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# Palmyrah Tree Inventory using High Resolution of Multispectral Satellite Images at Delft

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**Abstract:** The main objective of this study is to build a robust and user-friendly method that will allow palmyrah palm managers to count palmyrah trees using a remote sensing technique. Most of the palmyrah palm stands of the world today are unplanned naturally established seedlings of the palm including in the study area and it is in position to take in to account of statistics of population. In the plant science manual interpretation of aerial photographs and use of digital photogrammetry techniques are common for evaluating tree species composition. Various conditions surrounding trees, such as the density of grass and other trees, will affect tree detection and counting. Panchromatic and multispectral images can improve and increase the classification accuracy of land use and land cover using WorldView-2 imagery. In this study the total number of trees, true positive values, false negative values and final accuracy percentages for respective grama-niladhari divisions were found. In the above six Grama-Niladhari divisions it was observed that highest number (31,909) of palmyrah trees in delft east GN division and lowest number (3,900) was observed in delft center GN division. False negative values (21) were high to delft east; again highest accuracy (95%) was gained for the delft east GN division.

**Key words:** Palmyrah Census · VHR Images · Images Processing

## INTRODUCTION

Palmyrah plant is a perennial monocot plant with a long generation period of about more than one hundred and fifty years. Palmyrah (*Borassus flabellifer*) belongs to the family Arecaceae is a dioeciously in nature with the great majority of its economic edible products such as immature endosperm (nungu), mesocarp pulp (fruit pulp), tuberous seedlings (tuber) obtained only from female palms [1]. But sweet sap from the inflorescence (neera), toddy, palm sugar and non-edible products like brush fiber wood are obtained irrespective of whether the palms are male or female. However, differences in their yield or quality have been reported. Thus female palms are supposed to yield more neera on tapping from the inflorescence [2] and the female tree gives better and hard timber than the male tree and is also more expensive. Because of these variety of products could possible to extract it is an important economic crop not only in northern region but also in east and south part of country. Palmyrah plant is the most efficient multipurpose tree species in the world as much the consideration is given to coconut tree.

Production of this crop is now gaining popularity. Most of the palmyrah palm stands of the world today are unplanned naturally established seedlings of the palm [3] and there are no more exact statistics about population of palmyrah in Sri Lanka.

There are possible ways to get the census of palmyrah of using manual field counting, using aerial photographs and using GIS and remote sensing technique with the collaboration of high quality satellite images. Manual counting requires many workers to point out each tree in field and has potential problems related to accuracy of miss-counting or double entry. Remote sensing provides a potential approach for counting trees [4].

Today, location-the unifying theme of geography has taken on an even more important role in the plant sciences where it is considered an essential attribute to record and variable to consider, for the study of plants in

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fields ranging from agriculture to ecology [5, 6]. In the digital age that we live in, the cataloging of plants and the analysis of the influence that location plays on the growth and distribution of them is increasingly performed using geographic information systems (GIS). GIS is commonly defined as a system of personnel, computer hardware, software and data for capturing, managing, analyzing and displaying all forms of geographically referenced information [7].

The task of estimating tree production generally implies counting trees, a time consuming task that could benefit from the use of the very high resolution (VHR) satellite images now available, but also the near-global high resolution image coverage such as is provided by Google-Earth and other internet-based image services [8]. Very high spatial resolution remote sensing images represent a cost effective and reliable way of obtaining information about palmyrah trees. It may be the only practical manner to ensure a sustainable stewardship of trees with the necessary data about trees in a synoptic and repetitive form for large areas and over long periods of time [9].

A number of approaches have been proposed for the mapping of trees using Very High Resolution images. All these approaches use some primitive structuring element which is compared to the image or texture analysis or a combination of both. The use of some structuring element (usually a circular shape / cross shaped) is closely related to template matching (TM) [10].

In the plant science manual interpretation of aerial photographs and use of digital photogrammetry techniques are common for evaluating tree species composition [11]. Wehr and Lohr also reported "It is surprising to find this labor-intensive approach still widely used in developed countries? taking into account that the cost of using photo-grammatical methods is not much high. Crown counting can be difficult and inaccurate in field. Much depends on the quality of the image data, the physiognomy of the stand and the skill and experience of the photo interpreter [12].

Palmyrah tree density, age, management and varieties all affect palmyrah tree production capacity and tree density and distribution pattern is one of the parameter could be used to determine whether replanting is needed or not and it is must to have a data on palmyrah population in each area where it is possible to have palmyrah trees even not as 100% accurate reading.

Accurate inventories and monitoring of palmyrah palm areas are critical for plantation management and plant area expansion. Remote sensing is one of the most reliable measurement tool for accurate monitoring over large areas [13-15].

The main objective of this study is to build a robust and user-friendly method that will allow palmyrah palm managers to count palmyrah trees using a remote sensing technique. The palmyrah palm trees analyzed in this study have different ages and densities over the study area.

**Research Problems:**

- There is no updated data on palmyrah census
  Even though there is data as a numerical value of 11 mill palmyrah trees throughout the Sri Lanka but that is unknown of how did they find this value and it is questionable about its accuracy.
- Lack in knowledge in population pattern change
  It is obvious that if we have a rough idea about distribution pattern change with temporal factor only it is possible to do any developmental activities, management activities or even take any control measures in advance of without any damage to human who are depending on this industry business and tree population as well.
- Less concern about trees
  Though there are families associated with income generations from this trees but frequent of usage is getting diminish because of poor interest in this industry.

**Objectives of this Study:**

- To get the actual population of palmyrah in the respective Island in more possible way of more accuracy
- Develop a baseline to show distribution paternal change with time in past and future.
- To give an idea for do any improvement activities in the Island with the knowledge on concentration of trees with different GN divisions.

**Related Methods:** The simplest way to detect tree is to manually mark the trees on images or field surveying using GPS to collect the positions of trees and display their position on the image. However, if there a lot of trees in the areas, which can be large and contain more trees that turn this manual detection and field surveying can be a time consuming process and expensive. This case is where remote sensing technique gives its importance.

Broadly speaking, the tree detection can be considered as the tree detection problem which is an on-going research problem in remote sensing. The goal of tree detection is to extract tree positions or tree crowns from given data, i.e., photograph or laser point cloud. Existing methods for tree detection can be grouped in terms of data used. This work concentrates on using high-resolution image instead of LiDAR. A drawback of using LiDAR for detecting trees is the requirement of high point density, which is costly and requires large data storage. Moreover, using high resolution images, tree can be easily recognized and identified on images.

Aerial photograph and satellite imagery have been the most widely used data for the application of tree delineation or detection [16]. Wulder *et al*. performed a series of studies on the use of a local maximum filter to detect tree location in high spatial resolution imagery, i.e., airborne and satellite-borne images.

Ardila *et al*. [17] presented an active contour based method for the tree detection in urban areas using very high resolution image. The process starts with the computation of a normalized difference vegetation index image. The local peaks on the image are then detected.

Shafri *et al*. [18] proposed a method for detecting oil palm trees in an image of an oil palm plantation site. The input data was airborne hyper-spectral imagery which provides rich information for removing non-oil palms from the image. To detect oil palm trees, this method employed several processing algorithms. Texture analysis, i.e., grey-level co-occurrence matrix was used to make the oil palm area more homogeneous. Edge enhancement, particularly the Sobel edge filter, was then applied to delineate edges. Oil palm trees were then extracted by using a threshold technique. The shapes of the extracted oil palm trees were refined by morphology reconstruction and the number of oil palm trees was counted by blob analysis. The drawback of this approach is that only hyper-spectral image is required.

## MATERIALS AND METHODS

**Study Area:** Neduntheevu (also known by its Dutch name Delft) is an island in the Palk Strait, northern Sri Lanka. The island's area is 47.5 km$^2$ and it is roughly oval-shaped. Its length is 8 km and its maximum width about 6 km. Neduntivu is a flat island surrounded by shallow waters and beaches of coral chunks and sand. It is home to a small population of Tamil people, mostly living in quiet compounds close to the northern coast. The vegetation is of a semi-arid tropical type, with palmyra palms, dry shrubs and grasses that grow on the pale Grey porous coralline soil. This study analyzes palmyrah trees at Delft, Jaffna, Sri Lanka (9.540736°N 79.677769°E) (Fig. 1).


Fig. 1: Location of study area

**High Resolution Satellite Images:** World view imagery archived on 24 March 2017 was used in this study with bands consisting of visible red (630-690 nm), green (520-600nm) and blue (450-520 nm), NIR (near infrared, 760-900 nm) and panchromatic (450-900 nm).

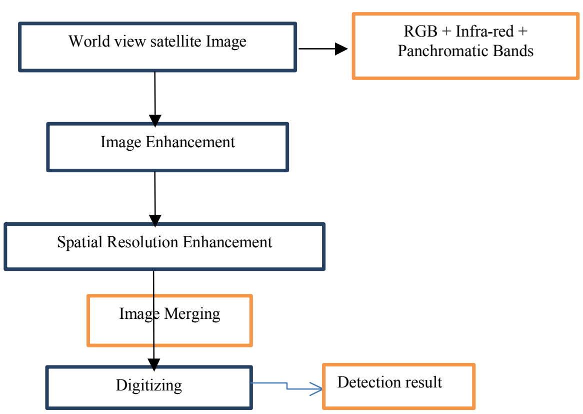
Information of image that we purchased for this study are Satellite / sensor-Worldview 2, Imagery type-Ortho Ready Standard / Archive, Band combination-Bundle (Panchromatic + Multispectral), Radiometric Resolution-16Bits / pixel, Maximum Cloud Cover-0.7% and spatial resolution is 40cm.

Various conditions surrounding trees, such as the density of grass and other trees, will affect tree detection and counting [19, 20]. Therefore, the main target in the present study is to build a robust method for tree detection and counting under any tree conditions and densities.

ArcGIS 10.4 was the type of software used in this study. In this research study, panchromatic and multispectral image was used for palmyrah plant detection because this allows the shape of the palmyrah plant canopy to be detected into detail.

Johnson *et al.* [21] reported that a panchromatic and multispectral image has more spatial information and minimizes the distortion of spectral information of a multispectral image with lower resolution. Lin *et al.* [22] reported that panchromatic and multispectral can improve and increase the classification accuracy of land use and land cover using WorldView-2 imagery.

Workflow of the proposed method




**Test and Validation:** The High quality satellite images were directly purchased from Genesiis software (pvt) Ltd and they are the registered dealers of Digital Globe which is an American company and they are satisfying the requirement of customers who need the VHR (very high resolution) images for different purposes.

To validate the results, palmyrah development board staffs and Palmyrah Research Institute staffs are helped in directly interpret and count the trees in the island. Manual interpretation of trees in test images and field was done by Palmyrah Development Board staffs with the help of Geography department from University of Jaffna and we have evaluated the results in the following way:

- The total number of trees (N) was determined by the interpreters;
- Matching trees were computed as true positives (TP)
- Unmatched trees (present on the image but absent from the results or present on direct interpretation but absent from images) were marked as false negatives (FN);
- The final accuracy was computed as (TP / (N+FN)) * 100.

**Accuracy Assessment:** An accuracy assessment was applied for the palmyrah plant feature extraction (as a point feature layer in GIS) and compared with the result of manual counting using on-screen digitization in five square polygons (each square polygon is $10m^2$), four of which were distributed in the fourth corners of every site plus one polygon in the center and values for these five plots were got into average. The number of palmyrah plants counted manually and the number extracted digitally from world view imagery were selected in the five (5) square polygons using ArcGIS 10.4; the results of these two counting methods were compared with each other to determine the accuracy of palmyrah plant detection and extraction.

In our case of plant identification the effects of varying illumination become an advantage rather than an obstacle, especially when the background is homogeneous.

The objective of this research is to introduce an adaptation of method to detect and count the palmyrah trees in Delft with the use of VHR images such as taken by World View 2 and 3. The black and white imagery from a false color composite of panchromatic imagery was processed in three ways (1) palmyrah palm tree detection, (2) delineation of the palmyrah palm area using the red band and (3) counting palmyrah trees and accuracy assessment.

Here the detection and counting of trees are done according to the specific illumination parameters of the image and the size of the trees present on the scene. A parameter of projected shadow clipping has also been added to take into account the fact that it was not always beneficial to use the whole shadow in situations where it was projected onto another tree and not on the ground. The height of the tree also affects the size of the shadow, so that it did not appear wise to set the height to a fixed value: it was made proportional to the crown radius [23].

## RESULTS AND DISCUSSION

The proposed methods for tree detection and tree counting in the present study were tested in six grama-niladhari divisions in Delft Island with different tree ages and densities.

**Palmyrah Tree Counting and Accuracy Assessment:** In the study of improving the precision of tree counting using high resolution multispectral images the field verification process showed that the treetop detection with species information obtained using this new approach produced relatively high accuracies for a variety of stands. The accuracy for the total number of trees per stand was higher than 84% [24]. After using a red band to reduce noise during palmyrah area extraction, palmyrah trees could be counted from the results of the converted polygon of palmyrah tree extraction to create a point layer. The present study encompassed a total area of 47.5 square kilometers for testing the proposed method, which were divided into six different study sites to determine palmyrah palm distribution.

In the above six GN divisions it was observed that highest number of palmyrah trees in delft east GN division and lowest number was observed in delft center GN division. Throughout the island the palmyrah trees were identified as grove not as other plantations like tea, rubber, teak. Because of this nature of plantation habit production as well as healthiness of tree crown and stem were identified as unhealthy. Having ideal plantation with proper spacing in the areas where there was no trees would get the timber with good strength will lead to higher market price.

In the study area it was found the majority of trees were ranged along the sea side because of suitable edaphic as well as climatic features and away from sea side towards the center part of island tree population has tendency to less in number due to low depth of soil that facilitate hardness to root for expansion into soil.

It is possible in the study area to expand the plantation of palmyrah tress but it is important to overcome the problem of availability of suitable areas with depth of soil as well as need to find the reliable water source.

Above images 1 to 6 represent delft west, delft center east, delft center west, delft center, delft east and delft south respectively.

The results of the study in detection and counting of oil palm trees using high resolution of multispectral satellite images improved upon the accuracy of several previous research studies that had an accuracy of about 90-95% [25]. In this study accuracy was calculated in terms of percentage for true positive values with total number of trees which were manually identified from field inspection. Though the false negative values were high to delft east, highest accuracy was gained for the delft east GN division. The least accuracy was gained for delft center and accuracy deviation was seven in between 95 and 88.

During oil palm tree extraction, several oil palm canopy/trees were not extracted and some objects were also extracted that were not oil palms. This is caused when some of the vegetation that surrounds oil palm trees has the same radiance values as the radiance values of oil palms. The oil palm area extraction results will affect the accuracy of oil palm tree counting because they are used to reduce noise during oil palm tree extraction. [25]. In this study also we had the same problem while detection of palmyrah trees because in some cases trees we identified were not as palmyrah but in some cases we missed few palmyrah trees as not like as it is that is because of fault

Table 1: Statistical information of trees from image as well as field inspection

| Method Area (GN divisions) | Area ($Km^2$) | Total number of trees | Polygon test ($m^2$) | Supervised tree counting in polygons (average of five) | Tree counted manually in polygons (average of five) | Palmyrah tree extraction difference |
|---|---|---|---|---|---|---|
| Delft East | 12.5 | 31,909 | 10 | 397 | 418 | 21 |
| Delft center East | 7.2 | 11,013 | 10 | 84 | 94 | 10 |
| Delft Center | 4.7 | 3,900 | 10 | 51 | 58 | 7 |
| Delft Center West | 5.8 | 8,560 | 10 | 82 | 88 | 6 |
| Delft South | 10.8 | 20,637 | 10 | 116 | 125 | 9 |
| Delft West | 6.5 | 27,543 | 10 | 219 | 238 | 19 |

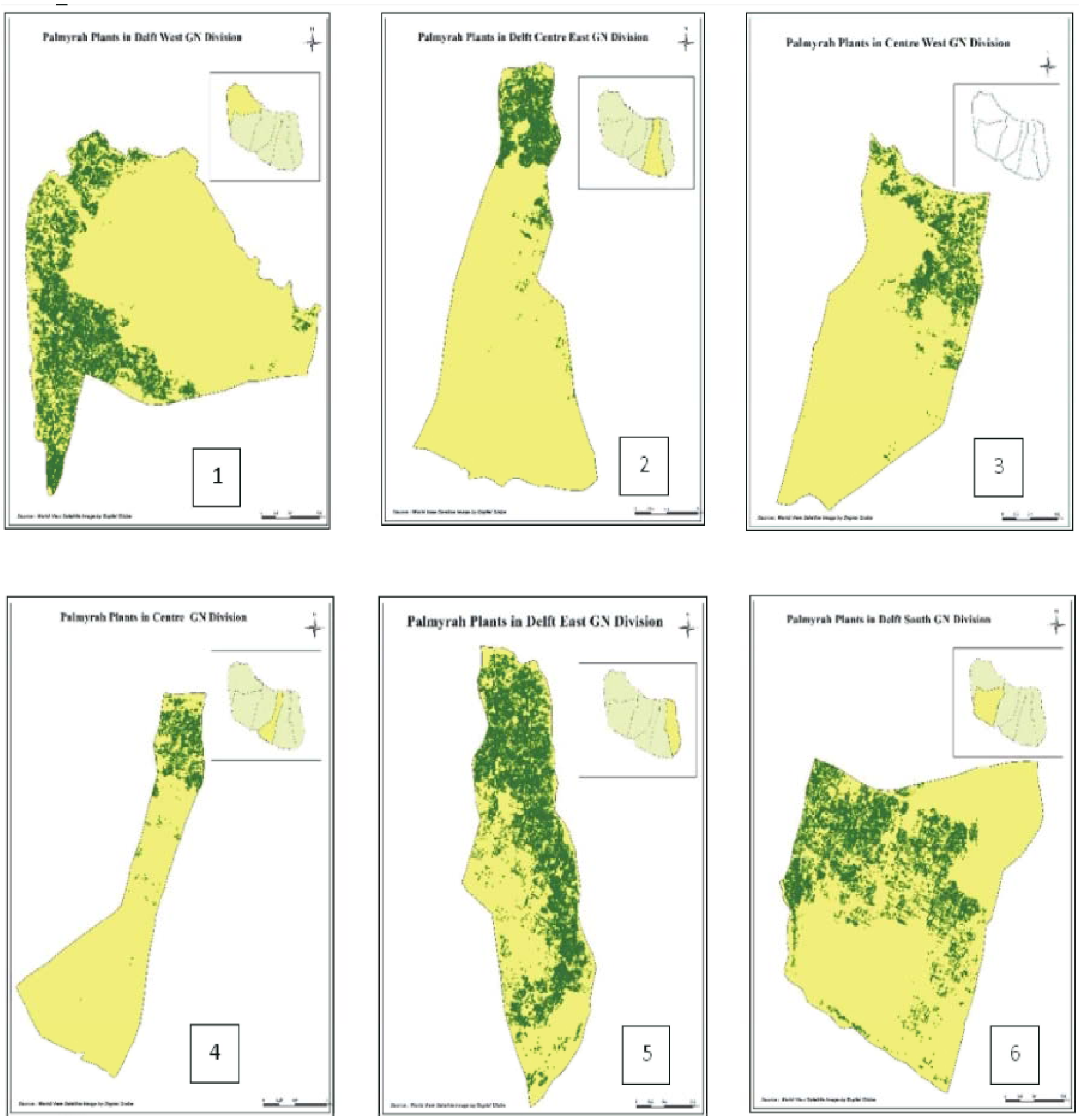



Fig. 2: Projected images of six grama-niladhari divisions after supervised classification of trees from VHR images.

Table 3: Accuracy assessment for palmyrah mapping for six GN divisions

| Method Area (GN divisions) | False negatives | Accuracy (%) |
|---|---|---|
| Delft East | 21 | 95 |
| Delft center East | 10 | 89 |
| Delft Center | 7 | 88 |
| Delft Center West | 6 | 95 |
| Delft South | 9 | 93 |
| Delft West | 19 | 92 |

identification and in this study we didn't use any technique to reduce noise effect while detection of palm trees. This would be the reason for not having 100 % accuracy at all instances.

## CONCLUSION

In this study palmyrah tree counting was done by using high resolution satellite images which were purchased from digital globe satellite image provider. By this study it was proved that tree identification and counting of palmyrah trees would become possible in quick and feasible manner. Final output of tree counting from this study was revealed in grama-niladhari division wise for better understanding and to get sound knowledge in implementing management practices at future.

The method proposed in the present study are easy to use for tree detection and counting or we can move with other image processing software that have a grayscale conversion function, stretching foreground and background functions, a Sobel edge detector, texture analysis co-occurrence, as well as dilate, erode, high-pass and opening filters as well.

## REFERENCES


1. Sankaralingam, A., G. Hemalatha and A. Mohamed Ali, 1999. Report on All India Coordinated Research Project on Palms, Agricultural College & Research Institute, Tamil Nadu Agricultural University, Coimbatore, pp: 40.
2. Davis, T.A. and D.V. Johnson, 1987. Current utilization and further development of the palmyrah palm (Borassus flabellifer L., Arecaceae) in Tamil Nadu State, India. Econ. Bot., 41: 247-266.
3. Kandiah, S. and S. Mahendran, 1986. A new method for culturing seedlings of palmyrah palm Borassus flabellifer L. Vingnanam-Journal of Science, 1: 40-43.
4. Wulder, M.J., O. White, O. Niemann and T. Nelson, 2004. Comparison of airborne and satellite high spatial resolution data for the identification of individual trees with local maxima filtering. Int. J. Remote Sens, 25: 2225-2232.
5. Haara and S. Nevalanine, 2002. Detection of Dead or Defoliated Spruces using Digital Arial Data, Forest Ecology and Management, 160: 97-107.
6. Pu, R. and S. Landry, 2012. A comparative analysis of high spatial resolution IKONOS and WorldView-2 imagery for mapping urban tree species. Remote Sensing of Environment, 124: 516-533.
7. Brian and J. Morgan, 2011. Geographic Information Systems for the Plant Sciences. Arnoldia, Vol.69, No 1, pp.14-22. http://www.jstor.org/stable/42955508
8. Cracknell., Arthur Philip, K. D.Kanniah, K.P. Tan and L. Wang, 2013. Evaluation of MODIS Gross Primary Productivity and Land Cover Products for the Humid Tropics Using Oil Palm Trees in Peninsular Malaysia and Google Earth Imagery. International Journal of Remote Sensing, 34(20): 7400-7423. Doi: 304 10.1080/01431161.2013.820367.
9. Shao, G. and K.M. Reynolds, 2006. Computer applications in Sustainable Forest Management, Vol. 11, Springer.
10. Friedl, M.A. and C.E. Broadley, 1997. Decision Tree Classification of Land Cover from Remotely Sensed Data, "Remote Sensing of Environment, 61: 399-409.
11. Wehr, A. and Lohr, 1999. Airborne laser scanning- an introduction and overview. ISPRS Journal of Photogrammetry and Remote Sensing, 54: 68-82.
12. Cracknell, Arthur Philip, K.D. Kanniah, K.P. Tan and L. Wang, 2015. Towards the Development of a Regional Version of MOD17 for the Determination of Gross and Net Primary Productivity of Oil Palm Trees." International Journal of Remote Sensing 36 (1):262-289.doi:10.1080/01431161.2014.995278.ENVI. 2014. "ENVI Classic Help." Exelis- ENVI52-Classic.
13. Tan, K.P., K.D. Kanniah and A.P. Cracknell, 2013. Use of UK-DMC 2 and ALOS PALSAR for studying the age of oil palm trees in southern peninsular Malaysia. Int. J. Remote Sens, 34: 7424-7446.
14. Wulder, M., K.O. Niemann and D.G. Goodenough, 2000. Local maximum filtering for the extraction of tree locations and basal area from high spatial resolution imagery. Remote Sensing of Environment, 73(1): 103-114.
15. Benediktsson, J.A., M. Pesaresi and K. Arnason, 2003. Classification and feature extraction for remote sensing images from urban areas based on morphological transformations, IEEE Transactions on Geo-science and Remote Sensing, 41: 1940-1949.
16. Wulder, M.A., J.C. White, N.C. Coops and C.R. Butson, 2008. Multi-temporal analysis of high spatial resolution imagery for disturbance monitoring. Remote Sens. Environ., 112: 2729-2740.
17. Ardila, J., W. Bijker, V. Tolpekin and A. Stein, 2012. Gaussian localized active contours for multitemporal analysis of urban tree crowns. In Proceedings of the 2012 IEEE International Geo-science and Remote Sensing Symposium (IGARSS), Munich, Germany, 22-27: 6971-6974.
18. Shafri, H.Z., M.N. Hamdan and M.I. Saripan, 2011. "Semi- Automatic Detection and Counting of Oil Palm Trees from High Spatial Resolution Airborne Imagery. International Journal of Remote Sensing, 32(8): 2095-2115. Doi: 10.1080/01431161003662928.
19. Jusoff, Kamaruzaman and Mubeena Pathan, 2009. Mapping of Individual Oil Palm Trees Using Airborne Hyper-spectral Sensing: An Overview. Applied Physics Research, 1: 15-30.
20. Kattenborn, T., M. Sperlich, K. Bataua and B. Koc, 2014. Automatic Single Palm Tree Detection in Plantations Using UAV-Based Photogrammetric Point Clouds. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences-ISPRS Archives, 40(3): 139-144. Doi: 10.5194/isprsarchives-XL-3-139-2014.

21. Johnson, Brian, Ryutaro Tateishi and Nguyen Hoan, 2012. Satellite Image Pan-sharpening Using a Hybrid Approach for Object-Based Image Analysis. ISPRS International Journal of Geo-Information, 1(3): 228-241. Doi: 10.3390/ ijgi1030228.
22. Lin, Chinsu, Chao-Cheng Wu, Khongor Tsogt, Yen-Chieh Ouyang and Chein-I Chang, 2015. Effects of Atmospheric Correction and Pan-sharpening on LULC Classification Accuracy Using WorldView-2 Imagery. Information Processing in Agriculture 2(1). China Agricultural University, 25-36. doi:10.1016/j.inpa.2015.01.003.
23. Szantoi, Z., S. Malone, F. Escobedo, O. Misas, S. Smith and B. Dewitt, 2012. A tool for rapid post-hurricane urban tree debris estimates using high resolution aerial imagery. Int. J. Appl. Earth Observe. Geoinf, 18: 548-556.
24. Katoh, M. and F.A. Gougeon, 2012. Improving the precision of tree counting by combining tree detection with crown delineation and classification on homogeneity guided smoothed high resolution (50 cm) multispectral airborne digital data', Remote Sensing, 4(5): 1411-1424. doi: 10.3390/rs4051411.
25. Santoso, H., H. Tani and X. Wang, 2016. A simple method for detection and counting of oil palm trees using high-resolution multispectral satellite imagery, International Journal of Remote Sensing, 37(21):5122-5134.doi:10.1080/01431161.2016.1226527.