precision farming adoption under agricultural systems in developing countries and it possesses near-real-time data acquisition for processing with lower pay-back period. The LARS system can be cost-effective through public or private sector small service providers under these environments.

Key words: Precision farming, LARS, Image processing, vegetative indices, crop parameters.



(a)	(b)	(c)

Figure 1: LARS application in N management and yield prediction; (a) The developed system, (b) Image acquisition from rice fields, (c) Correlation and rice yield prediction using NDVI values.



(a)	(b)

Figure 2: LARS application in pest infestation detection; (a) Image acquisition form oil palm field. (b) Correlation between the leaf chlorophyll content and NDVI values for discriminating healthy and infected oil palm in both young and mature stages.

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