# Drone Applications in Sustainable Forest Management and Monitoring in PNGFA

**Capacity Development Project for Operationalization of PNG Forest Resource Information Management System (PNG-FRIMS) for Addressing Climate Change**

## 1. Background

### Overview of drone & utilization

The applications of drone technology in Forestry have reached new heights by providing up-to-date, high resolution aerial imagery with reduced costs and time. Employed as a better alternative to satellite imagery and manned flight aerial photography, drones are fast becoming widely used in the mapping of forest areas for the purposes of management and monitoring forest resources (Banu & Borlea, 2016). By using drones to inspect the current status of forest areas and logging operations, forestry activities can be regulated with efficiency.

The Forestry sector in Papua New Guinea is regulated by the PNG Forest Authority (PNGFA), through the application of the Forestry Act, 1991 (as amended) and the "Logging Code of Practice" (LCoP) and the "Planning, Monitoring and Control Procedures" (PMCP) in the country. In recent years, PNGFA, with the assistance of JICA, have begun to introduce the utilization of GPS/GIS/Drone technology to assist in the traditional inspection methods in the implementation of LCoP/PMCP. While the traditional methods are still sufficient, the main purpose of the introduction of GPS/GIS/Drone technology is to increase the productivity of inspection methods by decreasing the amount of manpower needed, the time taken to complete inspections, and provide a more reliable snapshot of the current status of the target forest areas. GPS/GIS/Drone technology, used in line with the PNG-FRIMS, allows the ease in which information pertaining to forest resources and activities can be acquired and updated.

In line with the JICA-PNGFA Project, *"Capacity Development Project for Operationalization of PNG Forest Resource Information Management System (PNG-FRIMS) for Addressing Climate Change",* there have been three (3) drone training for PNGFA officers; in June 2018, October 2018 and February 2019. The aim of the training was to equip the PNGFA officers with the relevant knowledge and technical expertise in the use of GPS/GIS/Drone technology relating to Sustainable Forest Management (SFM) and to increase the capacity of the officers to be able to incorporate modern technology with the existing traditional inspection methods.

The training exercises were also instrumental in drafting the Drone Policy in PNGFA and the Safety Guidelines and Administration of Drone Usage. The policies and guidelines are key aspects of finding out where GPS/GIS/Drone technology is applicable and creating more innovative approaches in GPS/GIS/drone technology that will benefit both the JICA-PNGFA Project and PNGFA in the future.

# 2. Drone Policy in PNGFA and Possible Applications

## PNGFA Drone Policy: Key Principles for the Introduction of Drone Technology in PNGFA

- **Goal:** Drone technology is utilized as a part of forest monitoring framework in PNGFA, and accuracy and efficiency of forest monitoring is improved.
- **Selection and concentration: 1)** Plantation, **2)** Natural forest monitoring and, **3)** Forest Research (NFI)
- **Verification of possibility**
- **Cost analysis**
- **Risk management**

## Possible Applications of Drone Use in PNGFA

### 1. Possible Applications of Drone use in Plantations

- *Main Objective:* Strengthening capacity of plantation management contributing to increase timber production and economic growth in PNG.
- *Applicable/Possible Activities:*
  - Identification & security of potential areas for plantation development, Plantation management, Health Check, Area Calculation, Volume Estimation, Survival Assessment, etc.

### 2. Possible Applications of Drone use in Natural Forest Monitoring

- *Main Objective:* Improving efficiency and accuracy of forest monitoring in coordination with drone and other existent method in order to fully operationalize practicing LCoP/PMCP.
- *Applicable/Possible Activities:*
  - Natural forest monitoring based on LCoP, Planning, Regeneration planning, Site detection, Thresholds of re-entry, Rate of forest recovery, Invasive species, Spectral signature of flora, etc.

### 3. Possible Applications of Drone use in Forest Research

- *Main Objective:* Through research oriented activity, clarifying availabilities of drone to enrich and promote Plantation, Natural forest monitoring and NFI.
- *Applicable/Possible Activities:*
  - Measurement of tree height and crown size, Verification of vegetation types, Measurement of disturbance level, Determine crown & forest health

**Formulating the Policy**

The Drone Policy in PNGFA was first outlined during the discussions held in the first training. The policy covers much of the necessary precedents that needed to be achieved or established, the current situation of drone usage in PNGFA as well as laying the foundation for the Drone Applications in Sustainable Forest Management and Monitoring.

**Challenge for Forest Monitoring in PNG**

The two main points of raised in this respect refer to the Global Issue for Forest Monitoring and the Efficient Task Management by Promotion of Streamlining. The points highlight the responsibility of PNGFA in dealing with the balance of SFM and meeting the timber supply demands for both domestic and international markets, and how this balance can be maintained with the introduction of a more streamlined process, i.e., the use of GPS/GIS/Drone technology and PNG-FRIMS, working in harmony with existing traditional methods.

**Current situation and problem of Drone for Forest Monitoring**

As a monitoring tool, drones are robust and efficient with many different applications in Forestry. However, its use in PNGFA is still relatively a new undertaking and as such, guidelines, safety measures and verification of its feasibility in its incorporation into PNGFA is virtually non-existent. Furthermore, the possibility of introduction of drone use into PNGFA should not be seen as replacing traditional methods, but rather, adding onto it.

# 3. Standardization of Drone Usage

## Capacity Development

The table below highlights the activities that were undertaken during the three (3) trainings that were facilitated by JICA.

*Table 1: Summary of drone trainings*

| Training No. | First | Second | Third |
|---|---|---|---|
| Location(s) | ❖ PNGFA HQ, Port Moresby<br>❖ Kuriva Teak Plantation, Central Province | ❖ Sandaun PFO, West Sepik Province<br>❖ Amanab Blocks 1-4 FMA, West Sepik Province | ❖ PNGFA HQ, Port Moresby<br>❖ Marshall Lagoon FMA, Central Province |
| Date (Duration) | 12th – 20th June, 2018 (2 weeks) | 23th – 28th October, 2018 (1 week) | 18th – 28th February, 2018 (2 weeks) |
| Drone Used | DJI Phantom 4 Pro | DJI Phantom 4 Pro | DJI Mavic 2 Pro |
| Focus of training | 1. Safety measures and handling of drone equipment<br>2. Basic operation of drone flight<br>3. Image and Video Capture<br>4. Data processing<br>5. Drafting of the Drone Policy in PNGFA | 1. Review of skills, techniques and procedures from First Training<br>2. Discussions on the feasibility of Drone Utilization with LCoP/PMCP in Natural Forest Monitoring | 1. Review of skills, techniques and procedures from First and Second Trainings.<br>2. Practical applications of Drone Utilization with LCoP/PMCP and comparison with traditional methods of Forest Monitoring. |

*Fig.1: PNGFA officers learning the basic controls of drone flight.*

*Fig.2: PNGFA officers learning to process the drone-captured images*

*Fig.3: PNGFA officers performing manual inspection of forests.*

*Fig.4: JICA experts and PNGFA officers discussing the applications of drones in forest monitoring.*

*Fig.5: PNGFA officers and JICA experts monitoring an automated flight plan being executed by the drone.*

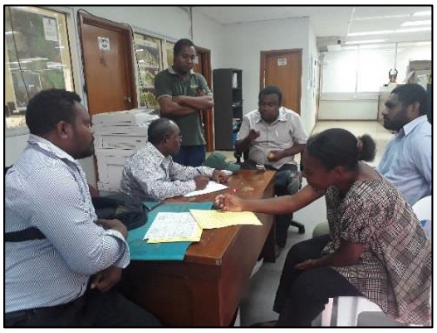


*Fig.6: PNGFA officers discussing and comparing manual inspection and drone-based inspection*

## Safe Administration Guideline for Drone Usage in PNGFA

Drones are fragile and delicate equipment and are prone to damage and loss. As such, safety measures regarding its use and operation must always be adhered to. This includes:

1. Making sure clearance is obtained from the Civil Aviation Safety Authority (CASA PNG), in reference to the drone specifications, airspace restrictions, exclusions zones and the purpose of drone use.
2. Maintaining a safe operating environment where there is acceptable weather conditions and optimal visibility. Preferable conditions include during the day, without windy or wet weather.
3. Handling of drone equipment is done with the utmost care during the assembly, flight and dismantling.
4. Pre-flight checks to inspect battery levels of devices, propellers, propeller guards, gimbal (camera) and other equipment must done before operation of drone.
5. Constant monitoring of the drone during flight to ensure control whether drone is in automated flight or manual flight. This is to prevent damage or loss in case of low battery or transmission problems.

*Fig.7: PNGFA officers learning how to properly assemble and dismantle the drone.*


*Fig.8: The Pre-flight Checklist published by CASA PNG (Excerpt from Post Courier - January 21st, 2019)*

# 4. Summary of Drone Performance

Currently, PNGFA has four drones in use today; three of which are Mavic 2 Pros and one Phantom 4 Pro. The Phantom 4 Pro was used in the first and second trainings. The Mavic 2 Pros were used in the third training. Their performance during training are shown below:

*Table 2: Phantom 4 Pro performance during First and Second trainings*

| Parameter | First Training | Second Training |
|---|---|---|
| Coverage Area | 4.5 ha | 187.56 ha |
| Flight Length | 1,119 m | 35,336 m |
| Flight time | 8 min | 2 hrs 10 min |
| Overlaps (vertical, horizontal) | 90%, 70% | 90%, 70% |
| No. of photos taken | 84 | 1194 |
| Batteries | 1 pack | 7 packs |
| Speed | 4.3 m/s | 7 m/s |
| Max. transmission distance | 500 m | 1000 m |

*Table 3: Mavic 2 Pro performance during Third Training according to each group*

| Parameter | Group 1 | Group 2 |
|---|---|---|
| Coverage Area | 154 ha | 133.34 ha |
| Flight Length | 22,832 m | 28,489 m |
| Flight time | 2 hrs 10 min | 66 min |
| Overlaps (vertical, horizontal) | 90%, 70% | 90%, 80% |
| No. of photos taken | 1,208 | 1,372 |
| Batteries | 12 | 6 |
| Speed | 6 m/s | 8.6 m/s |
| Max. transmission distance | 1200 m | 1000 m |

| Parameter | Group 3 | Group 4 |
|---|---|---|
| Coverage Area | 175 ha | 14.99 ha |
| Flight Length | 32,000 m | 2,640 m |
| Flight time | 2 hrs 32 mins | 13 min |
| Overlaps (vertical, horizontal) | 90%, 70% | 75%, 60% |
| No. of photos taken | 2,243 | 85 |
| Batteries | 12 packs | 1 pack |
| Speed | 7 m /s | 5 m/s |
| Max. transmission distance | 1200 m | 500 m |

**Limitations of Drone Utilization**

During the course of the trainings, there were a few limitations experienced that can affect the outcome of an operation. Listed below are some of the limitations and issues faced during the course of the trainings with regard to the drones that were used:

- ***Battery life***

The battery life (30 minutes) affects the missions with larger areas that need hours of operational flight time as there will be a need for constant charging and changing of batteries during missions

- ***Weather***

Drone operations can only be done during day time without foggy, wet or windy conditions. This conditions can damage the drone, limit battery life, and cause the loss of the drone.

- ***Details of features may not be visible by drone photos***

The photos taken with the drone may not always show features of interest. To increase the image resolution will require the drone to be flown at a low altitude, although this will affect the flight time.

- ***Skills/Knowledge of using Drone***

More trainings to be conducted to improve technical expertise and confidence of officers to properly pilot the drones.

- ***Access to Internet connections***

Internet connection is needed for the softwares to be used but this is lacking in the forest areas

# 5. Drone Utilization in PNG-FRIMS

## Natural Forest Monitoring and the Logging Code of Practice (LCoP)

The second and third training activities primarily featured the use of drones in Natural Forest Monitoring in implementing the Logging Code of Practice (LCoP). The flight missions undertaken were focused on the four (4) phases of logging operations; Pre-logging, Active Logging, Post Logging and Degraded. Each of the phases are accompanied with their own checklists based on the requirements and standards set in the LCoP. Shown below are samples of the checklist filled out by PNGFA officers:

| # | LCoP Activities | Key Standard | Available Measure | | | |
|---|---|---|---|---|---|---|
| | | | Surface Study | | Drone | |
| | | | Tape/Pole | GPS | Manual | Ortho |
| **Planning - Question crews about the marking system** | | | | | | |
| 1 | If crews know the marking system | - | ✓ Interview | | | |
| **Road construction - Inspect at least 4 length of 200 metres** | | | | | | |
| 2 | If roads are constructed to approved standards | - | * | ✓ | * | * |
| 3 | If excluded areas are free of soil | 6 | | ✓ | * | * |
| 4 | If roads are properly compacted | 7 | | ✓ | | |
| 5 | If roads follow approved surveyed roadlines | 8 | * | ✓ | * | * |
| 6 | If road corridor is less than 40 metres wide | 9 | * | ✓ | * | * |
| 7 | If adjacent streams are free of soil | 10 | | ✓ | * | * |
| 8 | If roads are properly drained | 11 | | ✓ | * | |

*Fig.9:*
*A sample of the check list for the Active Logging Site. The check list contains items from the Key Standards in the LCoP, which the officers fill out the best option and alternative option for the monitoring of these items, in ticks and asterisks respectively.*

## Plantation Monitoring

The first training activities focused on using drones to monitor Plantations. Drones were used to collect image data, which was then subsequently used to update the plantation inventory.

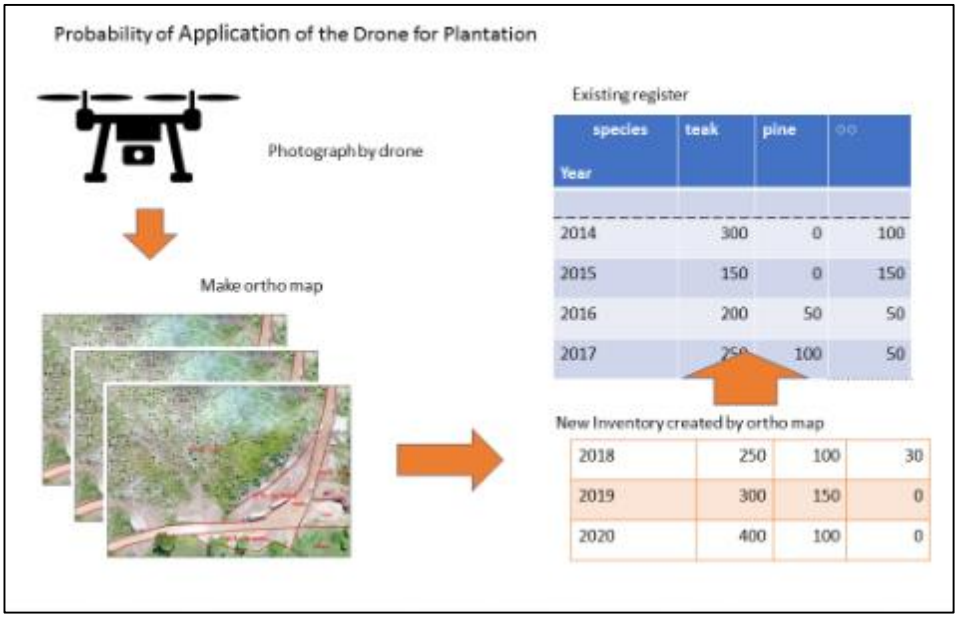



*Fig.10:*
*The process of capturing images using drones and producing orthophotos for updating new information into the Plantation Inventory.*

*Fig.11: Orthophoto to be used for Inspection of Natural Forests (overlayed in Google Earth)*

*Fig.12: Orthophoto to be used for updating Plantation Inventory (overlayed over existing information)*

## Forest Degradation Assessment

Forest Degradation Assessments aim to assess the reduction of the capacity of a forest to provide goods and services. In regard to the training exercises conducted, the degradation refers to the felling gaps and skid trails that result from the harvesting of logs in a forest area. The felling gaps and skid trails can be identified by the process shown below:

1. Image capture by drones, before and after logging operation
2. Removing logging roads from the analysis due to its dimensions (road width)
3. Running the images (IR band) through segmentation analysis in ENVI
4. Subtracting the log extraction data from the output by using field data.

The final result is the percentage of felling areas and skid trails that make up the degradation of the forest area.

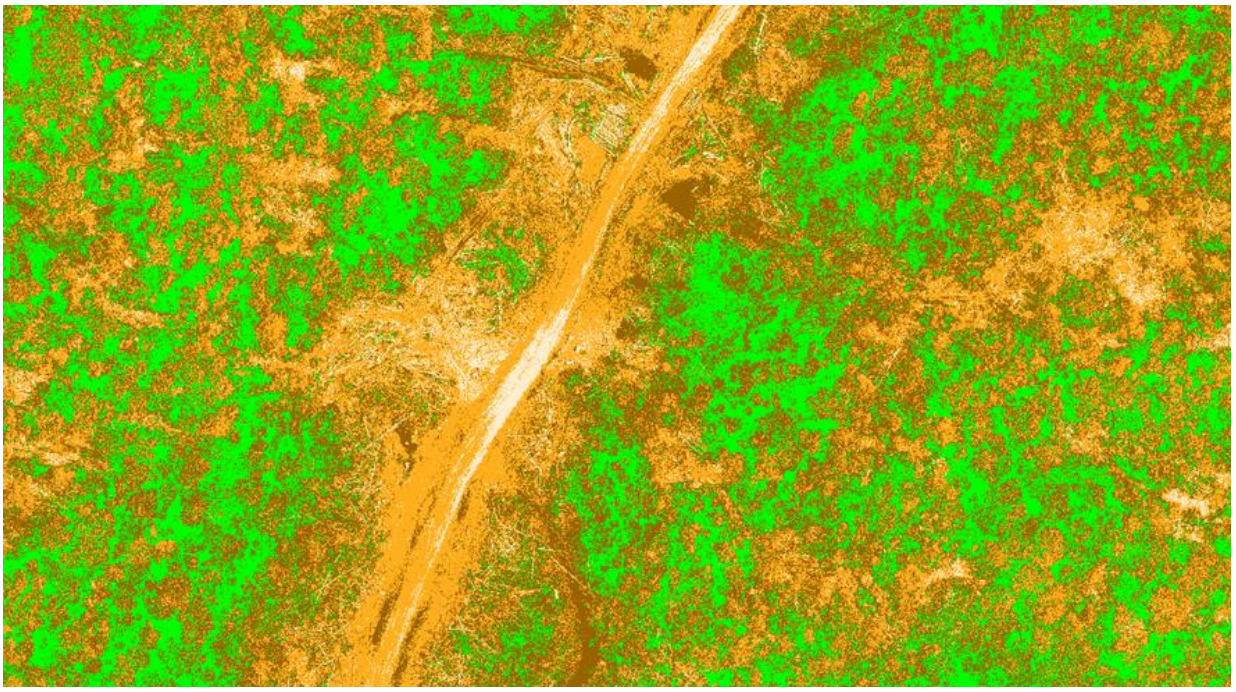


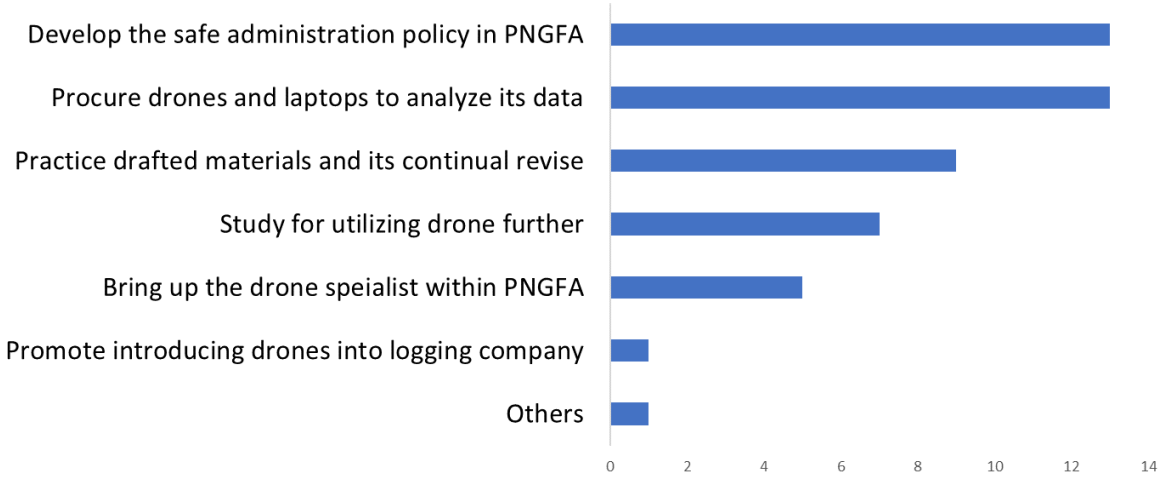
*Fig.13: The calculated aerial imagery showing the areas of degradation in orange and vegetation in green.*

# 6. Future Scenario

## Summary of Questionnaire Results

During the third training, survey questionnaires were given to the PNGFA Officers to gather opinions and experiences on the current inspection methods and the applicability of drones in field monitoring according to the LCoP. All officers agreed on the fact that the utilization of drones in PNGFA is important and that it is applicable in field inspections and monitoring. However, it was the general consensus that while drones are a powerful monitoring tool, further training is needed to better understand its full potential; thus, the optimal course of action is to integrate the use of drones with existing inspection methods.

The graph below shows a the overall opinion of the participating officers with regard to the improvement of field inspection with the utilization of drones in the future:




*(N=18, choose up to three items)*

The future of drone utilization in PNGFA is rife with potential. The three trainings conducted were very educational and motivating for PNGFA Officers who participated. The trainings have set the foundation and paved the way for the further development of capacity building, integration of modern technology into existing methods of forest monitoring and promotion of Sustainable Forest Management.

# 7. References


1. Banu, P. T., & Borlea, F. G. (2016, November). The Use of Drones in Forestry. Retrieved from Research Gate: https://www.researchgate.net/publication/316802665_The_Use_of_Drones_in_Forestry