UAV data acquisition, Processing and Analysis of Horticulture crop area assessment and monitoring in Nangkhrah Village, Ri-Bhoi District, Meghalaya

A PROJECT REPORT SUBMITTED TO THE
KARNATAKA STATE RURAL DEVELOPMENT AND
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IN PARTIAL FULFILMENT FOR AWARD OF THE DEGREE OF

Master of Science in GeoInformatics

Submitted by
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Certificate

This is to certify that the work embodied in the accompanying project report entitled **"UAV data acquisition, Processing and Analysis of Horticulture crop area assessment and monitoring in Nangkhrah Village, Ri-Bhoi District, Meghalaya"** has been carried out entirely by the candidate under my/our direct supervision/s and guidance and that the candidate has fulfilled the requirements of the regulations laid down for the "course" requirements of the Karnataka State Rural Development and Panchayat Raj University, Gadag.

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DECLARATION

I hereby declare that the dissertation entitled **"UAV data acquisition, Processing and Analysis of Horticulture crop area assessment and monitoring in Nangkhrah Village, Ri-Bhoi District, Meghalaya"** is submitted by me in the partial fulfillment of my internship of **Master of Science** in **GeoInformatics** from Karnataka State Rural Development and Panchayat Raj University, Gadag**,** and is a record of bonafide work carried out by me, under the guidance of **Dr. Bijoy Krishna Handique**, Scientist/Engineer 'SF' Department of Space, Government of India, Umiam – 793103, Meghalaya. I do here declare that the details enclosed in this report are true to the best of my knowledge.

Ravi Jadi

Date:

Place: Gadag

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Ravi Jadi

Abstract

In north eastern region (NER) of India, there are many challenges for getting accurate area estimation in the field of Agriculture, Horticulture, Forest mapping etc. because of small and fragmented land holding, terrace cultivation, cloud cover, hill shade etc. out of these the main problem is huge vegetation area. In such situations, UAVs is only one solution for the alternative and complementary solutions for remote sensing based crop area delineation, acreage estimation. Now a day almost all applications stand on the platform of remote sensing and GIS. In this scenario, the all research institute, GIS Companies and other institutes are needs the quality of Data. And they strongly believed that the quality of Data can only give the accurate result. The quality of data generated by the set of pre-processing and processing activities.

The pre-processing UAV Activities like type of Area, selection of Drone, proper flight planning, selection of camera or sensor (on demand), camera mode, Camera angle, sun angle etc. are noticeable. Second task is processing the captured data. The data is processing in Pix4DMapper Pro software and it is most powerful tool of photogrammetry. Usually this data is used for the object based classification. so for the quality of data is very important in decision and policy making. The main goal is capture the meaningful ground features and to investigate the strength and quality of the UAV data processing and analysis the output image for the assessment of Horticulture crop using Object based classification techniques.

The eCognition software is used for the object based classification and it included object based image analysis tools and algorithms. The algorithms are use as per the study area, here using Multispectral Segmentation and Spectral Difference Segmentation Algorithm. Finally, The UAV Data Acquisition and Data quality is assessment done by referring Quality report which is generated by Pix4DMapper software.

Horticulture crop assessment of based on Accuracy assessment based on the sampling and Ground Truth data. In that, the result generated by the statistical aspects like user accuracy, overall Accuracy, Producer Accuracy and Kappa Coefficient. Finally the ground truth provides the accurate result. The percentage of overall accuracy is 82% and Kappa coefficient is 80%.

Keywords: UAV, NER, Pix4DMapper, eCognition, Segmentation, OBIA, Cluster, Objects.

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Chapter 1: INTRODUCTION

1.1 Background of the study

In north eastern region (NER) of India, there are many challenges for getting accurate result in the field of Agriculture, Horticulture, Forest mapping, and Road map etc. In terms of small and fragmented land holding, cloud cover, terrace cultivation, hill shade etc. out of these, the main problem is huge vegetation area. In such situations, UAVs have emerged an alternative and complementary solutions for remote sensing based crop area delineation, acreage estimation (Handique, 2012). The UAV Data provide very high resolution of data so it's easy to identify the features. Many of the Western countries are already using this technology and get the spatial crop information. Based on this information the former understand the crop health, growth stage as well as rate, pest attack, water deficiency, need and excess of fertilizers, slope of land, height of crop etc. Based on this information the former can understand what exactly crop facing problem and in which particular location is required the treatment? Then the former can give the proper treatment to the affected crops.

In this scenario, The Unmanned Aerial Vehicle (UAV) is an aircraft without human on board, known as a drone or Remotely Piloted Aircraft (RPA) (Ansari Aadil Iqbal1, 2015). In past decades, the farmer's uses weak data collection tools that provide poor result and UAV platforms are helping for agricultural crop information and monitoring. It is very easy operating, flexible, provide VHR image. The data acquisition is low costs and more offered able on demand monitoring of crop field (Daniela Stroppiana1, 2015).

In this modern agribusiness, the UAV not only become a data collection tool but also analyse the effectiveness collecting crop data. The Quality of output data is based on the pre-processing of UAV Activities like selection of Drone, type of Area, proper flight Planning, selection of camera or sensor (on demand), camera mode, Camera angle, sun angle etc.

The DJI Technology Chinese based company and it is having experience in the professional UAV manufacturing unit and DJI series Drones are most popular in all kind of research field. Now it is specializing in data processing and delivers VHR of Orthomosaic image and also most important DEM / DTM / DSM and city-wide 3d model to use for a range of crop acreage and assessment *(www.pix4D.com).*

The Pix4Dmapper is Professional Photogrammetry software and all researchers are accepted output data and many of the research papers are published by using this processed data. The software process the data in 3 majorly steps,

1) Initial Process
2) Point Cloud Mesh
3) DSM Orthomosaic and Index

After initial processing the software provides the Quality report. In that report, there are set of information enclosed and the verification is based on the statistical information. After verifying, the next two processes are going on and get the Quality of point cloud, DSM and Orthomosaic data for the further Analysis.

The massive size of the datasets is requiring powerful workstation for image processing because higher-end image processing techniques are followed to establish more precision. Identifying spatial variability is obtained through the remotely sensed images of the crop field, image processing, GIS modelling approach, GPS usage and data mining techniques used for model development.

Further, the most important and challenging task is image processing and segmentation technique. It is used to by frigate an image into meaningful parts having similar features and properties (Alka Chauhan, 2019). The main aim of segmentation is representing an image into meaningful and easily analysable way. In the same way the segmentation is dividing several segments make into similar.

Some basic applications of image segmentation are as fallows

1) Content based image retrieval.
2) Automatic traffic control systems.
3) Medical imaging.
4) Object detection and Recognition.
5) Tasks and Video surveillance.
6) Artificial intelligent understanding devices etc.

The eCognition software is used for the object based classification and it included image analysis tools and many more algorithms. The algorithms are used based on the study area so as per this study area, here using Multispectral Segmentation and Spectral Difference Segmentation Algorithm. The classified output segmentation is mapped in ArcGIS software and the qualitative analysis is based on the error matrix and accuracy assessment based on the sample training and ground truths.

1.2 AIMS AND OBJECTIVES

The main Aims and objective of the project are

1. Meaning full UAV data acquisition.
2. Proper UAV data processing and investigates the strength and quality of data.
3. Analysis the output image for the assessment of Horticulture crop and other features classes using Object based classification techniques.
4. Accuracy assessment by using various statistical tool.

1.3 SCOPE OF WORK

In this area, the crop acreage estimates are brought out using by eye estimation and it is not gives accurate result. Even though, the accuracy result is very less by using satellite data. Because this area fully coved by mixed cultivation, small farming, and always cloudy. The UAV data is only one solution for prescribe result. So the scope of work is to estimate crop area and discrimination the other features using object based classification method. Many of the projects are not completed in this region because of heterogeneous features. This technology provide very high resolution data i.e.. less than 5cm spatial resolution and also DSM, Point cloud data are help to find the height of the objects.

1.4 Literature review

- ***UAV Remote Sensing Techniques for Agriculture***

In this new era, the Application of UAV and benefits for promoting space technology tools for governance and various developmental activities and it has taken up a leading role in the initiate use of Unmanned Aerial Vehicle for large number of applications such as natural resources management, project monitoring, infrastructure development, research and development, disaster response and rescue, etc. and also they said that the Capacity building, training and outreach are important activities taken up by NESAC for promoting use of UAV remote sensing at central/state/academic/research institutions and individual level (P.L.N.Raju, 2014).

In NE region is characterized by undulating terrain, wide variations in altitude and slopes with diverse cultivation practices. In this region, large number of tribal communities is practicing shifting cultivation. In this scenario they selected as Satellite remote sensing has been found extremely useful for agricultural assessment, including crop area, condition and yield assessment, drought assessment, irrigation management, land use/land cover and soil mapping and so on. Finally, they concluded that value addition of horticultural crops in the region. For identifying best suitable sites for the establishment of different infrastructure facilities, GIS based analysis only helps (B.K.Handique C. G., 2017).

- ***Review of Aerial Platform and UAV Technology***

The technology helps to identify the features in mixed crops; the details information's using UAV. The UAV operation is less expensive than MAV and it is environmental friendly as it not generates the CO_2 and more noise. It provides highly accurate and detailed observation. This data used in many applications such as environmental, agricultural and natural resources monitoring. Bu also they said that the huge amount of data, provided by UAVs, pose a new challenge in terms of processing, storage and transmission techniques. Many of the organisations are focuses on applications of UAV for the management and monitoring of natural resources and disasters and showcase a few recent studies carried out in NER (B.K.Handique J. G., 2016).

Data collection with UAVs have been known to fill a gap on the observational scale in remote sensing by delivering high spatial resolution data and temporal resolution data that is required in crop growth monitoring. A major advantage over satellite imagery is the independence of clouds and revisit time and fast data acquisition with real time capability (Berni et al., 2009; Eisenbeiss, 2009). Remote sensing technology data is most flexibility in data acquisition (Shahbazi et al., 2014). Those characteristics make UAVs highly suitable for many agricultural applications (Swain and Zaman, 2012). Compared to satellite remote sensing, aerial imagery is more applicable to precision crop management due to the following advantages:

■ Images can be acquired frequently over the study area throughout the crop growing season,

■ Image acquisition can be rescheduled to a cloud free day if there is data mask due to cloud on the day of acquisition,
■ Superior resolution- high spatial resolution showing soil and crop growth variability,
■ Cost per acre is relatively low when scanning large areas

Though aerial remote sensing is more relevant to precise crop management in terms of resolution, it does have problems like band to band registration, geo-rectification and mosaicking of images that involve manual efforts, bidirectional reflectance variations, and lens vignette effects. Apart from these issues, aerial remote sensing offers the best soil and crop growth variability information with very high spatial resolution less than cm but satellite sensors cannot provide cm level spatial resolution.

In these areas with mixed cropping pattern, aerial remote sensing can be effectively used to delineate the crop type and land use. For the crop insurance, policy making can use the Drones, because it not only to determine the actual cultivable land, but also during the claims process to understand the extent of crop loss and the actual yield. The high resolution imagery helps to in getting accurate data to enable crop insurance companies and they are able to give proper compensation to affected farmers.

The benefits of UAVs surpass its disadvantages in ways like:

- ❖ When equipped with high precision cameras, they can help adjusters understand the true health of a field using a multispectral sensor.
- ❖ With their ability to cover distances quickly, drones can reduce the time it takes to settle claims from days to hours.
- ❖ Based on weather condition, drones can also be proactively positioned in the areas of high claim activities and also deployed the moment of a new order comes in.
- ❖ Additionally, since drones can relay real time information back to remote specialists in, more claims can be resolved within a shorter time frame, making for a faster and streamlined insurance process.

- ***Review of UAV Data Processing***

The collected images are processed in a state of the art tool resulting in a generation of dense 3D point clouds and the algorithm is developed in order to estimate geometric tree parameters from 3D points (M. Karpina, 2016). Stem positions and tree tops are identified automatically in a cross section, followed by the calculation of tree heights. The automatically derived height values are compared to the reference measurements performed manually. However, the proposed method should be improved. For this reason we will try to determine optimal data acquisition conditions and we will combine various UAV sensors in order to increase accuracy of three height determination (M.Kalpana).

The Vegetation monitoring over time is important in a changing world due to climate change. The technical properties and its limitations of the camera can be rectified by to a certain degree by radiometric calibration and pre-processing method used. (Adlar, 2018).

The validation of UAV data can do by using commercial software. It can generate digital surface model (DSM) were provided from some vender. One software is based on the bundle method using conventional Photogrammetry, another one is based on structure-from-motion method (SfM) under computer graphics technology. It is wavered to choose which software to generate DSM derived from drones. In this work, the accuracies of DSM were verified using the software such as Image Master (TOPCON), PhotoScan (Agisoft) and Postflight Tera 3D (sensefly). The experiments carried out some cases that UAV's height and camera resolution were changed. UAV also were used both of the fixed wing type and the rotor wing type. The results show that the software based on SfM provides the precisely centimetre order DSM without the ground control points (GCP) and the deference of accuracy by UAV's altitude shows non-linear using the camera with the lens distortion is large (Tokunaga, 2015).

- ***Review of Object based classification:***

In object based classification method generally, the segmentation algorithm separate the feature on the basis of homogeneity and combined with local and global optimization techniques. The multiresolution segmentation is one of the basic algorithm procedures in the software eCognition software for object based classification and it is successfully applied to many different problems in the fields of remote sensing, medical image analysis and structure analysis (BAATZ, 2012).

There are some critical limitations of UAV imagery interpretations techniques for analysis of time-series data, higher imagery variances and very large data sizes (Jarlath O'Neil-Dunne, 2014). The detailed species delineations, which were derived from multiresolution segmentation, it delineating tree density segments and label species association robustly, compared to previous hierarchical frameworks (Yan-Ting, 2014).

OBIA approaches developed to overcome the limitations of the pixel-based approaches. It incorporates with spectral, textural and contextual information to identify thematic classes in otho-image. OBIA is to do segment the image into homogeneous objects. The segmentation parameters like compactness, shape, and scale are pre determine before start the process *(Mason et al. 1988).*

Chapter 2 : STUDY AREA

2.1 Geographical Location:

The study was carried out in Nangkhrah Village, Umling Block, Ri-Bhoi district of Meghalaya state (Fig. 1). The study area comes under the East Khasi Hills District and lies between North Latitudes **25.920750** and between East Longitudes **91.891190**. It is also parts of the Khasi kingdoms viz parts of Mylliem Syiemship, Khyrim Syiemship, Nongspung Syiemship, Nongkhlaw Syiemship, whole of Nongpoh Sirdarship (erstwhile Nongpoh Syiemship), Myrdon Sirdarship and the erstwhile Nongwah Syiemship. This places which fall under the 'Areas of Differences' between Assam and Meghalaya.

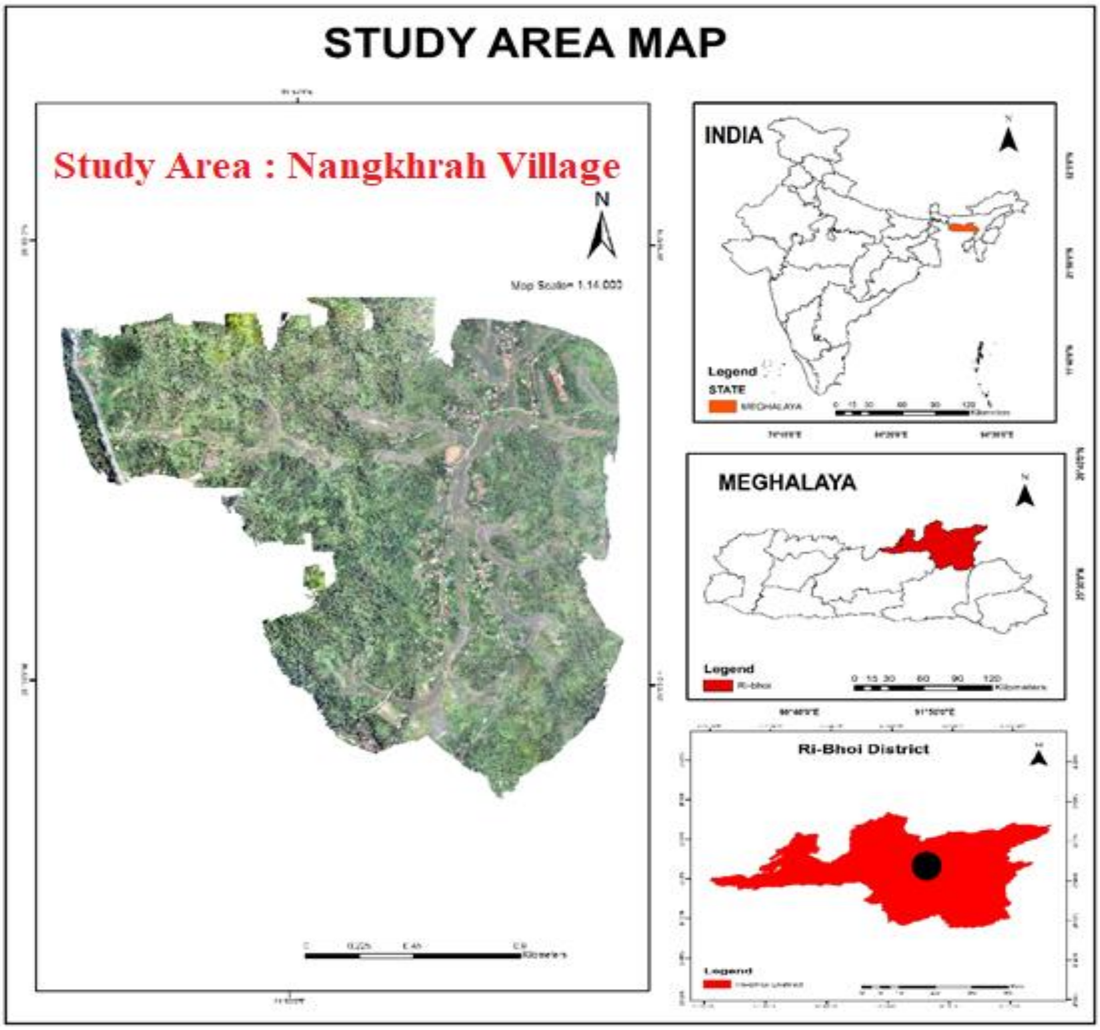

Figure 1: Graphical representation of Study area

It is main group of Khasi Tribe. In schools, they are using Khasi dialect subject as a major subject. Along with Khasi community we can found other group of tribes in the Ri-Bhoi district those are Garos, Marngars, bodos, Karibs and Lalungs. Few decades ago this area belongs to Assam state so usually they know the Assamese language. The Bhois people fallow the matrilenial system. The Ceremonial dance held annually at Nongbah (Raid Nongpoh) by Ka Seng Pynneh Riti Khat-ar Lyngdoh. Usually held in the last part of January *(http://cgwb.gov.in).*

Agricultural and Horticulture background:

In this place horticulture crops is dominant crop. In the agricultural production system, before that there is not having any objective methodology for collection of crop statistics and also the crop acreage estimates are brought out using by eye estimation (B.K.Handique C. G., 2017). The cultivation system is carry over in different such as mixed cropping, multi-storey cropping pattern, shifting cultivation, intercropping cultivation etc. are the challenges for crop Assessment and acreage estimation. The horticultural crops like orange, pineapple, ginger, turmeric etc. are important economic crop. The heterogenic crop area under Umling block for conducting the UAV survey with an aim to discriminate the different horticultural crops based on their spectral characteristics like tone, shape, texture etc. (B.K Handique et.al, 2017).

2.2 DATA AND MATERIALS

2.2.1 DATA:

- ***UAV Data***

  In this project using UAV data and it provide Red Band, Green Band and Blue Band. The spectral information of the bands as below

Table 1 : RGB Band spectral details

Sl.No	Band	Wavelength(nm)	Spatial Resolution(cm)
1	Red band	620-750	10
2	Green band	495-570	10
3	Blue band	450-495	10

- ***Google image :***

  Google inc is the one of the biggest software company in the world. They are contributed their technology in all area. In that Google map is the one of the popular website. It provides latest high resolution remote sensing data. In this project for flight planning Google map was used and this map is interlinked with DJI Go mobile application. It is freely available in mobile application as well as website platform.

2.2.2 MATERIALS

Pix4DMapper Software

Pix4DMapper is a Switzerland based drone mapping Software Company. The Pix4DMapper Pro is the professional photogrammetry software. It is working by internet connectivity. The software need minimum hardware requirements for processing the image.

- ❖ Microsoft Windows 7/8/10/Server 2008/Server 2012 with 64 bits.
- ❖ The recommended Processes Intel i5 or i7 or Xeon
- ❖ Integrated graphic cards Intel HD 4000 or above or Any GPU that is compatible with OpenGL 3.2.

- Minimum RAM : 8GB (Must increase if the images are more)
- Storage device (Minimum 500GB)

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eCognition Developer Software

ECognition Developer is powerful software for object-based image analysis. The software is developed by Trimble Munich (Germany) and Trimble Inc (USA) collaborated Geospatial Company. For the automatic analysis of remote sensing data, it is used in earth sciences to develop rule sets or applications for eCognition Architect. eCognition Developer used for all common remote sensing tasks such as vegetation mapping, , change detection, feature extraction and object recognition based on the class generated. The object-based approach facilitates analysis for medium to high resolution satellite data, high to very high resolution aerial image, lidar data, radar data and even hyper-spectral data.

Features & Benefits

- Superior collection of object-based image analysis tools and algorithms
- Analyses raster, vector and point cloud data
- Intuitive development environment for scalable from a single desktop to enterprise production workflows.
- Software Development Kit (SDK)
- Online access to ruleset resources

Superior Object Based Image Analysis Tools and Algorithms:

The eCognition Developer software offers a comprehensive collection of algorithms tailored to the different aspects of image analysis. The user can choose from a variety of segmentation algorithms such as multiresolution segmentation, spectral difference segmentation, threshold segmentation, quad tree or chessboard. The classification done by using some algorithms ranges from sample-based nearest neighbour classification fuzzy logic membership function. Layer operation algorithms allow pixel based filters such as slope, aspect, edge extraction or user defined layer arithmetic to be applied (Source, http://www.ecognition.com/suite/ecognition-developer).

ArcGIS Software

The legend of professional GIS software company Esri (Environmental Systems Research Institute) is an international supplier of geographic information system (GIS) software and aslo web GIS, geodatabase management applications etc. The company is headquartered in Redlands, California.

In this project, ArcGIS 10.5 was used for mapping by using the exported output from the eCognition.

Microsoft Office

Microsoft office package is the application oriented software. In that, Microsoft excel is used for the Table creation. Chart creation and Error matrix by ground truth table.

CHAPTER 3: METHODOLOGY

3.1 Flow chart

Depending on the UAV data acquisition, data processing and data analysis process following flow chart to prepare them for use in subsequent data analytics.

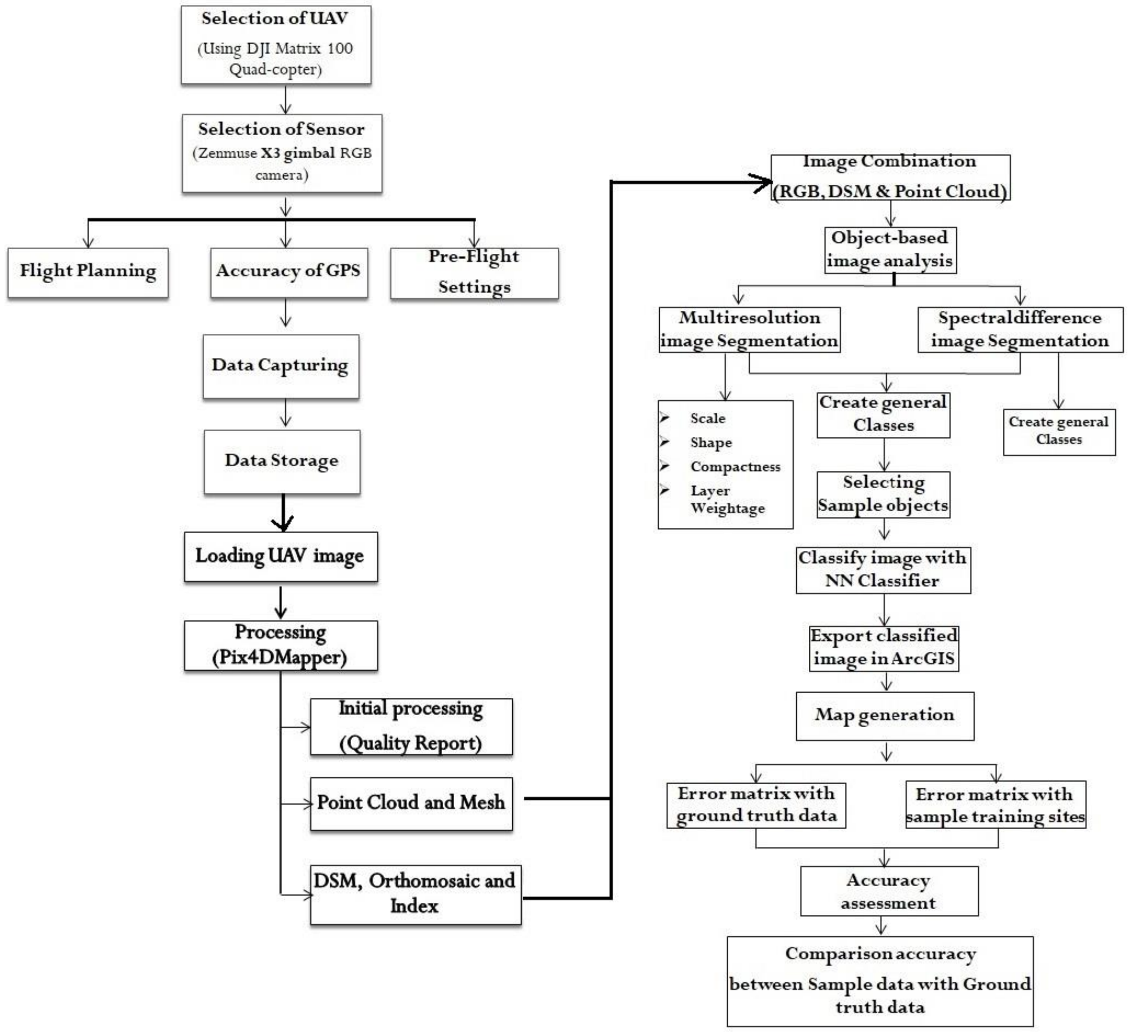

Figure 2 : flow chart

CHAPTER 4: UAV DATA ACQUISITION

4.1 BACKGROUND STUDY UAV

UAV is the short form of Unmanned aerial vehicle usually it says as drone. It is an airborne system or an aircraft operated remotely by a human operator or autonomously by an on-board computer. Now a day, we can find various types of UAV's. In that Fixed wing UAV and Rotary based UAV are popular in uses based on their own nature.

The '***fixed wing UAV'*** is able to carry more weighted sensors as payloads and it carry longer distances with higher performance and also it can fly during rough windy conditions. The '***Rotary based UAVs'*** are capable for take-off vertically and also landing vertically. It performance wisely and maintain a visual on a single target for extended periods of time.

The positive impact of unmanned aerial vehicle is not burdened with the physiological limitations and also it is very less expenses of human pilots. The research purpose many of the Scientists conduct experiment in flexible way (Everaerts_et.al, 2008). In this project rotary based UAV is used.

What are the benefits of UAV?

- It is cheaper, light weight and smaller in size.
- The operations of UAV are very less expensive than other aircraft and also environmentally friendly as it generates very less carbon dioxide and not irritating noise *(Anen and Nebiker et al., 2007).*
- It has been enabled the rapid collection of high resolution data over a region of interest.
- With the fast growing need for highly accurate and detailed observation data required in many applications such as environmental, agricultural and natural resources monitoring.
- It can able to fly in Low altitude and significant growth in recent years *(Réstas, 2006).*
- It is offer low operational cost, flexible nature and rapidity of use and *(Martínez-de Dios, 2006).*
- It can use in harmful or dangerous hazards such as forest fire monitoring, landslides, Floods, avalanche, accident etc *(Casbeer, 2006).*
- It has emerged as an efficient supplement to remote sensing data*(Handique et al., 2016)*

Now a days the number of applications are using UAV remote sensing, such as agricultural monitoring and assessment forest resource assessment including wildlife monitoring, disaster management, large scale land use land cover mapping, 3D modelling etc (Herwitz et al., 2004). The big amount of data, provided by UAVs, poses a new challenge in terms of processing, storage and transmission techniques *(Handique et al., 2016).* In this project more focuses on the initiatives of Agriculture related applications of UAV for the management and of natural resources carried out in NER.

Before going to Survey activity must fallow the set of rules and regulations. First take the permission from Consult District Officer because the flight flaying on the civilian place and after take the permission from local body. Later fix the date based on the permission given by the consulting officer.

The practical part operation to be executed on field in order to perform good UAV survey of a agriculture field crop, Horticulture, forest plot, settlements etc.

The UAV surveys are quite new techniques to acquire data therefore the methodologies and the workflows to be fallowed as shown in the figure (3).

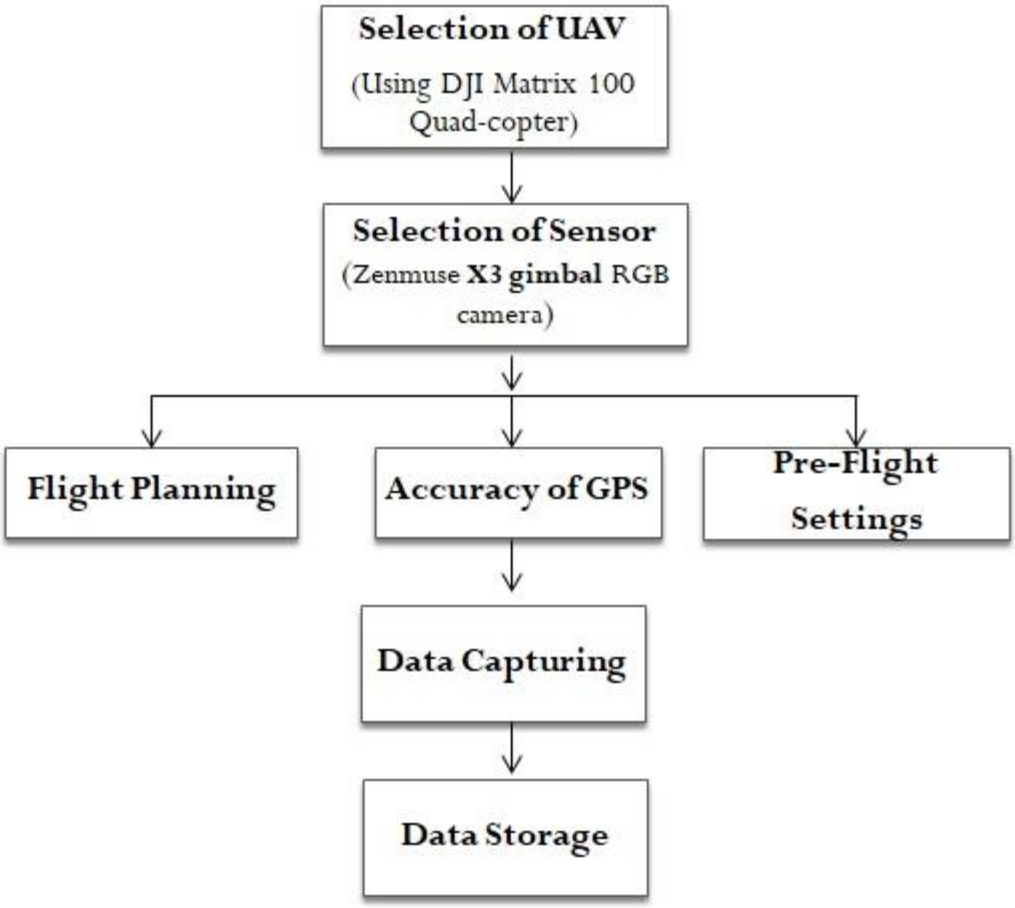

Figure 3 : Flow chart of UAV Data Capturing process

The entire project process takes place majorly UAV data capturing, Data processing and data Analysis.

4.2 SELECTION OF UAV

The selected UAV model is DJI Matrix 100 Quadra copter. It is one of the professional air vehicles and approved by various research institute. As per the project requirements can attached the other components to this UAV. Every UAV has design By using some parameters and assembled and it is done by NESAC.

Figure 4: DJI Matrix 100 Quad-copter image.

The DJI Brand Company is produce innovative products and focus on safety and responsibly and fully owned by subsidiary Shenzhen Dajiang Baiwang Technology Co.Ltd. In 2016, the company got Environmental Management System Certification and got a ISO 900:2015 certificate for best Quality Management System Certifications and also in 2017, got SGS ISO 1400:2015 certificate. Table () : *UAV* Technical specification of aircraft *(Source,www.dji.com).*

Table 2: Specification about the DJI Matrice 100 Quadra copter

Model	DJI Matrice 100
Weight (battery included)	Up to 28 lbs / 3.4 kg
Dimensions	25 x 22 x 13 in (frame arms and GPS mount folded)
Hovering accuracy(P-Mode, with GPS)	Vertical: ± 0.5 m, Horizontal: ± 2.3 m
Max angular velocity	Pitch: 300_/s, Yaw: 150_/s
Max speed of ascent	5 m/s
Max speed of descent	4 m/s
Max speed	22 m/s (ATI mode, no payload, no wind) 17 m/s (GPS mode, no payload, no wind)
Max flight time	Approximately 23 min
GPS Used	RTK

The NESAC conducted number of flight tests have been carried out to capture the useful. The flight performance of the quadcopter was tested in terms of payload carrying capability, endurance, flight height and coverage. All test flight results have been found satisfactory considering the proposed flight plans for different applications.

4.3 IMAGE SENSOR

All of DJI s UAV technologies best supporting sensor is Zenmuse X3 gimbal (figure 5), For ensuring to get stable, professional footage every time, camera must be fixed properly and steady.

Figure 5 : Zenmuse X3 gimbal sensor image.

The 3-axis gimbal constantly draws on data fed by intelligent flight controller, so it understand the aircraft's flight parameters and it computes the proper motion correction per every millisecond.

- The Angular velocity, momentum, inertial force and even GPS data allows the gimbal to apply countering power and force, must fix the camera perfectly level no matter how you fly.
- It can control the speed of 120°/s for tilt and 180°/s for rotation by the operator.
- It is working Ultra-fast processor that is unique.
- This processor controls motors on all three axes: yaw, tilt, and roll.
- It can maintain compensate for motion and tilt in real-time,
- The Brushless motors runs the gimbal are built for higher precision and a longer life.
- The gimbal handle the stress of flight.
- It is possible to control 360° of rotation and -90° to +30° of tilt, all within ±0.03° of accuracy *(www.dji.com).*

4.4 PRE-FLIGHT SETTINGS

Pre-Flight settings are very important in UAV data capturing process. The settings done in **DJI go** app, which is provided by the DJI Company. It can download from any mobile App stores. Here iPhone tab used for visual media and attached to the remote controlling device. Confirm the settings done in this app.

Table 3: DJI go App settings specification

Setting	**Specification**
Date of Survey	17-05-2019 and 12pm
Image Overlap	Side overlap :70 Front overlap :60
Altitude	120m
Resolution	10cm
ISO	Auto

Once the all settings over then fly the UAV and capture the ground features. The captured image is stored in the storage device in the ".jpeg" or ".geoTiff" format. The setting part as below

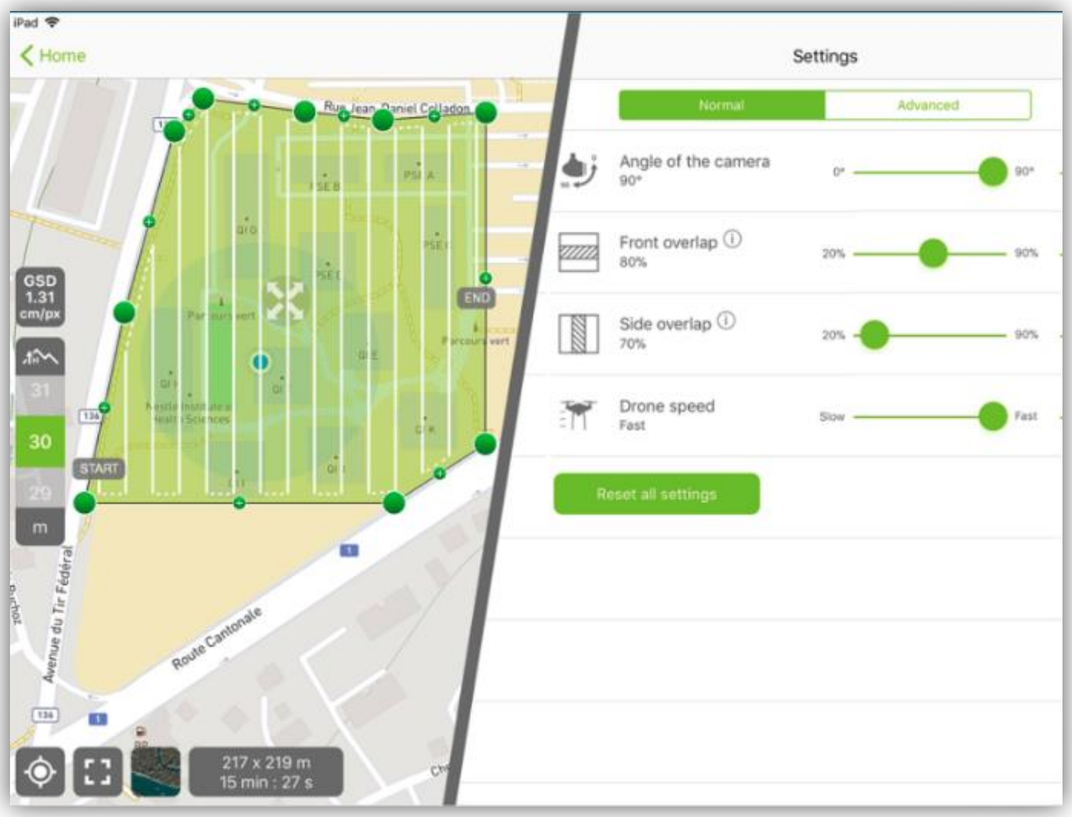

Figure 6 (a): Pre-flight setting in DJI Go app.

4.5 FLIGHT PLANNING

The study area covered more than 300 ha of land. Based on this area a proper flight planning is required for the performance of UAV. The Selected UAV is having the capacity to cover all area in one fly. The DJI go App is preloaded Google map, by referring this map can plan the path of the flight movement in Visual Display and here iPod used and this App is available in both Android App store as well as IOS App store. The study area covered more Vegetation and as per our study is discrimination of features so focus on more height of Tree clads, Settlements and also less height of Agriculture crops. By considering all aspects, the UAV must fixed flight at the altitude of 120m. The area having heterogeneous type of crops, the overlapping of the image is selected as Front overlap is 65 and Side overlap is 70. By considering all these aspect, the flight planned as shown in figure 6(b).

Figure 6(b): Flight Planning

4.6 ACCURACY OF THE GPS ON-BOARD UAV

The real time location accuracy of the pixels captured by the camera mounted in the drone on the ground is very important function and also UAVs are equipped with agricultural equipment's, GPS, for inflight recording with accuracy of ± 5 ft. Every flight, the camera was tightly fixed on a two axis gimbal and pointing vertically(nadir) downwards covering the entire field to generate the Orthomosaic images in posts processing (Mengmeng Du, 2017).

4.7 DATA STORAGE

The operation of UAV and Data transfer is working in Wi-Fi mode which is interacted between remote controller, DJI Go App and Drone GPS receiver and Transmitter. The UAV send the captured Image to remote controller and which is having huge store capacity.

4.8 UAV Survey activity during data capturing:

The survey activity carried in the study area. The team included our Guide and UAV technical person. The operator fallows as per or requirements.

Figure 7: ***UAV data acquisition activity and area survey activity.***

CHAPTER 5: UAV DATA PROCESSIONING

5.1 BACKGROUND STUDY OF PHOTOGRAMMETRY

Photogrammetry is the one of the major task in the UAV projects. The UAV comprises the use of an aerial photogrammetric in survey platform that can be remotely operated, partially operated or fully automatic; in general platform carries a common or infrared digital camera system to

- Capture images.
- A GNSS receiver to provide position for each frame
- A Inertial Measurement Unit – IMU composed by gyroscopes, accelerometers, barometers and compass, which allows determination of the exterior orientation for each image taken during the flight.
- A small CPU that controls all systems and a radio link that enables data download and human control by a remote system (Fabiano da Cruz Nogueira, 2017).
- The larger automation software are designed for Processing UAV by compared to the classical photogrammetry software, because they used Computer vision algorithms that process, calibrate a lot of images.
- They are optimized and of simple operation for the generation of products with less control on the processing steps and on accuracy of the geometric orientation parameters.
- Require as minimum input only the images and the coordinates of each frame. In that there are two parameters are optional, those are Camera calibration parameters and external orientation angles (ω, ϕ, κ), because the software can determine them implicitly at aerial triangulation and block adjustment, although with low accuracy *(Fabiano da Cruz Nogueira,2017)*. So when seeking quality, this data is recommended.

Finally, automatic photogrammetric processing can be completed only with positions from on-board GNSS, but for better accuracy is convenient to use Ground Control Points – GCP and check points for quality control(*Kung et al (2011) and Ferreira et al (2013))*. As the images obtained from UAVs have few centimetres GSD, to maintain positional accuracy in that order, GCP survey must be performed with appropriate procedures. Suppose the image positions and slopes are adverse or the mapping areas with uniform texture as water surface and vegetation during this stage it is difficult to block formation and georeferencing.

The Pix4Dmapper is an image processing Photogrammetry software. It is legal and Professional software. The entire image process explained as shown in flow chart.

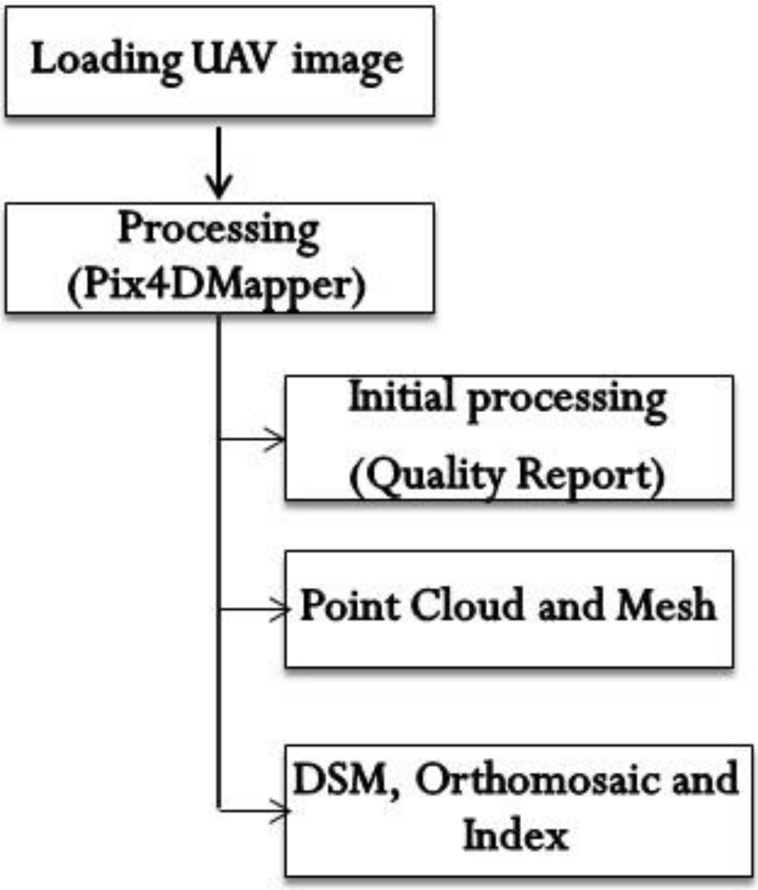

Figure 8: Flow chart Processing of UAV data processing in Pix4DMapper software.

5.2 Loading/Importing UAV Image

Run the Pix4DMapper software and import all captured image in that software and we can see the entire images according to the flight plan.

The Processing majorly done in 3 steps

1) Initial Process
2) Point Cloud, Mesh process
3) DSM Orthomosaic and Index process

5.3 Initial Processing Details

Initial Processing is completed; the Quality Report is automatically generated and displayed. Suppose, if it is not displayed automatically can open the PDF Quality report file generated in the output folder. However, it is automatically displayed in Pix4D Desktop once a step is completed *(https://support.pix4d.com/hc/en-us/articles/202558679-Quality-Report-Specifications).* This process going on by the calibrating all images in Pix4DMapper. The software starts read the similar features in two corresponding images and show the calibrated images. Finally, the software provides the Quality report and in that it provide entire image information like Summary of the processing, Quality Checked repost, Image Calibration Details, Bundle Block Adjustment Details, Geolocation Details and also it provide the each processing details in like Initial Processing Details, Point Cloud Densification Details and lastly DSM, Orth-mosaic Details. The details about the data as fallows. If initial processing failed, the data is not good for analysis. It is recommended to verify the following information in the Quality Report:

5.3.1 Quality Report:

The Quality report provide statistical report and preview of the image, quality check reports, bundle block adjustment etc as explained below.

- **Summary of the processing**

The software provide the details about the processed date, which camera model used, average ground sampling distance and total Area covered. The software provides this information by reading the imported UAV Captured image Metadata.

Project	nongkhrah_RGB_17_05_2019
Processed	2019-05-21 10:09:43
Camera Model Name(s)	M100_X3_3.6_4000x3000 (RGB)
Average Ground Sampling Distance (GSD)	3.61 cm / 1.42 in
Area Covered	0.8737 km^2 / 87.37 ha / 0.3375 sq. mi. /302.008 acres
Time for Initial Processing (without report)	39m:24s

Figure 9: Summary of the processing report

- **Quality Checked report**

The Quality of the data can be seen in the Quality report gives accurate result for analysis. So for the Pix4DMapper software initial provides five important aspects based on that we can judge the data can use or not.

Verify that:

- ❖ All the checks are green.
- ❖ All or almost all the images are calibrated in one block.
- ❖ The relative difference between initial and optimized internal camera parameters is below 5%.
- ❖ The GCP error is must be below 3×GSD.

Images	median of 45780 keypoints per image	
Dataset	733 out of 760 images calibrated (96%), all images enabled, 4 blocks	
Camera Optimization	4.45% relative difference between initial and optimized internal camera parameters	
Matching	median of 6595.23 matches per calibrated image	
Georeferencing	yes, no 3D GCP	

Figure 10: Quality Checked report

- **Preview**

The displayed images are the low resolution preview of the Orthomosaic and the DSM before step 2, just for visual inspection of the quality of the initial calibration. Suppose the Orthomosaic is skewed, there might be an error with the project orientation and GCPs may be required. If the DSM contains large seams or artefacts, there might be due to multiple blocks in the reconstruction. If there are holes in the Orthomosaic and DSM, check the Quality Checks section and the 2D Key point Matches graph.

Verified that the Orthomosaic:

- ❖ It is not containing any holes.
- ❖ It is not having distortions.
- ❖ It is the correct orientation.

Figure 11: Preview of image

- **Image Calibration Details**

In order to calibrate an image, enough keypoints of that image need to be matched accurately with other images of the project. Every keypoint that is matched in at least two images required to allow the generation of a 3D point. One uncalibrated image is not calibrated because no matches with other images were found or because no matches have been labelled as accurate. Therefore, in order to calibrate this image, new matches between it and calibrated images need to be defined manually (https://support.pix4d.com).

In this process, the number of Calibrated Images area 733 out of 760 and Number geolocated Images 760 out of 760 images. This calibration done automatically that can be shown in ray cloud as shown in figure (12).

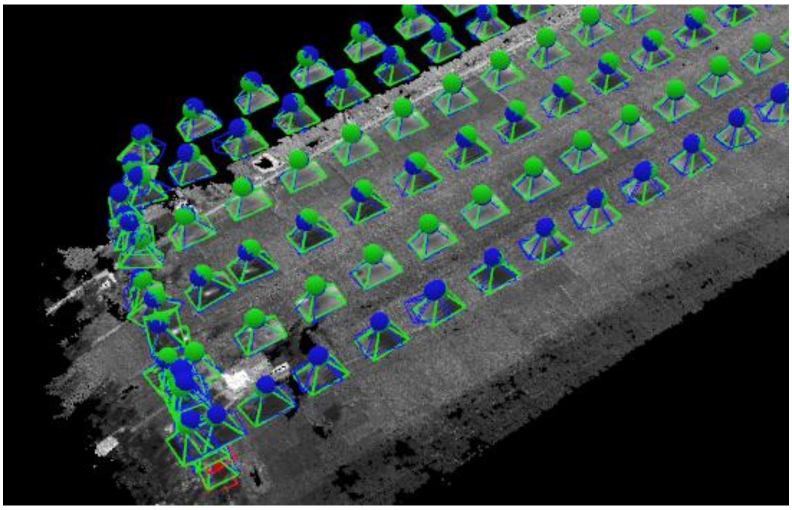

Figure 12: Ray Cloud vision

- **Initial Image Positions**

This is the top view of the initial image position. In this figure can see the green line fallows the position of the images in time starting from the large blue dot.

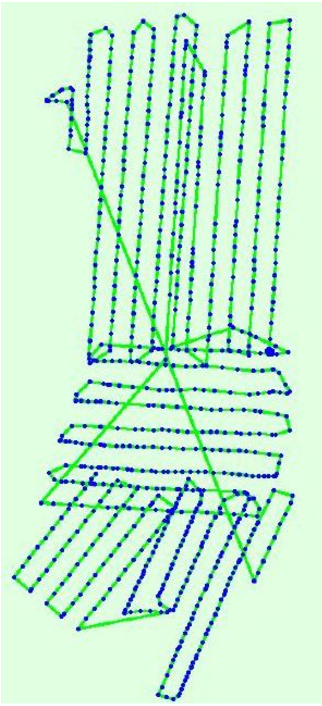

Figure 13(a): Initial Image Positions

- **Computed Image/GCPs/Manual Tie Points Positions**

This graph shows the difference between the initial and computed image positions, the difference between the initial and computed GCPs/Check Points positions (if any), the MTPs positions (if any) and the uncertainty ellipses of the absolute camera positions.

Images: There might be a small offset between the initial and computed image positions because of image geolocation synchronization issues or GPS noise. If the offset is very high for many images, it may affect the quality of the reconstruction and may indicate severe issues with the image geolocation (missing images, wrong coordinate system, and/or coordinate inversions).

If they are correct, the camera calibration can be improved by:

- Increasing overlap/image quality.
- Removing ambiguous images (shot from the same position, take-off or landing, too much angle, image quality too low).
- Introducing Ground Control Points.
- Enable linear shutter optimization in the Image Properties Editor.

An offset between initial and computed position may indicate severe issues with the geolocation due to wrong GCP/Check Point initial positions, wrong coordinate system, and/or coordinate inversions, wrong marks on the images, wrong point accuracy.

- Uncertainty Ellipses: The absolute size of the uncertainty ellipses does not indicate their absolute value because they have been magnified by a constant factor noted in the figure caption. In projects with GCPs, the uncertainty ellipses close to the GCPs should be very small and increase for images further away. This can be improved by distributing the GCPs homogeneously in the project.
- In projects only with image geolocation, all ellipses should be similar in size. Exceptionally large ellipses may indicate calibration problems of a single image or all images in an area of the project.

This can be improved by:

- Adding Manual Tie Points in the area.
- Re-matching and optimizing the project.
- Removing images of low quality.

Offset between Initial (Blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top view (XY plane). Front view (XZ Plane). Red dots indicate disabled or uncelebrated images. Dark green ellipses indicate the absolute position uncertainty of the Bundle block adjustment result. The Red dots indicates that uncelebrated images as shown in Figure 13(b).

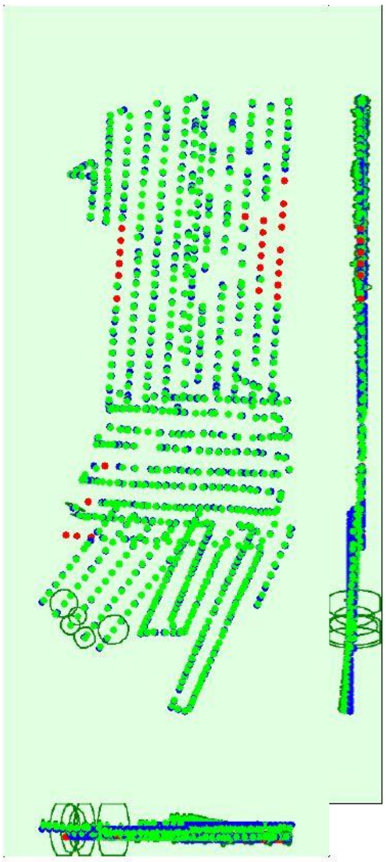

Figure 13(b): Computed Image/GCPs/Manual Tie Points Positions

- **Absolute Camera Position and Orientation Uncertainties**

In projects with GCPs, a large sigma can signify that some areas of the project (typically those far away from any GCPs) are less accurately reconstructed and may benefit from additional GCPs. The absolute camera position and orientation uncertainties is as shown in table(4).

Table 4:The absolute camera position and orientation uncertainties

	X9m)	Y(m)	Z(m)	Omega(Degree)	Phi(Degree)	Kappa(Degree)
Mean	0.377	0.369	0.904	0.251	0.265	0.078
Sigma	0.278	0.255	0.626	0.700	0.764	0.195

Verified that:

- For projects only with image Geolocation, the absolute camera position uncertainty is similar to the GPS accuracy and that the **sigma is smaller than the mean**.
- For projects with GCPs, the absolute camera position uncertainties are similar to the accuracy of the GCPs.

- **Overlap :**

This graph shows the number of overlapping images for each pixel of the Orthomosaic. It only takes into account the calibrated images. Red areas indicate too low overlap. This may lead to low-quality 3D reconstruction in these areas. The overlap is an important parameter for the overall quality. For precise 3D modelling and mapping applications, the overlap should be in green, i.e. each pixel should be visible in more than 5 images.

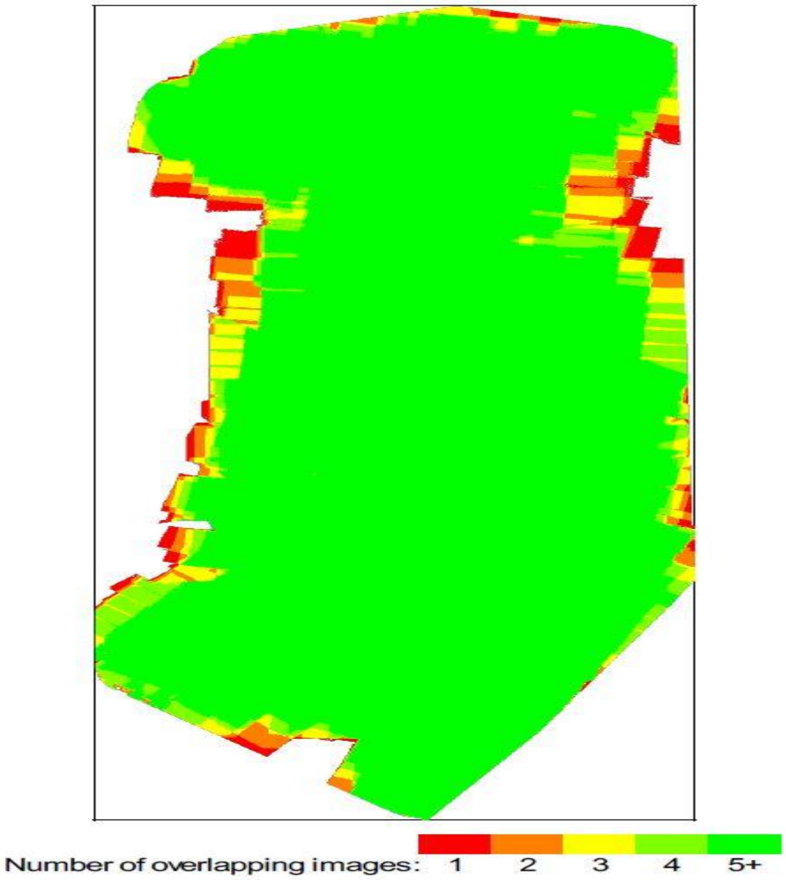

Figure 14: Number of overlapping images computed for each pixel of the Orthomosaic.

In this image can see the Red and yellow areas indicate low overlap for which poor results may be generated. But Green areas indicate good image and its overlap is more than 5 images for every pixel. Good quality results will be generated as long as the number of keypoint matches is also sufficient for these. Likewise, the quality of image indicated by more overlapping of image and indicated in different colour.

- **Bundle Block Adjustment Details**

The bundle block adjustment is a very powerful tool, but good results only can be achieved if the input data are without problems and if a qualified program will be used. There are several bundle block adjustment programs on the market which are not qualified – by the operator support, by the support of the automatic blunder detection, by the self-calibration and by the possibility of an analysis of the achieved results. In addition, some programs do need a computation time in the range of hours while this can be done also in few seconds. It is depending upon the tie points and it connecting the images. Local geometric problems cause the Gaps in the connection. The another parameter is colour code and it is depending upon number of images per point *(Baz et.al)*

The strip adjustment can be based on photo or model coordinates. Neighboured models can be connected by similarity transformation using also the model coordinates of the projection centres. The summation of systematic and random errors effects on the photo strips *(Baz et.al).*

As per current process the Bundle block adjustment report as below table

Number of 2D Keypoint Observations for Bundle Block Adjustment	5207432
Number of 3D Points for Bundle Block Adjustment	1843867
Mean Reprojection Error [pixels]	0.300

Figure 15 : Bundle Block Adjustment Details report

- **Internal Camera Parameter**

The image quality is depends on the internal camera parameters and which are percentage of correlation between the internal camera parameters and it describes the camera parameters relate to each other and it explain how much change occurred one affects to the others. Basically, the camera parameters must be independent, especially when characterizing the interior orientation of a new camera. Thee correlation between camera parameters is expected or can even be helpful in detecting certain types of problems.

Correlation between the camera parameters might occur in projects with:

- Uniform data such as: flat terrain relative to flight heights, GCPs placed in specified height and ATPs/MTPs/GCPs at the edges of the images, all images taken with the same orientation.
- In Nadir point images, the correlation occurred between the parameters of radial distortion and between the 2 principal points coordinates, might occur.
- In Oblique images, the correlation occurred between the focal length and the coordinates of the principal point and also occurred between the coordinates of the principal point and the tangential distortion parameters might occur.

M100_X3_3.6_4000x3000 (RGB). Sensor Dimensions: 6.317 [mm] x 4.738 [mm]

EXIF ID: M100_X3_3.6_4000x3000

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	2285.714 [pixel] 3.610 [mm]	2000.000 [pixel] 3.159 [mm]	1500.000 [pixel] 2.369 [mm]	0.000	0.000	0.000	0.000	0.000
Optimized Values	2183.801 [pixel] 3.449 [mm]	1975.432 [pixel] 3.120 [mm]	1524.319 [pixel] 2.407 [mm]	-0.133	0.125	-0.044	-0.000	0.000
Uncertainties (Sigma)	4.569 [pixel] 0.007 [mm]	0.275 [pixel] 0.000 [mm]	0.216 [pixel] 0.000 [mm]	0.001	0.001	0.001	0.000	0.000

Figure 16 : Internal Camera Parameter Details report

Almost all in projects, correlation between the radial distortion parameters (R1, R2, R3) are assigned by R values and which describe the lens and they are bound by physical constraints.

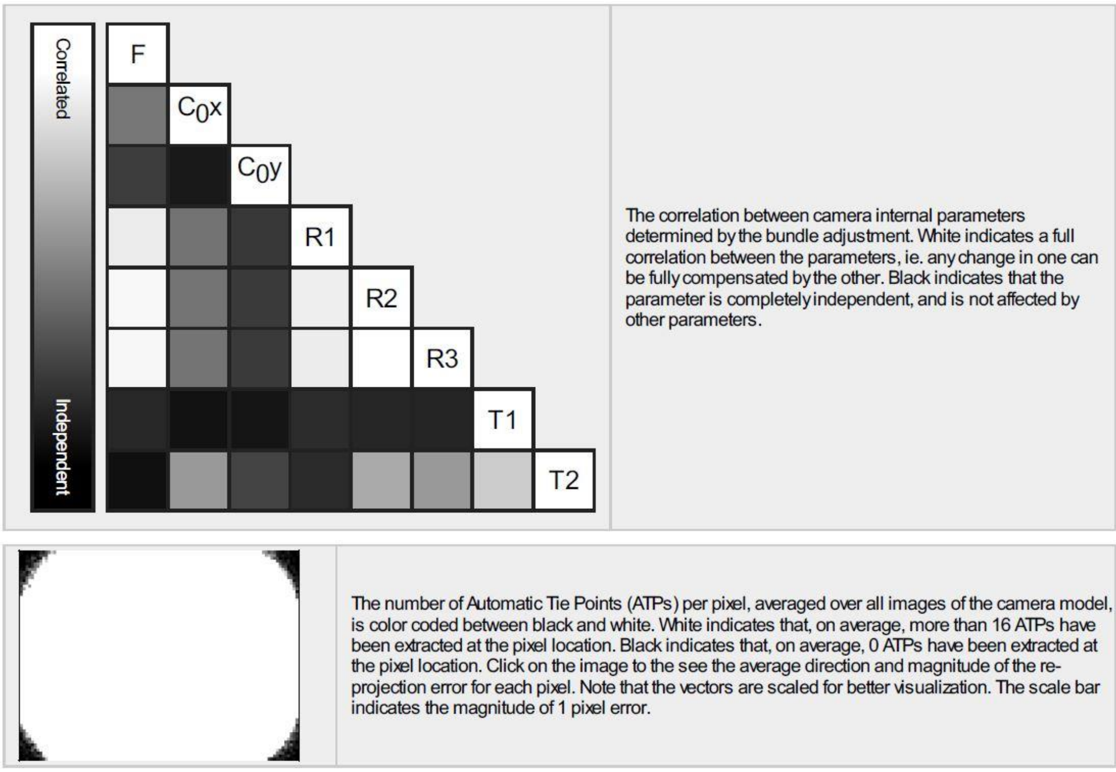

Figure 17: Correlation between camera internal parameters details.

The correlation between the camera internal parameters is determined by the bundle block adjustment. The correlation matrix displays based on the internal parameters compensate each other. The White boxes indicate a full correlation between the parameters and the Black boxes indicate that, the parameter is completely independent not affected by other parameters.

The following help with decorrelation:

- Accurate camera positions (e.g. RTK, or at least GPS), combined with GCPs.
- Terrain depth variations.
- MTPs at multiple depths and near image edges for oblique projects.
- Different camera orientations (eg. rotate at ends of grid rows, so images will be at 180°).
- Using All Prior for the internal parameters optimization.

Having the leading parameters (the focal length (F) and the coordinates of the principal point (c0x, c0y)) highly correlated can be an indicator of a problem with the reconstruction. In this stage, recommended to process the initial process with the all Prior option for the Internal Parameters Optimization:

- ***2D Keypoint***

The fallowing figure displays the statistics information about the keypoints and that matches to each camera model. The quality of image must matches more 2D keypoints.

	Number of 2D Keypoints per Image	Number of Matched 2D Keypoints per Image
Median	45780	6595
Min	31100	59
Max	59520	23128
Mean	45538	7104

Figure 18: Keypoints per Image

- ***3D Points from 2D Keypoints Matches***

Every 3D point are generated by the matched 2D keypoints, which is observed on minimum 2 images. As fallowing table explain about the number of 3D points generated by observing N images. When the number images higher, then the 3D points is clearly visible and also get the more accuracy.

3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	1206471
In 3 Images	329531
In 4 Images	134124
In 5 Images	65536
In 6 Images	35791
In 7 Images	21271
In 8 Images	13097
In 9 Images	8960
In 10 Images	6681
In 11 Images	4916
In 12 Images	3687
In 13 Images	2880
In 14 Images	2239
In 15 Images	1821
In 16 Images	1498
In 17 Images	1217
In 18 Images	853
In 19 Images	779
In 20 Images	650
In 21 Images	519
In 22 Images	359
In 23 Images	319
In 24 Images	195
In 25 Images	114
In 26 Images	102
In 27 Images	101
In 28 Images	67
In 29 Images	32
In 30 Images	27
In 31 Images	12
In 32 Images	8
In 33 Images	6
In 34 Images	4

Figure 19: 3D Points from 2D Keypoints Matches

- ***2D Keypoint Matches:***

The image computed position can visible on top view and it is link between image matching. The dark point links indicate the number of 2D points matched between the images. The brought point link says weak links and it required manual Tie points. The relative camera position uncertainty (Nx magnified) of the bundle block adjustment result indicated by Dark green ellipses. More details as shown in *figure 20.*

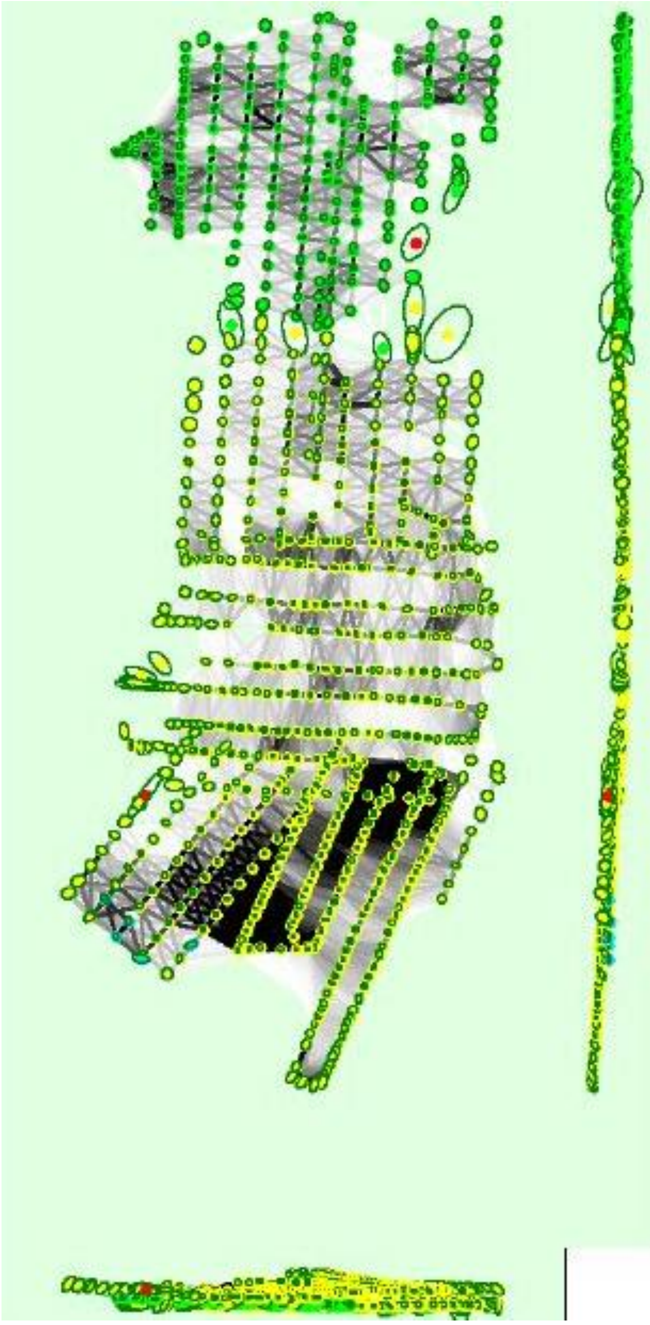

Figure 20: 2D Key points matches

- **Geolocation Details**

The input coordinates for these images are considered as inaccurate. Pix4Dmapper managed to find their correct optimized position but they are not taken into account for the following Geolocation Variance tables.

- **Absolute Geolocation Variance :**

Min Error [m]	Max Error [m]	Geolocation Error X [%]	Geolocation Error Y [%]	Geolocation Error Z [%]
-	-15.00	0.00	0.00	0.95
-15.00	-12.00	0.00	0.00	1.36
-12.00	-9.00	0.14	0.14	3.14
-9.00	-6.00	1.36	4.23	5.32
-6.00	-3.00	5.18	9.14	13.78
-3.00	0.00	42.02	28.79	24.01
0.00	3.00	46.25	49.39	25.24
3.00	6.00	3.41	4.50	14.87
6.00	9.00	1.64	3.82	7.37
9.00	12.00	0.00	0.00	3.82
12.00	15.00	0.00	0.00	0.14
15.00	-	0.00	0.00	0.00
Mean [m]		0.000030	0.000002	0.000103
Sigma [m]		2.081776	2.920653	5.203784
RMS Error [m]		2.081776	2.920653	5.203784

Figure 21: Absolute geolocation errors report

The Columns X,Y,Z show the percentage of images with geolocation errors within the predefined Error intervals. The geolocation error is the difference between the interval and computed image positions.

The notable thing is the image geolocation errors do not correspond to the accuracy of the observed 3D points. The details about as output image as fallow

- The geolocation error intervals between -1.5 and 1.5 times the maximum accuracy of all the images is represented by The minimum and max Errors.
- The percentage of images with geolocation errors in X direction within the predefined error intervals. The geolocation error is the difference between the camera initial geolocations and their computed positions.
- The percentage of images with geolocation errors in Y direction within the predefined error intervals. The geolocation error is the difference between the camera initial geolocations and their computed positions.
- The percentage of images with geolocation errors in Z direction within the predefined error intervals. The geolocation error is the difference between the camera initial geolocations and their computed positions.
- The mean / average error in each direction (X,Y,Z).
- The standard deviation of the error in each direction (X,Y,Z).
- The Root Mean Square error in each direction (X,Y,Z).

Finally The Image Processed Details shown as below details

Hardware	CPU: Intel(R) Xeon(R) Gold 5120 CPU @ 2.20GHz RAM: 128GB GPU: NVIDIA Quadro P6000 (Driver: 24.21.14.1163)
Operating System	Windows 10 Pro for Workstations, 64-bit

Coordinate Systems

Image Coordinate System	WGS84 (egm96)
Output Coordinate System	WGS84 / UTM zone 46N (egm96)

Processing Options

Detected Template	No Template Available
Keypoints Image Scale	Full, Image Scale: 1
Advanced: Matching Image Pairs	Aerial Grid or Corridor
Advanced: Matching Strategy	Use Geometrically Verified Matching: yes
Advanced: Keypoint Extraction	Targeted Number of Keypoints: Automatic
Advanced: Calibration	Calibration Method: Alternative Internal Parameters Optimization: All External Parameters Optimization: All Rematch: Auto, no

Figure 22: *The detail about the Image Processing and coordinate system.*

5.4 POINT CLOUD, MESH PROCESS

A set of data points in 3D coordinates system that explains about the external surface of a terrain or object. The keypoints is nothing but the characteristic point, which is found in the image. Suppose the 2 keypoints are shown on two different images are found to be same, that keypoints is called matched keypoints. 3D point is generated by the group of correctly matched keypoints, that keypoints can be matched together, when there is high overlap between 2 images. If the terrain is flat with homogeneous visual content like agriculture fields and it is difficult to extract common characteristic points (keypoints) between the images. In order to achieve good results:

- The overlaps between images have been increased to at least 85% frontal overlap and at least 70% side overlap.
- Accurate image geolocation have been provided. The GCPs have helped in increasing the accuracy of the image location.

The output processing option and the result as shown figure (23).

Image Scale	multiscale, 1/4 (Quarter image size, Fast)
Point Density	Low (Fast)
Minimum Number of Matches	3
3D Textured Mesh Generation	no
LOD	Generated: no
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	10m:39s

Results

Number of Generated Tiles	1
Number of 3D Densified Points	2484119
Average Density (per m^3)	7.16

Figure 23: Point Cloud Densification Details

Final output generated in two form one is Point cloud file that is in the format of ".las",".laz", ".xyz". and another one is Orthomosaic image that is in the format of ".tiff" format.

5.5 DSM, ORTH-MOSAIC DETAILS

Digital Surface Model file contain elevations that include building, vegetation, power lines and other above ground objects, The ground is only seen when there is nothing else on it. So for the Sensor detect the according to the object height and shape that can store in the spatial information. The DSM provide Altitude (Z factor) by considering the Inverse Distance weighting(IDW) interpolation method was implemented to generate the DSM from dense point cloud data.

DSM=Height of the object + DTM

Orthomosaic files containing Arterial Photographs geometrically corrected so that the scale is uniform with ground distance (GSD).The details of the DSM and Orthomosaic information generated by Software as fallows

DSM and Orthomosaic Resolution	1 x GSD (3.62 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: no
Time for DSM Generation	08m:31s
Time for Orthomosaic Generation	01h:26m:12s

Figure 24 : Orthomosaic and Digital Surface Model

The DSM (Digital Surface Model) is a 2.5 D model of the mapped area. Each pixel of the raster GeoTIFF file and each point of the vector point cloud contain (X, Y, Z) information. They do not contain colour information. By definition, digital surface models (DSMs) represent the spatial distribution of terrain attributes. It is a file containing elevation values representing the terrain height. Such models are needed for plant height (PH) and plant growth (PG) analysis with CSMs.

CHAPTER 6 :
OBJECT BASED CLASSIFICATION AND ACCURACY ASSESSMENT

6.1 SEGMENTATION

Image segmentation is one of the important parts of analysis. For digital image processing they used segmentation algorithms and segmentation technique is used to partition an image into meaningful parts having similar features and properties *(Alka Chauhan,2019)*. Simplification for classification is the main task in this process. The image Segmentation represents meaningful information.

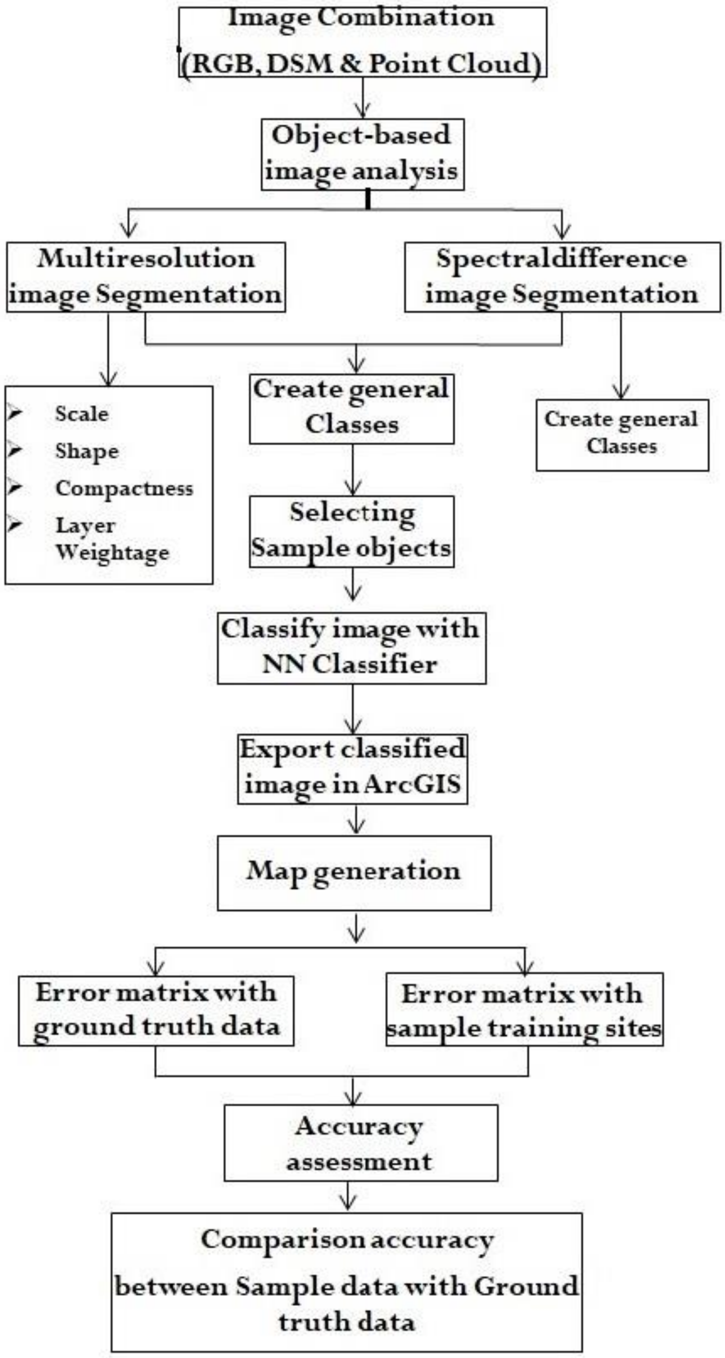

Figure 25: Flow chart of image segmentation and statistical analysis.

After segmentation, there is need of dividing several segments and make similar features is another step for image analysis. Image segmentation is used in some basic applications like, 1) Content based image retrieval. 2) Automatic traffic control systems. 3) Medical imaging. 4) Object detection and Recognition. 5) Tasks and Video surveillance. 6) Artificial intelligent understanding devices etc.

The 2 types of image segmentation, first one is concerned with specific region of the image is called Local segmentation and another one is to concern with segmenting the whole image, consisting of large number of pixels is called Global segmentation.

6.2 Methods of segmentation

In OBIA is arrived based on the some segmentation methods, those are

6.2.1 Thresholding Method

The simplest method of image segmentation is called the Thresholding method. These methods divide the image pixels with respect to their intensity level. These methods are used over images having lighter objects than background. The selection of these methods can be manual or automatic i.e. can be based on prior knowledge or information of image features. Thresholding can be implemented either globally or locally. Global (single) Thresholding method is used when there the intensity distribution between the objects of foreground and background is very distinct. Local Thresholding is also called as adaptive Thresholding (Senthilkumaran, 2016).

6.2.2 Clustering methods

This method of technology are making segment of the image into clusters. Which are having common characteristics of the pixels. Hierarchical method and Partition based method are the two methods of Clustering. In eCognition software having number of algorithms for finding the clusters, but the software can do in two types of clustering.

1. Hard Clustering:

It is one of the simple techniques which is divide the image into cluster, that is combining similar pixel group together and make a meaningful unique object. This system based on the texture, tone, shape etc. of the image. The given values either 1 or 0 i.e. in case the particular pixel is this belong to particular cluster or not. For example, the hard cluster technique is 1 k-mean which is based on the HCM technique. The nearest cluster centre is assigned by the all the computed centre pixels. The cluster quality is maximize the similarity of the intra cluster and also the inter cluster equality is minimize.

2. Soft clustering:

In this technique, suppose if the image is having noise, it never allows dividing the real life cluster. A single pixel can belong to more than one clusters and this type of degree belonging membership values and it is more flexible than other techniques.

6.2.3 Region-growing methods

In this method, the pixels are grouped together make a cluster and again the clusters are merged with similar reflective cluster. Region based segmentation is bounded by the Thresholding technique. Region based segmentation is derived by Similarity Based Segmentation. There won't be any gap due to missing edge pixels in this region based segmentation the boundaries are identified for segmentation. The edge flow is converted into a vector form due to changes in the colour and texture. There are two basic techniques based on this method

6.2.4 Region splitting and merging methods

Region splitting technique is used when the mixed feature make into the single cluster in that time by splitting the cluster into two parts and make it as two different unique features (Dilpreet Kaur, 2014). Merging techniques is used for merging two similar clusters into unique cluster.

6.2.5 Edge-based methods

In image segmentation process, the basic step is edge detection. It divides an image into object and its background. Edge detection split the image by depending on the change in intensity of an image or pixels value. Grey histogram and Gradient are two main methods for detecting edge detections in image segmentation. In edge based segmentation methods, begins edges are detected and after they are connected together to form the object boundaries to segment the required regions. Grey histograms and Gradient based methods are known as edge based segmentation methods (Dilpreet Kaur, 2014). The sobel operator, canny operator and Robert's operator etc. are edge detecting techniques. Result of these methods is basically a binary image.

6.3 Object Based Classification

6.3.1 Segmentation in eCognition Software

The eCognition Developer-8.0 software are used all common remote sensing tasks. Those are object recognition, vegetation mapping, change detection and feature extraction etc. The OBAI approach is facilitates for image analysis of all quality of data sources, such as lidar, radar, hyper spectral data, high resolution satellite data and very high resolution aerial images.

6.3.2 OBIA Tools and Algorithms.

The eCognition Developer software provide algorithms for image analysis. The user can decide the algorithm based on the project and nature of work. In that multiresolution segmentation is the basic algorithm for OBIA. Like that quad tree, chessboard and Spectraldifference segmentation and many more algorithm also used for segmentation for the identifying the homogeneity of classes. The main scope of these classification algorithms used after the sample based nearest neighbour method, fuzzy logic membership function or specialized context-driven analysis (Pratyush Kumar1, 2018). The slope of the area, aspect, feature edge extraction or user defined layer arithmetic to be applied in Layer operation algorithms and it allow the pixel based filters.

- ***Homogeneity Criteria***

In a given 3-dimensional feature space, two adjacent image objects (or initially image pixels) f1d and f2d are termed similar, if their features in the feature space are closely spaced; i.e. they are at a short distance 1 from each other. If the distance is shorter and more likely, then they are to belong to the homogeneity criteria. The degree of fitting results from:

$$\boldsymbol{h} = \sqrt{\sum_{d} (f_{1d} - f_{2d})^2}$$

This difference can be normalized via the standard deviations $\boldsymbol{\sigma_{fd}}$

$$\boldsymbol{h} = \sqrt{\sum_{d} \frac{(f_{1d} - f_{2d})^2}{\sigma_{fd}}}$$

The mean spectral homogeneity of the entire image objects decreases when the pairwise data clustering of two image objects to a larger image object. The aim of an optimization procedure must therefore be to minimize the reduction of the homogeneity associated with each clustering. An image object should be clustered with the neighbouring segment with which there is the lowest reduction of homogeneity.

The segmentation procedure uses the following definitions for object homogeneity:

- **the colour homogeneity (colour):**

  Sum of the standard deviations of the spectral values of the object pixels over all the channels

- **The shape homogeneity (shape):**

  The relative deviation of the edge length derived from the most compact shape (circle). This is defined in two ways:

1. **Edge criterion (smoothness**):

   The ratio between the length of the object edge (l) and the edge length of a bounding box (b).

$$\mathrm{h} = \frac{\mathrm{l}}{\mathrm{b}}$$

2. **Area criterion (compactness):**

   The compactness is deviation from the ideal shape, given by the ratio between length of the object (l) and the root of the object size (n) in pixels.

$$\mathrm{h} = \frac{\mathrm{l}}{\sqrt{\mathrm{n}}}$$

The shape homogeneity h f (shape) is composed of the two criteria of smoothness (S) and compactness (C) as follows:

$$hf = (1 - wf)S + wf\,C,\ mit\ wf = Gewicht\ (hf)$$

The homogeneity h for each image object results from the color homogeneity hc and the shape homogeneity h f .

$$h = (1 - wc)hc + wch\,f,\ mit\ wc = Gewicht\ (hc)$$

these criteria can be interactively selected by the user in eCognition Before each segmentation. Furthermore, the required proximity (4th neighbourhood [standard setting] or 8th neighbourhood [taking the corners into consideration]) can be adjusted as well as the scale.

6.4 Segmentation Algorithms

The eCognition software having more than 20 Algorithms in that, as per study area go through used two algorithms.

1) Multiresolution Segmentation
2) Spectral difference Segmentation

6.4.1 Multiresolution Segmentation:

The multiresolution segmentation used in the eCognition image analysis system fulfils important demands made on a segmentation method for the remote sensing field. In comparison to segmentation methods currently in use, the eCognition image analysis software can be regarded as one of the most powerful systems available at present for the field of remote sensing. The segmentation procedure permits an extraction of various sizes of image objects in a project (multiresolution aspect) so that real-world objects of any magnitude can be identified and classified. Furthermore, it permits the segmentation strategy to be modified depending on the goal. This can be varied by weighting the parameters of colour and shape, and the choice of the neighbourhood (multimethod aspect).

The multisource aspect is fulfilled by the possibility of incorporating various types of additional information Other demands made on an efficient algorithm are the reproducibility of the results and an acceptable speed, even for large data sets. Reproducibility in the sense of repeating the segmentation of the same satellite scene that has already been segmented is completely fulfilled by eCognition. The speed can be described as acceptable even if the segmentation of large high-resolution UAV scenes takes a certain amount of time. In the 8.0 version of eCognition the problem of reduced speed with large data sets has been tackled by a large data handler.

The purposes of the segmentation parameters are (Hofmann, 2001):

- **Scale parameter:**
  - The scale parameter Influence by the average object size.
  - It determines the maximal allowed heterogeneity of the objects.
  - The objects size becomes larger by giving larger value in scale parameter.
- **Shape/Color:** adjust the influence of shape vs. color homogeneity on the object generation. The higher the shape value, the less spectral homogeneity influences the object generation. (The value between 0 to 0.9)

- **Smoothness/Compactness:** determine the compactness or smoothness of the resulting object. With a selected shape value, the user can influence the compactness or smoothness of the final object..(The value between 0 to 1)
- **Image Layer weights:** determine the weight of each spectral band in the segmentation. It is used to control the influence of each band on the object generation. *(ex, for Vegetation NIR band selected as 1 and Red band selected as 2 and other bands select 0)*
- **Level settings:** The order of the level generation affects the objects' shape (top-down vs. bottom-up segmentation). It determines based on the newly generated image segmentation. The labelling level based on the segmentation, either grouped or individual features. Here Mixed horticulture is grouped so named as Level 1, suppose if we go for identifying the individual horticulture is named as Level2 and it is becomes sub-objects of an existing level.

The aim of segmentation is the construction of a network of image objects in which smaller image objects are sub objects of larger superordinate objects. This hierarchical network simultaneously represents information from image objects of different sizes. It is thus also possible to process very heterogeneous images, such as high-resolution satellite scenes or aerial photographs, that have real-world objects on various scales (e.g. buildings, districts of a town, and towns and cities in a landscape).By means of the network structure each image object "knows" its context, its neighbourhood as well as its superordinate and subordinate objects, and relations can be defined between these objects. Figure 3.3 gives a schematic representation of the principle of the hierarchical network of individual segmentation levels, and Fig. illustrates this with real RS data. This network of image objects forms the basis for the object-based classification in eCognition.

The method of multiresolution segmentation is based on the assumption of a colour and spatial continuity of individual image objects. The segmentation algorithm fallowed by heuristic optimization procedure, which is minimizing the mean heterogeneity of the image objects for a given resolution over the entire image (LINGNAU, 2003). A minimization of the heterogeneity leads to more homogeneity so that in the following the expression maximization of homogeneity will be used. In order to optimize the homogeneity, the mean homogeneity of the image objects together with their size (number of pixels) is weighted, and the sum of this weighted homogeneity is maximized over all the image objects (Baatz at.al, 2000).

Multiresolution segmentation functions as a region growing method. This is regarded as a region-based algorithm (cf. Section 2.3). Here, the eCognition image analysis system follows the bottom-up approach. Starting from individual pixels, the segments grow on the basis of a large number of pairwise data clustering (cf. Hofmann et al. (1996) and Hofmann and Buhmann (1997)), which take place regularly and uniformly over the entire picture. The decision to coalesce is taken on the basis of local homogeneity criteria and optimization procedures, which maximize the mean homogeneity of the image objects and the reproducibility. The discussion of the homogeneity criteria and the optimization procedures follow the descriptions in Baatz and Sch¨ape (2000). Here, use is made of the concept of maximization of homogeneity, whereas Baatz and Sch¨ape speak of a minimization of heterogeneity.

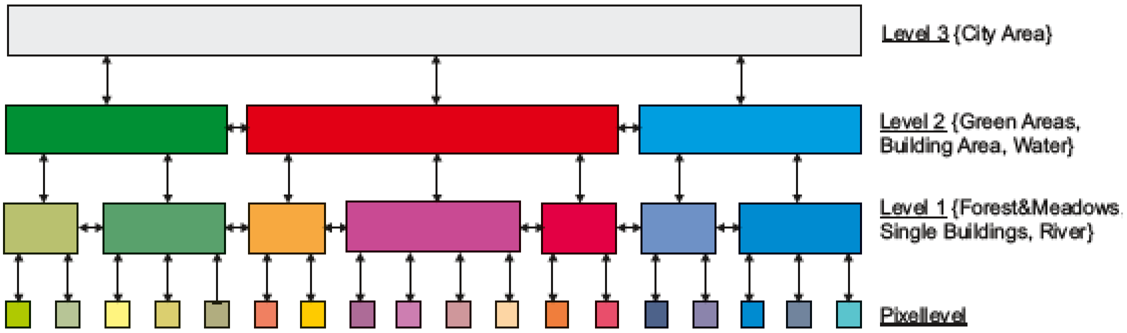

Figure 26: Structure of a Hierarchical Network.

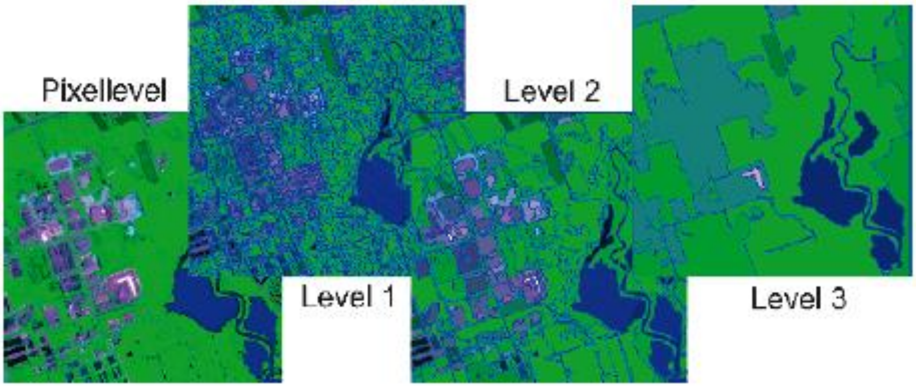

Figure 27: A hierarchical Network of Segmentation level in eCognition

6.4.2 *Spectraldifference Segmentation:*

This algorithm is used for secondary level segmentation fallowed by Multiresolution segmentation. It is also called as object merging algorithm. It works on the bases of neighbouring similar objects with a spectral mean value below the given threshold (maximum spectral difference) will be merged and create new object. To use this segmentation algorithm, it required to have segmentation (level) already in place. It cannot create a new level of segmentation.

After classifying certain surfaces at the LC_ANALYSIS level, namely vegetation, water, shadows and built-up areas (including houses, buildings, roads, parking lots, infrastructure, and other man-made urban objects), the image object level was refined in order to change the point of view and target other surfaces, especially bare soil, mostly present as agricultural land.

The Spectral difference algorithm used to reduce the number of image objects in the image scene. This algorithm allowed for merging of several smaller image objects that in reality does not represent anything meaningful into larger image objects that often represent larger real world objects better. The figure (28) shows the eCognition process Tree.

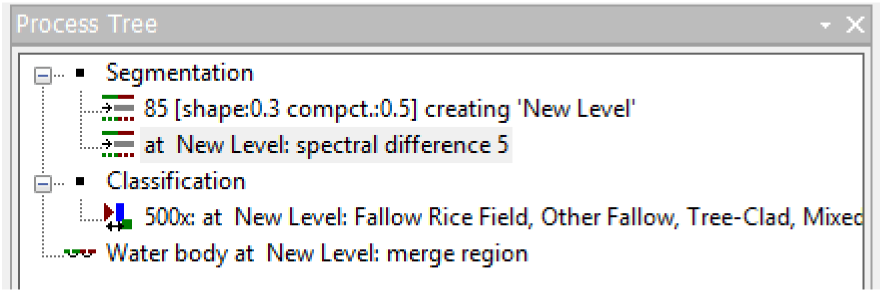

Figure 28: eCognition Process Tree.

6.5 Nearest Neighbour Classification:

In Object based classification techniques, the segmentation is based on the trial and error bases. In this process more than 100 training conducted. For every successive processing, keen observation required on every cluster. The cluster created by the software and which is generated by the shape, size, tone, texture and geometric shapes on the UAV Data. The segmentation moves on by giving the different value and Algorithm used. In this way the Multiresolution Segmentation Algorithm and Spectral Difference Algorithm used and all bands are considering as same weightage and also given the numerical value to Segmentation parameters like Scale, Shape and Size. Many test training conducted by changing the Numerical values in Scale, Shape and Compactness.

The sampling of train class compares all segmentation as fallows

❖ **Shape similarity:**

The geometric form of individual spatial objects is called Shape. It describes based on the specified norms (e.g. circle, square, or triangle). The normalized perimeter index (NPI) is directly propositional to the equal area of circle (eac), and inversely propositional to the equal area of the object. The formula of NPI is,

$$\mathrm{NPI} = \frac{\mathrm{P_{eac}}}{\mathrm{P_{obj}}}$$

Where, *Peac* is the *eac*'s perimeter

This index is used for compare the geometric form of a classified object and also corresponding reference object(s) defined for accuracy assessment. The similarity of the shape (S) is,

$$S = r_{npi^k}$$

Where, rnpi is from classified object's NPI to the reference object's NPI, and k = +1 when rnpi ≤1.0, and the value –1 otherwise. S values range in the [0, 1] interval. A classified object that matches the reference object's form has a value of 1.0.

❖ **Theme similarity**

It described by well classified objects and represents categories assigned to reference objects (Lizarazo, 2014). The % of area of reference object's, which is intersects the classified object's area is derived by

$$\boldsymbol{T = \frac{A_{int}}{A_{ref}}}$$

Where A_{int} is the area of the geometric object representing the point set intersection (OGC 2011) between the classified object and the reference object, and A_{ref} is the area of the reference object's geometry. T returns the percentage of the reference object's area that overlaps the corresponding classified object(s). Values range in the (0, 1] interval. A classified object that completely covers the reference object and matches its thematic category has a value of 1.0. Any classified object that intersects the reference object but does not match its thematic category has a value of 0.0.

- ***Edge similarity:***

A single set of coordinates within a coordinate reference system which is described by direct position of an object (OGC, 2011). A position similarity index considers the centroid position of classified and reference objects. The edge similarity (E) was evaluated by calculating the percentage of the reference object's boundary coincident with the classified object's boundary using fallowing Equation.

$$\boldsymbol{T} = \left(\frac{\boldsymbol{l_{int}}}{\boldsymbol{p_{ref}}}\right)^{\boldsymbol{k}}$$

where lint is length of the boundary of the geometric object representing the point set intersection between the boundary of the classified object and the boundary of the reference object, P_{ref} is the perimeter of the reference object, and k is given the value +1 when lint is less than or equal to P_{ref}, and the value −1 otherwise. Note that boundaries of reference objects have an inherent 'width' due to the uncertainty of the data sources and processing techniques (Skidmore and Turner 1992). The epsilon band is defined as a zone of uncertainty around an encoded line within which there is a certain probability of observing the 'actual' line. The epsilon distance can be considered as the maximum error to be tolerated. The epsilon distance can be defined based on the spatial accuracy of the data sources, i.e. equal to the reported ground distance (horizontal error) at a given confidence level (e.g. 95%). E returns the percentage of the reference object's boundary that overlaps the boundary of the corresponding classified object(s). E values range in the [0, 1] interval. A classified object with a coincident boundary has a value of 1.0.

- ***Position similarity:***

The edge or boundary is defined as the set of line segments that represents the limit of an entity (OGC 2011). An edge similarity index considers both exterior and interior boundaries. Of corresponding objects.

$$\boldsymbol{P} = \boldsymbol{1} - \frac{\boldsymbol{d_{cent}}}{\boldsymbol{d_{cac}}}$$

where d_{cent} is Euclidian distance between the centroid of a reference object and the centroid of the corresponding classified object(s), and *dcac* is the diameter of the combined area circle. P returns a value describing the closeness of the corresponding set. P values range in the [0, 1] interval. A classified object with a correctly predicted position has a value of 1.0.

Traditional pixel-counting-based approaches to accuracy assessment are insufficient for the object-based image processing paradigm (Nikolas Clinton et.al,2010). The accuracy of the segmentation needs little attention because the real object extracted by image segmentation and it is common in many segmentations based studies. The assumption of the landscape of interest is a finite number of objects; the spatial information about these objects is useful in the ultimate classification of the object. Representation of the objects in the segmentation is important, since this shape information will eventually be presented to a classifier to identify a pattern used for object labelling.

Evaluating the quality of a classification result is of high importance in remote sensing since it gives evidence of how well the classifier is capable of extracting the desired objects from the image. Therefore, a thorough classification accuracy assessment is critical as part of this assessment process. In order to conduct a classification accuracy assessment, validation data are required to compare with the classification predictions. Such validation data are often called “ground truth” or referenced data (Verbyla, 2002).

6.6 Comparison of segmentation result with different scale parameters

	
(a) M S: Scale-85 , Shape- 0.3 , Compactness-0.5 And SS : 3	*(b) M S: Scale-85 , Shape- 0.3 , Compactness-0.5 And Sd S :4*
	
(c) M S: Scale-85 , Shape- 0.3 ,	*(d) M S: Scale-85 , Shape- 0.3 ,*

Compactness-0.5 And SS :5	*Compactness-0.5 And Sd S :6*
	
(e) M S: Scale-85 , Shape- 0.3 , Compactness-0.5 And SS :7	*(f) M S: Scale-85 , Shape- 0.3 , Compactness-0.5 And SS :8*

Figure 29: Illustration of Segmentation Results with different scale parameters.*(Algorithm used for Segmentation, Ms S- Multi resolution Segmentation and Sd S- Spectral difference Segmentation)*

Here begins used Multiresolution Segmentation Algorithm and giving by the values of segmentation parameters. The shape parameter having its own limitation in the size of value, From 0 to 0.9 and Compactness also having the limitation value from 0 to 1. By conducting many experimental training, the compactness not affect more on segmentation by changing the value so 0.5 keep constant and varies in the shape value. Based on the study area and features are segmented by proper settings in segmentation parameter. The final segmentation gets by hundreds of training and also must observation need on the image because many changes occurred by every training. In this process the Scale plays a very important role. When the scale increases the cluster size also increases, it means that the homogeneous pixels are club together based on the Nearest Neighbour pixels and made a polygon that we call it as cluster and later call it as Object.

In Image Object Information window show the total number of pixel in a single object and also it shows each band information and Rule set information. Once the Multiresolution segmentation is finalized the primary and very important part is over. In this project the final setting is selected by the segmentation parameter values in Multiresolution Segmentation Scale are 85, Shape-0.5 and Compactness-0.5.

Next part is to merge the homogeneous clusters and make it as meaning full object. Here the Spectraldifference Segmentation Algorithm used for merge neighbouring object according to their mean layer intensity values. This algorithm merges the objects based on the Segmentation settings in the edit process window and the most important parameter is Maximum spectral difference parameter value. In this parameter, the size of the value directly proportion to the number of homogeneous objects merge. After conducting many training finally selected Spectral Difference segmentation is 5. The entire classification processed by using Nearest Neighbour Classification techniques.

Figure 30: Final segmentation Result, M S: Scale-85 , Shape- 0.3 , Compactness-0.5 And SS :5

The study area is having mixed feature and irregular geographic area. In this area the dominant class covered as Horticulture, Agriculture crop and Forest. In this Segmentation process first focus on the Forest (Trees) because the many of the horticulture crop beneath the trees so it is very easy to do the cluster of homogeneous objects. The crone of trees are visible almost all similar in shape. Next bigger aspect is Fallow rice filed. Once the sample is classified the fallow rice field properly, 60% work is accurate. After take random sample of all features.

6.7 Field Survey and Ground truth collection

To Survey the characteristics and spatial distribution of Horticulture crops in the study site, a filed investigation were carried out on 17th May, 2019. A iPhone 6 mobile (GPS enabled) used to record the precise locations of Horticulture crops, Tree clad, Road, Fallow rice field, Shrub, Settlements, Other Fallow and water body. And then these locations were verified with UAV image and Google earth. According to these filed investigations in the study site, the primary Horticulture crop included Banana, Pineapple, Orange, Mango, Litchi etc many of the horticulture crops grown along with the shrubs and tree clads. Due to change in solar elevation angle, there are some shadows on the UAV images. In this study considered as Horticulture area assessment is main focus for that almost all classes used in the object-based classification.

Reference data were collected from the UAV image, The UAV image and Field observations that area verified by local experts. As per study area there 8classess area classified and each class having 26 ground truth collected randomly. As result, 208 ground truth samples were randomly selected.

Table 5: Number of ground investigation points

Sl No	Land Cover Type	Testing Sample	
		Training Sample	Ground Truth Sample
1	Mixed Horticulture	468	26
2	Tree-Clad	376	26
3	Fallow Rice Field	32	26
4	Shrub	124	26
5	Road	65	26
6	Other Fallow	33	26
7	Settlements	79	26
8	Water Body	26	26

6.8 ACCURACY ASSESSMENT

Object-based image classification accuracy will get after the sample training is complete in both thematic and spatial (geometric) aspects. The final result is based on the statistical outputs. Once the overall accuracy is more than 80% , the result is very good and acceptable.

In this study two statistical accuracy assessment techniques were used.

6.8.1 Error Matrix (EM)

An error matrix is a square array that expresses the number of sample units assigned to a particular category relative to the actual category as verified on the ground. An error matrix is a very effective way to represent accuracy because the accuracy of each category is clearly described, along with both the errors of inclusion (commission error) and errors of exclusion (omission error) (Jensen, 1996).

In that, there are 3 sub-types of accuracy.

Producer's Accuracy

User's Accuracy

Overall Accuracy (Jensen, 1996).

6.8.2 **KAPPA analysis (Khat).**

KAPPA analysis is one of the statistical methods for the study of discrete multivariate technique and it is used in accuracy assessment (Congalton et.all, 1983). KAPPA analysis is also used for measure of agreement or accuracy (Rosenfi eld et.al, 1986 and Congalton et.al, 1991). The accuracy assessment of the object-oriented carried out in eCognition and Microsoft excel, using the available accuracy assessment tools in the respective software packages. These assessment tools provide the error matrix and calculate the producer's, user's, overall accuracy, as well as the Kappa accuracy level. Producer's accuracy give the result based proper training set pixels of the given class.

User's accuracy indicates the probability that a pixel classified into a given category actually represents that category on the ground (Md. Rejaur Rahman et.al, 2007).

Kappa statistics indicate how much better the classification is compared to one where randomly assigned class value to each object. The principal advantage of computing KHAT is the ability to use their value as a basis for determining the statistical significance of any given matrix. In the object-based classification accuracy assessment, test sample points were identified for each land use/land cover from the sampling data or ground truth data (GPS data). The error matrices were then used to perform a comparison of the accuracy of two classifications, one is based on the Sample and another based on the Ground Truth (GCP). The Kappa value is more than 80% considered as good classification and less than 40% is poor classification.

The Kappa coefficient is formulated as

$$\widehat{K} = \frac{M\sum_{i=j=1}^{r} n_{ij} - \sum_{i=j=1}^{r} n_i n_j}{M^2 - \sum_{i=j=1}^{r} n_i n_j}$$

Where $\widehat{K}$=Kappa accuracy,

r = Number of rows in error matrix

n_{ij}=Number of observation in ith row, jth column

n_i = Number of observation in ith row

n_i = Number of observation in jth column

M= Number of observation in matrix

Generally, the kappa coefficient is written as

$$\widehat{K} = \frac{OA - CA}{1 - CA}$$

Where $\widehat{K}$=Kappa accuracy,

OA= Overall Accuracy

CA= Chance agreements

CHAPTER 7: RESULTS

7.1 About analysis

In this section, all the final results of the work are presented and described. At first, the results of land cover classification are presented, including classification Accuracy assessment, several statistics for each class are calculated, and later an approach and results for accuracy assessment of Mixed Horticulture density classification is discussed.

7.2 Image object level hierarchy

During the development of image analysis process in eCognition software environment, image object level hierarchy consisting of several image object levels was established, where every level represents different objects or classes and image objects have relationships with their super and sub-objects defined. Table 4 describes the image object level hierarchy. The levels were created in the order that is illustrated in the process flow diagram in the previous chapter.

Table 6: Description of the created image object level hierarchy

Sl No	Image Object Level	Description
1	Multispectral Segmentation Level	Segments representing objects with pixel homogeneity Here, the final segmentation is Scale-85, Shape-0.5 and Compactness-0.5 .
2	Spectral Difference Level	Segments representing objects with high spectral homogeneity

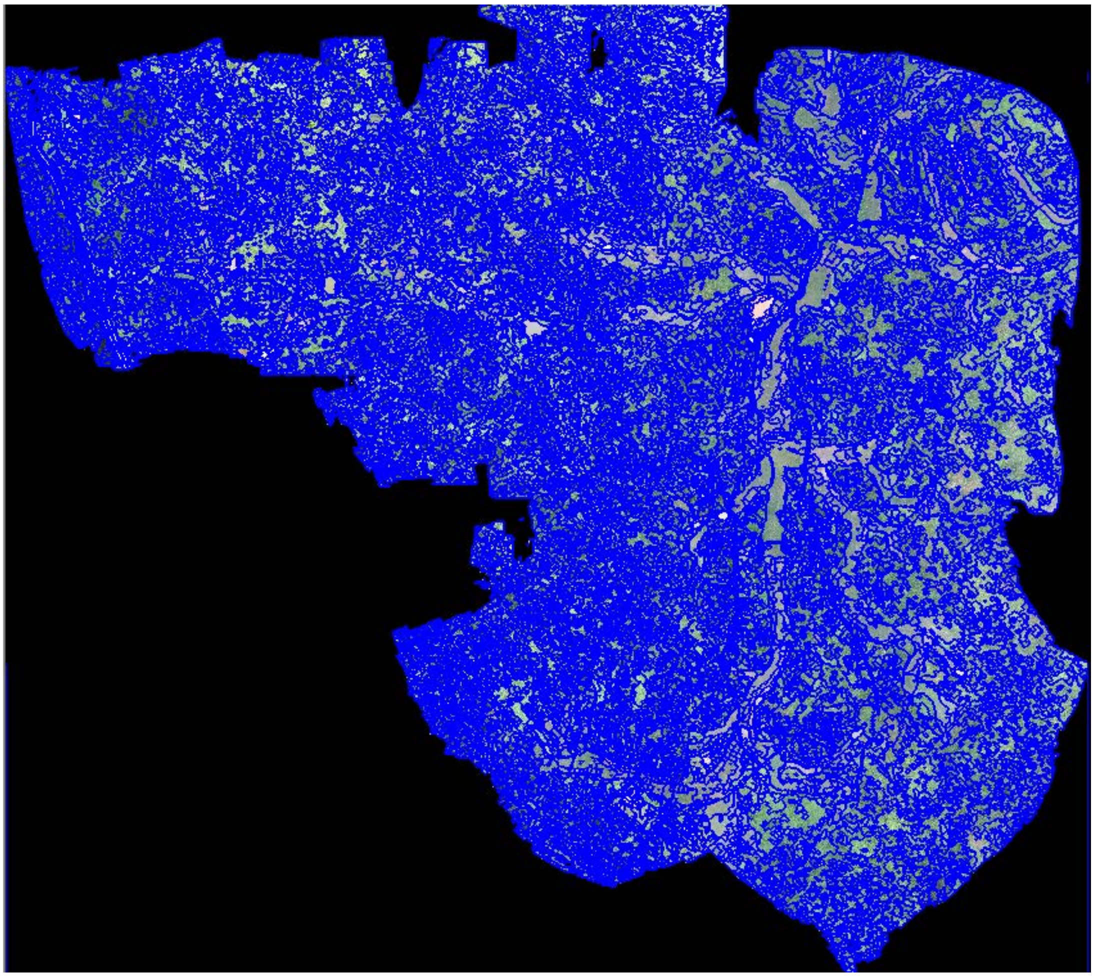

Figure 31: Final segmented image (Full Image).

Each object/Geometry having spatial information like number of Pixels , mean of each bands/layers etc. more details as shown in figure(32).

Feature	Value
Object features	**Customized**
Green Leaf Index (GLI)	-0.00383557
NGRDI	-0.00242039
RGBVI	-0.00766704
VARI	-0.00488033
Layer Values	**Mean**
Layer 1	133.92
Layer 2	133.27
Layer 3	134.68
Layer 4	255
Geometry	**Extent**
Number of pixels	1347702
Relations to sub o...	**Area of**
unclassified (1)	(undefined)
Relations to Classi...	**Class name**
Class name(0,0)	Fallow Rice Field
Class-Related	**Area of classified ...**
unclassified	196856054 Pxl

Figure 32: Image Object Information

7.3 Nearest Neighbour Hierarchical classification method

The object based classification is done by using Nearest Neighbour Hierarchical classification method. The classification process (rule set) was designed to identify 8 classes: Horticulture crops, Tree clad, Road, Fallow rice field, Settlements, Shrub, Other Fallow and water body were produced in the process. The classification based on the number training conducted by using random sample from each classes.

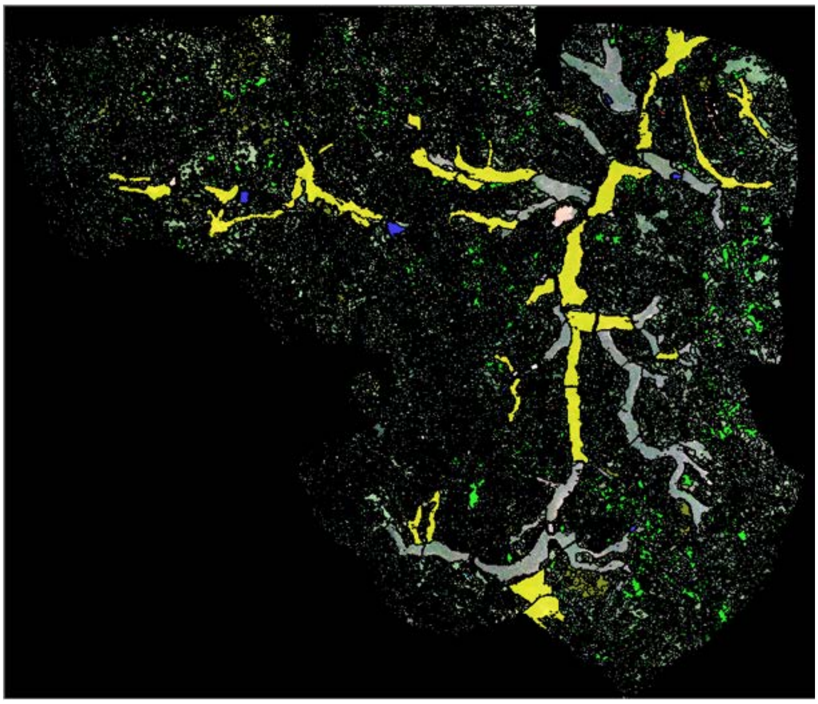

Figure 33: Sample class selected for automatic classification

The eCognition software can classify the classes by assigning the sample training class. The system read the similar and nearest objects by considering the geometric shape , as shown in image object information *Figure 32*. The classified image as fallow *figure (34)* and also can see the Class Hierarchy.

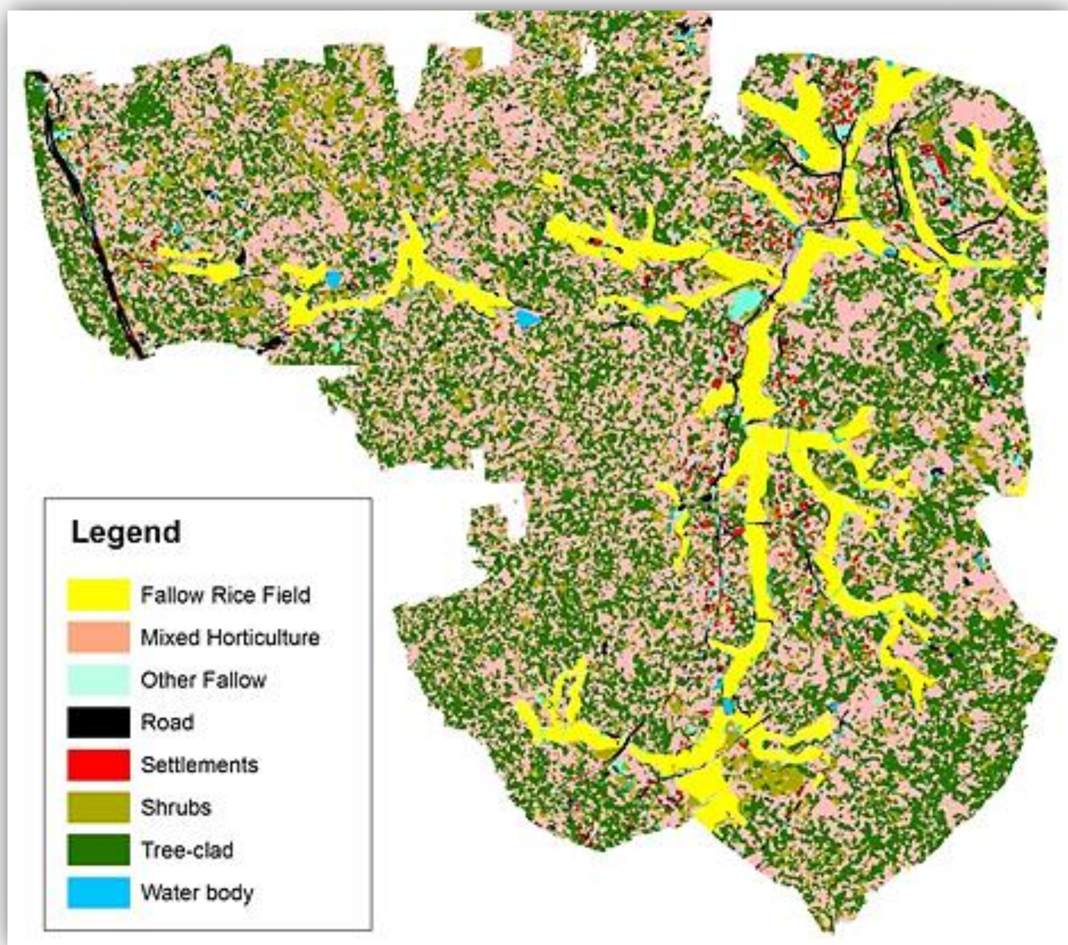

Figure 34: Object Based Classified image generated by eCognition

After the classification, the each object becomes a polygon and having spatial information that can be export in Vector file and finally processing is ArcMap and generate the Map.

7.4 Final Classified image by combining the extracted classes

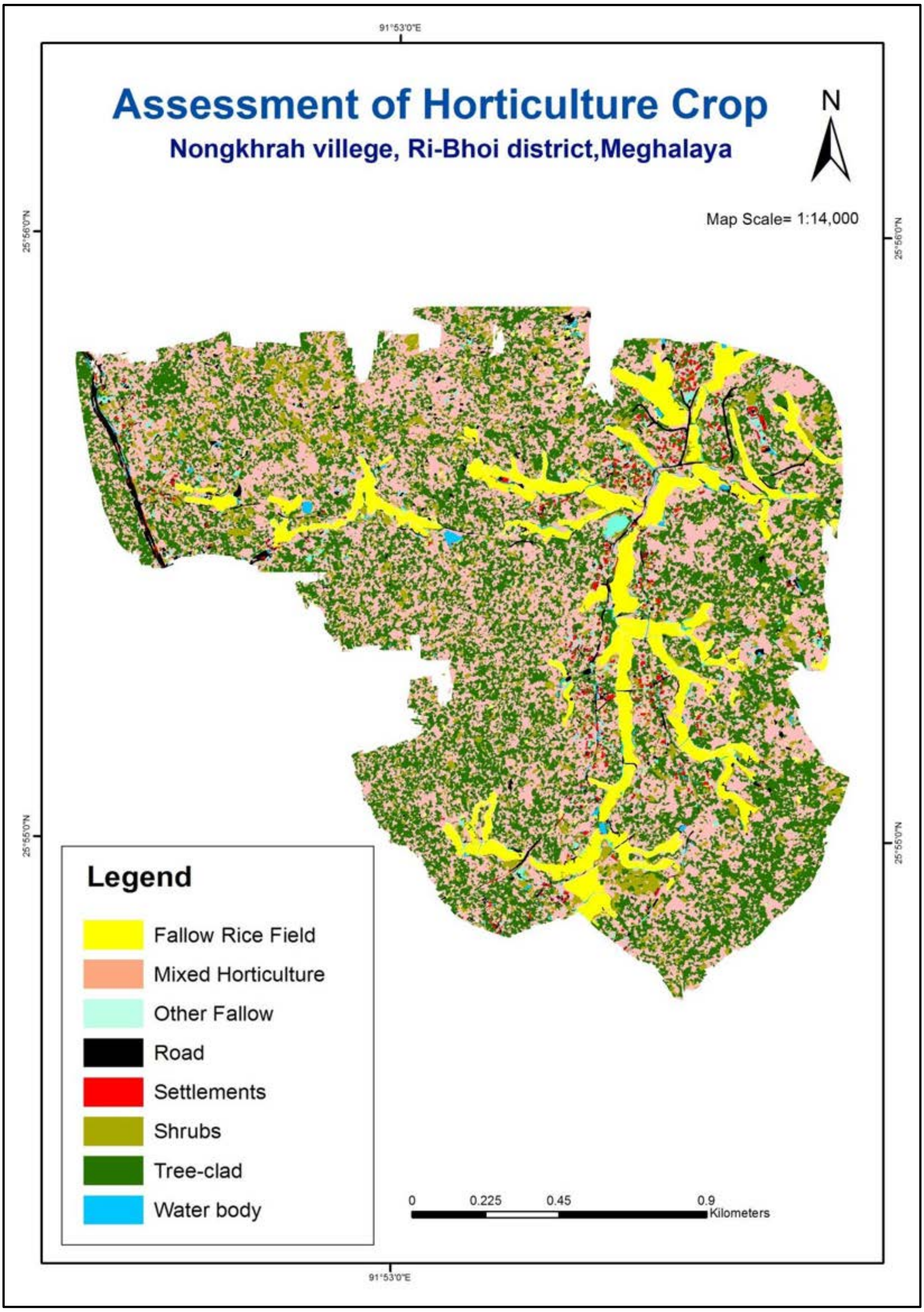

Figure 35: Final classified image by combining information classes extracted from classified images with relatively high user and producer's accuracy.

The Legend explains about the classes selected in the study area. In NE region, there is not having village boundary because of hill region. Here can find the places based on the Grid system.

7.5 LU/LC AREA ASSESSMENT

After performing the land cover classification, statistics were calculated for the resulting land cover map, such as total area and relative area of each class, in order to illustrate the result quantitatively and see the portion of each class on the whole area. (Table 7) illustrate the results of this area calculation.

Table 7: Class wise area Assessment

Sl No	Class Name	Area (ha)	Area in %
1	Mixed Horticulture	124.41	41
2	Tree-Clad	104.95	35
3	Fallow Rice Field	33.22	11
4	Shrub	24.08	8
5	Road	5.86	2
6	Other Fallow	4.03	1
7	Settlements	3.72	1
8	Water Body	2.04	1

The Following chart, explains the percentage of area covered by class wise.

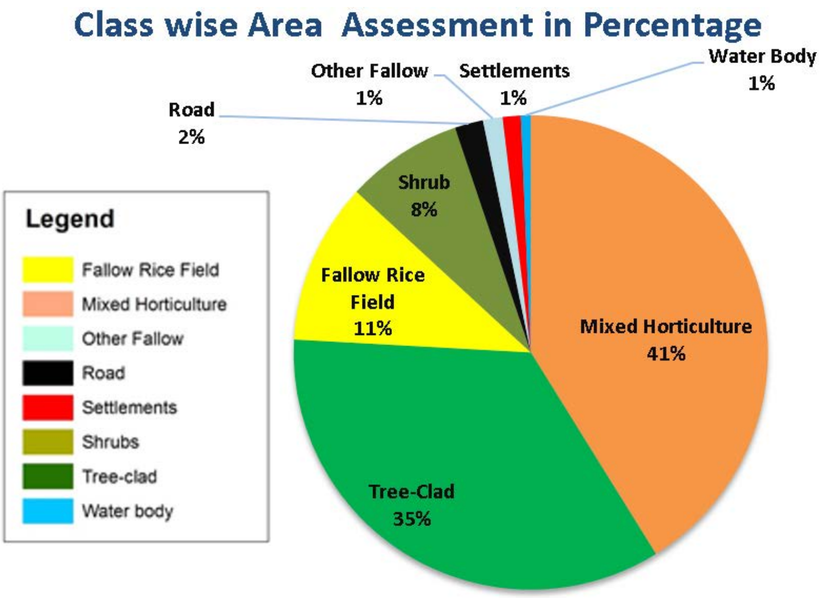

Chart 1: Class wise area Assessment in Hector

The study area full covered Vegetation and in that Horticulture is dominant crop. The total area of this site is 303 Hector land. In that around **41%** of land covers **Mixed Horticulture**. The scenario of horticulture is mixed with Tree clads, shrubs and also along with settlements. It is not possible to classify only Horticulture by using RGB sensor image. By using this image can possible Level 1 classification, it means that mixed classification. In that place banana, Pineapple, Orange, Ginger, Lemon, Litchi, Mango fruits area dominant but all area having different texture and tones but there is lot of miss classification occurs during individual classification. One more important thing is the Pineapple fruit is grown under the tree clads. So that Level 2(Individual Horticulture Identification) fails. The study fixed on the Level 1 classification.

Another dominant area covered by Tree clad. In this place can get more species of Trees. In that, Bamboo is common everywhere and this Tree clad covers 35% in the study area. Next 3rd dominant area coved by Fallow Rice Field that is covered 11%. During February month all crops area harvested and they get ready the land for cultivation. In that scenario the other fallow land and Fallow Rice Field reflected in same tones. So there is chance of miss classification. Even the road networks also miss classification occurs in other Fallow as well as Fallow Rice Filed and also Shrubs. The 4th dominant area covered by Shrubs and it covers 8% of the area. Remaining Road is 2%, other fallow land is 1%, Water Body is 1% and also Settlements is also 1% covered the area in this Study area.

7.5.1 Spectral band Information of classified image

The Spectral Information of classified image getting by Taking mean of all segment of individual layer (Bands). Here the graph shows that the highest spectral reflectance in settlements and lowest in forest *(chart 2).*

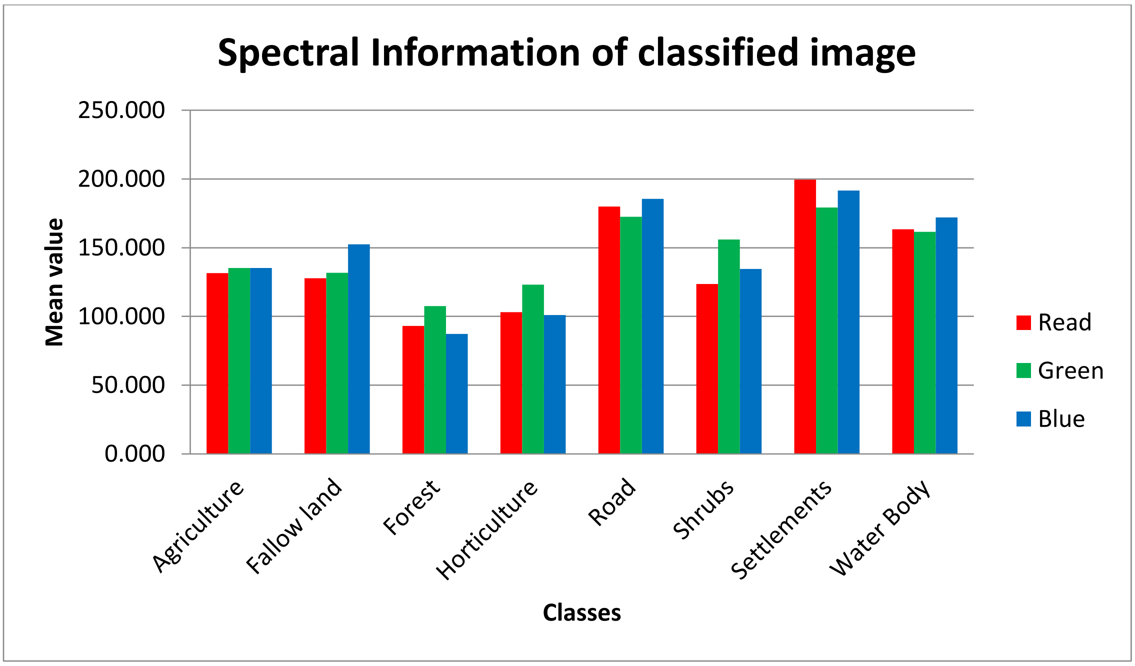

Chart 2: Spectral information of classified image.

7.6 SOFTWARE ACCURACY

The eCognition software provides the Statistical information in that Classification stability, Best classification result and lastly it provides the error matrix based on the sample.

7.6.1 Classification stability

In classification stability can provide the information of the number of object per each class and its mean values, Standard value, minimum and maximum values. The details a shown in the figure (36)

Classification Stability

Class	Objects	Mean	StdDev	Minimum	Maximum
Fallow Rice Field	1152	0.002458609382	0.002807067825	3.695487976e-006	0.02359825373
Tree-Clad	29296	0.01218439178	0.0309694213	5.960464478e-008	0.1776611
Mixed Horticulture	30175	0.003698644891	0.007331710154	0	0.1908333
Settlements	2227	0.05652081394	0.09792333935	2.205371857e-006	0.5638285
Shrub	4616	0.002734780002	0.005615010241	0	0.07619184256
Water body	729	0.00544575098	0.006413151318	9.894371033e-006	0.04834902287
Road	2102	0.007642956686	0.009776268727	1.490116119e-006	0.09549194574
Other Fallow	1306	0.01027123381	0.01166418595	1.847743988e-006	0.09304982424

reduce expand Close

Figure 36: classification stability report

7.6.2 Best Classification Result

The software calculate itself and provide the best classification by referencing the mean, standard deviation minimum and maximum band values and provide the best result by class wise.

Best Classification Result

Class	Objects	Mean	StdDev	Minimum	Maximum
Fallow Rice Field	1152	0.9962986	0.005452431117	0.9337463	1
Tree-Clad	29296	0.9866213	0.04920068267	0.2376103	1
Mixed Horticulture	30175	0.9952764	0.01124285218	0.6872181	1
Settlements	2227	0.9845584	0.04202677097	0.161	1
Shrub	4616	0.9956386	0.01247791923	0.765	1
Water body	729	0.9917842	0.01851006499	0.719	1
Road	2102	0.9903763	0.01657089379	0.6836872	1
Other Fallow	1306	0.9887654	0.016143922	0.602	1

reduce expand Close

Figure 37: Best classification result

7.6.3 Error Matrix based on Samples Objects

Accuracy assessment for the final classified image based on the sample training class is given by the error matrix in table. From this error matrix, the eCognition software provides accuracy based on the assigned sample of training class. ***The producer accuracy, user accuracy and kappa coefficient is 100% accuracy.***

Error Matrix based on Samples

User Class \ Sa...	Fallow Rice Field	Tree-Clad	Mixed Horticulture	Settlements	Shrub	Water body	Road	Other Fallow	Sum
Confusion Matrix									
Fallow Rice Field	32	0	0	0	0	0	0	0	32
Tree-Clad	0	376	0	0	0	0	0	0	376
Mixed Horticulture	0	0	468	0	0	0	0	0	468
Settlements	0	0	0	79	0	0	0	0	79
Shrub	0	0	0	0	124	0	0	0	124
Water body	0	0	0	0	0	26	0	0	26
Road	0	0	0	0	0	0	65	0	65
Other Fallow	0	0	0	0	0	0	0	33	33
unclassified	0	0	0	0	0	0	0	0	0
Sum	32	376	468	79	124	26	65	33	
Accuracy									
Producer	1	1	1	1	1	1	1	1	
User	1	1	1	1	1	1	1	1	
Hellden	1	1	1	1	1	1	1	1	
Short	1	1	1	1	1	1	1	1	
KIA Per Class	1	1	1	1	1	1	1	1	
Totals									
Overall Accuracy	1								
KIA	1								

reduce expand Close

Figure 38 : Computer generated Error Matrix based on Samples Objects

The training sample collected randomly throughout the image. As per the project more sample training conducted on Horticulture (468 samples) and Tree-clads (376 samples) because this is the dominant in this area.

7.6.4 Error Matrix based on Ground Truth

Accuracy assessment for the final classified image *(Figure 38)* is given by the error matrix in table. The error matrix done by the ground truth method and it shows ***overall accuracy is 82%*** *and* ***Kappa coefficient is 80 %*** individual user and producer accuracy mentioned in table.

Classes	**Mixed Horticulture**	**Tree-Clad**	**Fallow Rice Field**	**Shrub**	**Road**	**Other Fallow**	**Settlements**	**Water Body**	**Sum**	**User Accuracy per Class**
Mixed Horticulture	**24**		**2**						26	**92%**
Tree-Clad	**1**	**25**							26	**96%**
Fallow Rice Field	**4**		**22**						26	**85%**
Shrub				**24**			**2**		26	**92%**
Road				**1**	**21**		**4**		26	**81%**
Other Fallow	**7**	**3**	**1**			**15**			26	**58%**
Settlements		**1**					**23**	**2**	26	**88%**
Water Body	**1**	**5**					**3**	**17**	26	**65%**
Total	**37**	**34**	**25**	**25**	**21**	**15**	**32**	**19**	208	
Producer Accuracy	**65%**	**74%**	**88%**	**96%**	**100%**	**100%**	**72%**	**89%**		
Overall Accuracy	**82%**									
Kappa Co efficient	**80%**									

Figure 39 : Error Matrix based on Ground truth

As per the objectives, the assessment of Horticulture (Mixed Horticulture) area is main goal so the result got 92% accuracy and also 96% of Tree clad also part of Horticulture. Because many place pineapple is grown along with tree clads and also shrubs. There are 2 miss classification occurs in fallow rice field because the Horticulture segments and fallow land segments are similar area, geometrical shape, size, number pixel, perimeter etc. and in this region the horticulture is not having particular pattern that's why many miss classifications assigned in Horticulture classes. The details of other classes are shown in the table.

The ground truth collecting each class by 26 GCP's and total is 208 GCP's of 8 Classes.

a) Mixed Horticulture

b) Tree-Clad

c) Fallow Rice Field

d) Shrub

e) Road

f) Other Fallow

g) Settlements h) Water Body

Figure 40: Ground truth sample collected by each class's photos

7.6.5 Comparison between Error matrix between sampling method and Ground Truth method

Comparing both methods found some error in classification by using sample method. The following table interpreted details about the Overall accuracy, kappa coefficient.

Table 8: Comparison between Error matrix between sampling method and Ground Truth method

Classes	Error matrix based on Ground truth		Error matrix based on Sample	
	Producer Accuracy	User Accuracy per Class	Producer Accuracy	User Accuracy per Class
Mixed Horticulture	65%	92%	100%	100%
Tree-Clad	74%	96%	100%	100%
Fallow Rice Field	88%	85%	100%	100%
Shrub	96%	92%	100%	100%
Road	100%	81%	100%	100%
Other Fallow	100%	58%	100%	100%
Settlements	72%	88%	100%	100%
Water Body	89%	65%	100%	100%
Overall Accuracy	82%		100%	
Kappa Co efficient	80%		100%	

While conducting ground truth, there is huge difference occurred in result because, the software classified the classes based on the area, geometrical shape, size, number pixel, perimeter etc. by training sample. Suppose if the one segment as sample class assigned. The segment value is 1.0, after processing classification it start comparing similar features object by considering all aspects like area, geometrical shape, size, number pixel, perimeter etc. when the object comes similar feature it assigned as per the assigned sample class else it assigned miss class.

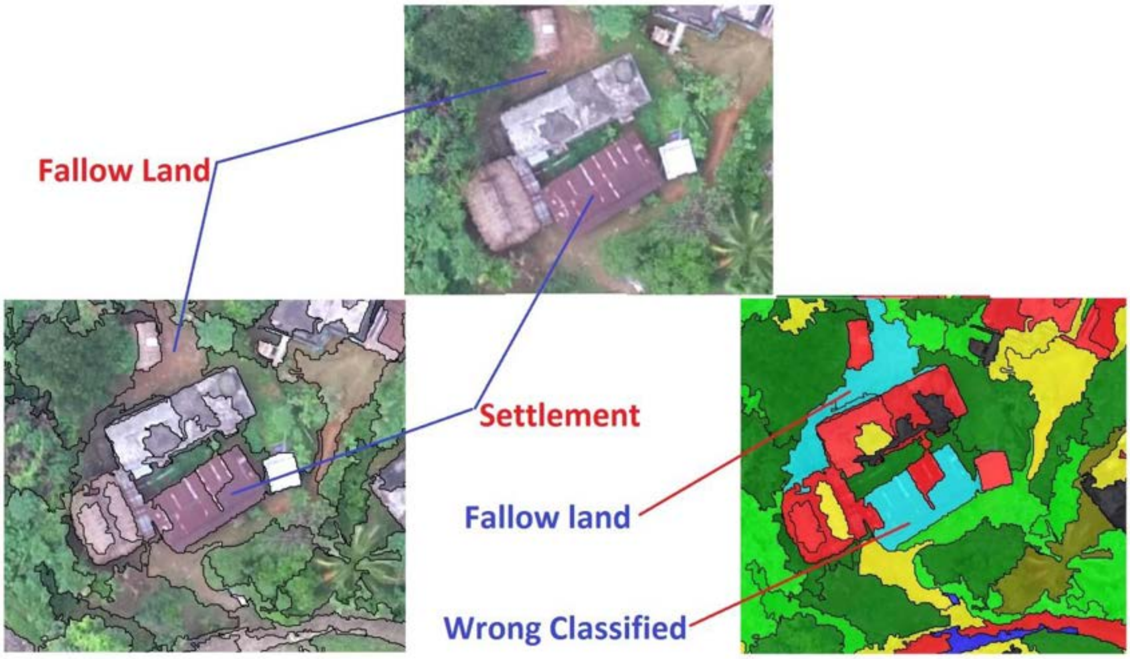

Figure 41: Miss Classification in segmentation.

There is lot of miss classification occurs but it is only now after the ground truth. So ground truth verification must be necessary.

CHAPTER 8:
CONCLUSION AND DISCUSSION

We develop a UAV-based RGB sensor (Camera) platform that collected a series of field images with Very high resolution on the Nangpoh region. The quality of data based on the proper flight plan, suitable UAV and sensor.

The clever job is to calibrate the UAV captured images in photogrammetry software. In that Pix4DMappaer is one of the user friendly and professional photogrammetry software. It generates the Quality of report after initial process. In that, we can conclude based on the quality check aspects, those are number image calibration, camera optimization, georeferencing, number of keypoints per image. And also verify the image using statistical information like absolute camera position and orientation uncertainties, Bundle Block Adjustments details, Relative camera position and orientation uncertainties, Geolocation details, projection and coordinate system, Point cloud densification details and Digital Surface model (DSM) and Orthomosaic. After referring all these information must see the image is having radiometric error or not because some time there is chance of error in image that to at the edge side of image and also we can find the black holes in image. The hole is formatted because of sensor not sense the object properly so the 2D and 3D key points are not able to calibrate. In that scenario must be take care about the feature and during Ground truth collecting time must verify the feature.

Finally, the object based classification is one of the latest technologies for precession of crop area estimation as well as monitoring. So the eCognition developer software is one of the professional software especially for object based classification. The Multiresolution segmentation and Spectraldifference segmentation are the algorithm used for object based segmentation and NN Classifier is used for the classification based on the sampling method.

The main objective is assessment of Horticulture area in Nangpoh village. The area is horticulture dominant but the horticulture practice is not proper way. The banana, Pineapple, Orange, Zinger, Litchi, Mango are the major horticulture crops. It is not easy to estimate crop area estimation by regular Satellite Remote sensing. The UAV provides cm spatial resolution data. The accuracy assessment is carried out by two methods one is based on the sampling method and based on Ground truth method. The sampling method is software generated report and it shows 100% to all user accuracy, producer accuracy, overall accuracy and Kappa coefficient. When we gone for Ground truth verification we found lot of miss classification happened because of similar segmentation of other classes.

Finally the ground truth provides the accurate result. The percentage user accuracy of the classes Mixed Horticulture is 92%, Tree Clad is 96%, Fallow rice field is 85%, Shrubs is 92%, Road is 81%, other fallow is 58%, settlements is 88%, water body is 65% by comparing all classes the other fallow is very less because the other fallow is very less and it included mixed horticulture crops and tree clads so many of miss classes area assigned with other class. The producer accuracy of the classes Mixed Horticulture is 65%, Tree Clad is 74%, Fallow rice field is 88%, Shrubs is 96%, Road is 100%, other fallow is 100%, settlements is 72%, water body is 89%, in this the many missed classes are assigned to Mixed Horticulture so the Mixed horticulture having very less in producer accuracy but 92% in user accuracy. Overall accuracy is 82% and Kappa coefficient is 80%. The classification is good because the minimum percentage of Kappa coefficient is 80% so our result also 80%.

After analysis 20% results comes error because of the main reason is that the information of RGB images is very limited, and its spatial resolution is 10cm. which cannot reflect more physiological information. Commercial RGB camera provides spectral characteristics. By this data possible only Level 1 (for estimate mixed Horticulture) but not possible to level 2(classification of indivisible horticulture crops). For level 2, the data must be Multispectral data with red_edg and NIR band and apply ruleset method by using various vegetative indices.

8.1 Acknowledgements

The UAV(DJI M100), Sensor(Zenmuse X3 gimbal) , Pix4Dmapper Pro software and ArcGIS software are used in this project was provided by North Eastern Space Application Centre, Government of Inadi, Dept of Space, Umiam, Meghalaya.

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8.3 **Appendix**

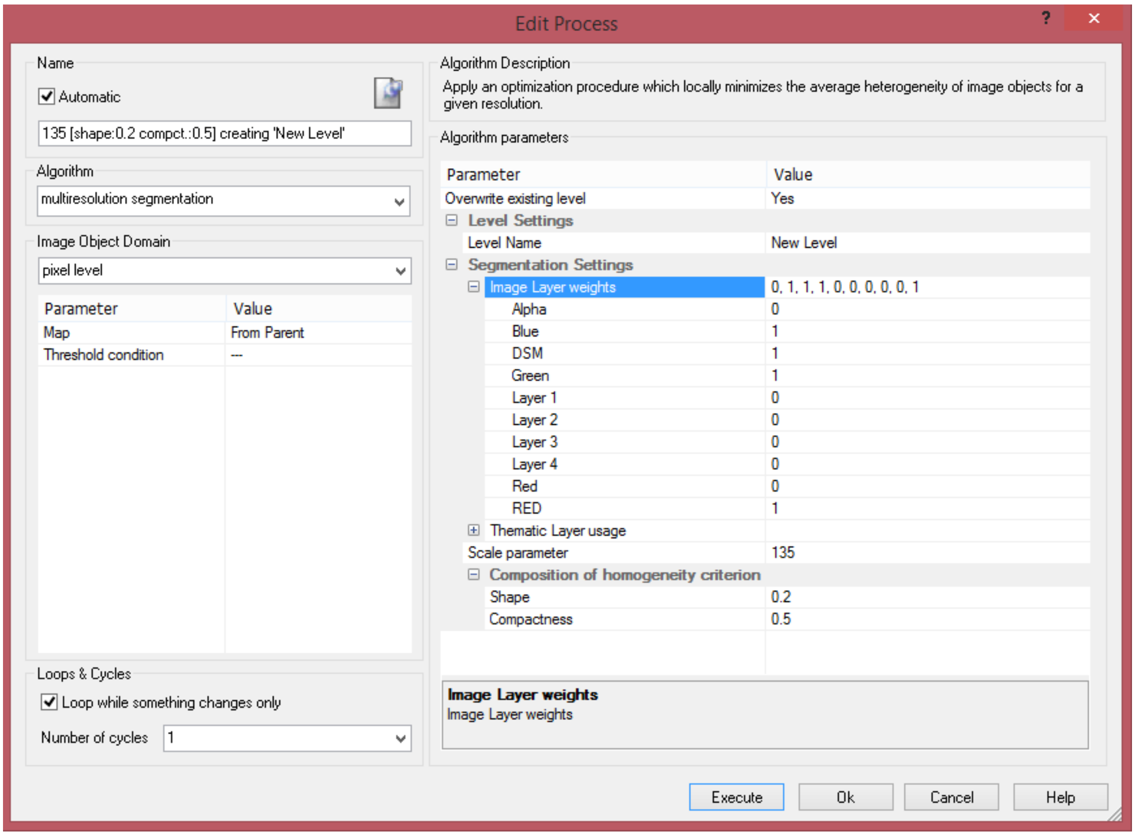
- **Nongg Ortomosic image**

This image captured by same UAV and Same sensor. But it is having 4cm spatial resolution and the features are clearly visible. When the resolution increases, the accuracy of result increases.

Object Based Classification:

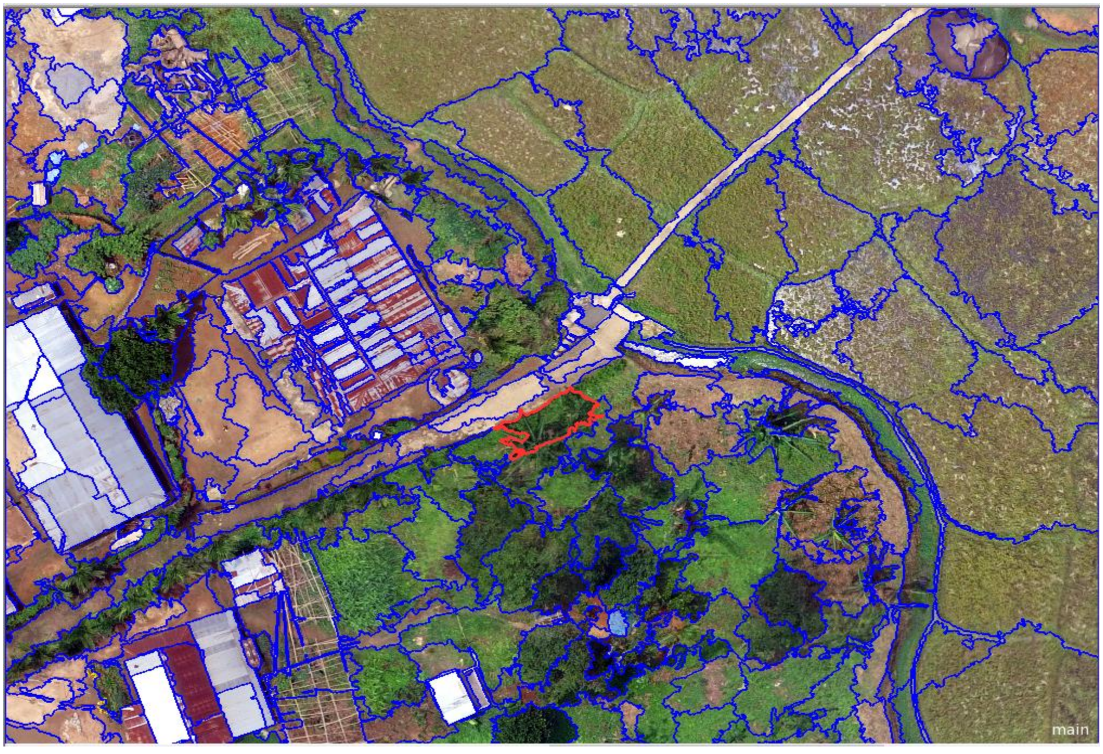
SEGMENTATION : Scale -135, Shape-0.2 and Compactness-0.5

ALGORITHM : Musltiresolution Segmentation

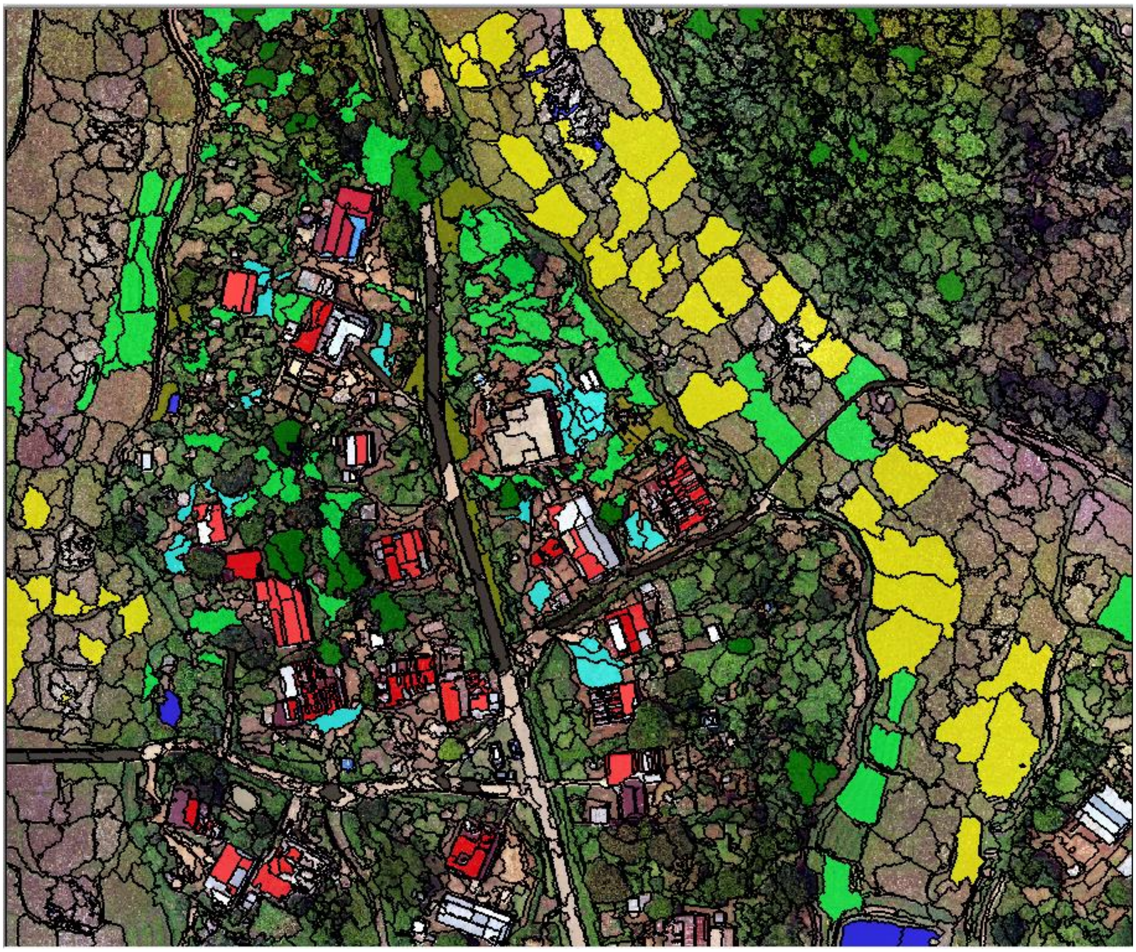


Final segmented image :

Subset of the same Image:

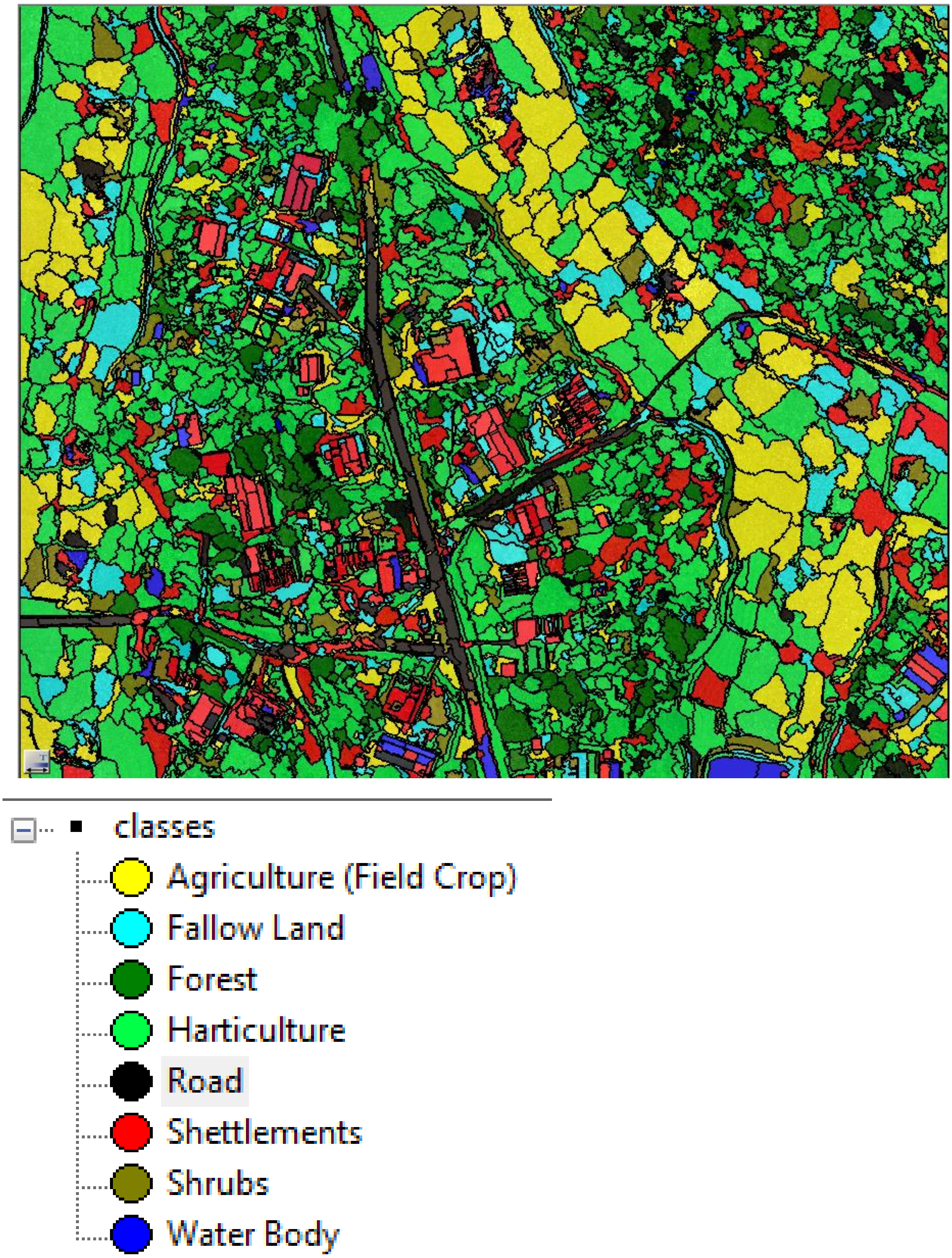


Sample object features:



Subset of Sample training:

Final Classified Image:



The 4cm spatial resolution UAV data (RGB) is gives more accurate than 10cm data. This project is planned by using 4cm RGB and Reg_Edg and NIR band data but due to sensor problem the image not calibrated properly. But during first flight we get a good calibrated image that only processed and used for analysis.