PACIFIC ISLANDS GIS&RS NEWSLETTER

25 Years Pacific GIS&RS Newsletter

As of October 2018, the Pacific Islands GIS and Remote Sensing Newsletter has reached its 25 years of milestone! The 1st Newsletter was published in October 1993. During the time, there was a need for regular information platform as there was no Fiji medium (i) to report and document the monthly GIS&RS User Meeting, (ii) to distribute new developments in the areas GIS, RS and upcoming GPS applications, (iii) to report about data available in Fiji.

The Newsletter started as a simple print out of a WordPerfect written A4 document edited by Wolf Forstreuter and Les Allinson. In 1994, SOPAC's Director Phillip Müller supported the Newsletter with professional staff and Lala Bukarau joining the team. James Britton (USP) joined the newsletters working group in 1998. During that time users of other Pacific states were interested in the newsletter where SOPAC printed and posted to Pacific island countries.

Shortly afterwards, a network was established of national focal points, which than produced bigger quantities and which was distributed to subscribers in country. By the end of the nineties the Newsletter was able to be downloaded from the SOPAC website, however, the postage of newsletters continued as the countries e-mail access was very limited.

Figure 01: The first GIS&RS Newsletter edited by Wolf Forstreuter and Les Allinson, printed at SOPAC, Fiji. See: http://www.picgisrs.org/wp-content/uploads/2018/05/9301.pdf

The newsletter can still be printed if there is a need, however, this is an exception. The second last issue was published two years ago as there was no time which could be allocated to this publication. The PGRSC took ownership and the newsletter will be published again in regular intervals.

The importance is that the newsletter is the only publication, which focusses on spatial data application in Pacific Island Countries.

This newsletter focusses on remote sensing and database application critical for low lying islands in the Pacific, which is the coconut resource mapping. Remote sensing, GIS, GNSS and database application provide the tools to conduct a statistical sound assessment of the available resource, where sub-metre resolution image data is the essential part.

Another issue touched by this newsletter is the growing potential of UAV as remote sensing platform. UAV is moving into some application covered by very high resolution image data before.

Happy reading and please consider sharing an article to be included in the next publication.

Newsletter Editorial Team

WOLF Forstreuter

SEREIMA Kalouniviti

NAVNEET Lal

IN THIS ISSUE

Initiated in 1993, the Pacific GIS&RS Newsletter, which is now facilitated through the PGRSC Council, has since been an information and knowledge tool for the Pacific region.

Country Governments and Regional Agencies are Gearing up to Map and Assess the Status of Oceania's Blue Carbon Ecosystems - Jan Steffen, GIZ

Building on the momentum of UNFCCC COP 23 under Fijis leadership the delegations of Pacific Island countries are in the final preparatory stages for COP 24 in December in Katowice, Poland. Following the establishment of the International Partnership for Blue Carbon during COP 21 in Paris an increasing number of COP sessions and side events have highlighted the importance of seagrass meadows, saltmarshes and mangrove ecosystems in regard to their capacity to absorb and store carbon.

Accounting for less than 1% of total plant biomass, seagrass, mangroves and salt marshes cycle as much carbon as all other plant biomass, sequester carbon at rates up to 66x faster than terrestrial forests and store up to 5 times more carbon per hectare. Pacific Island Countries possess significant Seagrass and Mangrove resources, which also provide additional ecosystem services such as shoreline protection, ensuring food security, providing tourism revenue and maintaining water quality.

While reports on local mangrove and seagrass habitat loss have been increasing over recent years, no adequate baseline data exist to determine changes in regard to the total national extent of seagrass and mangrove habitats, or to strengthen targeted management solutions. Standardized methods for the assessment of carbon stocks and emissions in seagrass and mangrove areas have been established in 2012, but these have not yet been applied consistently in the region.

During a number of recent national and regional conferences policy makers and researchers have underlined the need to increase blue carbon and REDD+ efforts to reduce the decline of coastal biodiversity and mitigate the potential loss of the regions important coastal carbon sinks.

Building on financial support provided by the German and the Australian Government, SPREP, SPC and GIZ in close collaboration with national and regional partners developed the concept for a "Pacific Blue Carbon Initiative", aiming to support Papua New Guinea, the Solomon Islands, Fiji and Vanuatu as the countries with the most extensive seagrass and mangrove areas in the region in their efforts to map the national seagrass and mangrove status, and to assess carbon storage capacity and related ecosystem services in national priority sites. Resulting national inventories of seagrass and mangrove habitats and associated blue carbon sinks and ecosystem service values will allow governments to strategically strengthen management and rehabilitation efforts.

As part of the close collaboration with national and regional technical agencies the "Pacific Blue Carbon Initiative" intends to work closely with the regions remote sensing and GIS practitioners to refine and adapt remote sensing data and technology for seagrass and mangrove mapping and related carbon storage assessments.

Coconut Resource Inventory -Wolf Forstreuter SPC-GEM Division

The coconut is one of the major income generating resource in the Pacific for low lying islands with products such as copra, virgin coconut oil, timber and other minor goods. It has been regarded as a major source of income for outer islands in the Pacific and has contributed to the decrease in migration of population to the main islands. A comprehensive baseline data and representation is required to improve the use of the coconut resource i.e. (i) the area, (ii) the number of palms per hectare, (iii) the fertility and age of the palms, (iv) the available timber volume, (v) the health condition. The availability of very high resolution space born image data, will enable the mapping of large areas of coconut resource at a lower cost within a short period of time. However, not all parameters can be mapped from space. Field work is essential to measure and count all the parameters such as age, production, volume and health. In capturing the field measurements in a statistically sound way the parameters could be linked to palms per hectare and total area.

The SPC Geoinformatics Unit had carried out coconut resource assessment for Rotuma, Kiribati, Tuvalu, Samoa and Federated States of Micronesia. The activity involved the following steps (i) area assessment and stratification with very high resolution satellite image data, (ii) palm counting with the image data, (iii) field measurements, and (iv) database establishment for data analysis.

Stratification and Mapping of Coconut Palm Area

The first step of the interpreter is the mapping of the coconut area. Space born image data such as QuickBird with 60 cm spatial resolution and other DigitalGlobe satellites with 50 and 30 cm resolution allow a separation from coconut and other vegetation. This is performed visually be using the texture information, where a palm can be recognised as a little star. The interpreter delineates the area where he identifies sufficient coconut palms from the other vegetation and none vegetation land cover. Sufficient coconut palms has a bench mark of a minimum of 25 palms per hectare.

Figure 01: Stratification of coconut palms on very high resolution image data. DCO = dense coconut, CP = coconut plantation or medium, SCO = scattered coconut, the 50 x 50 m grid helps the interpreter

The next step is the coconut palm area stratification. Which is also performed as visual approach[1]. The interpreter overlays a 50 x 50 metre grid[2] over the image data and delineates scattered coconut (25 – 50 palms per hectare), medium dense coconut (50 – 150 palms per hectare) and dense coconut (above 150 palms per hectare), where he knows the bench mark as ¼ of the hectare limit.

Calculating the Amount of Palms per Hectare

An estimation of available coconuts per islands can be derived using the available stratified area and multiply by average coconut palms per stratum and average production per palm. However, it is more precise and does not add much to the cost to calculate the exact number per coconut palms per stratum in a statistically sound way.

As the area is already overlaid with an UTM grid of 50 metre grid cells, the grid is used to systematically[3] select grid cells for further investigation. As a next step the interpreter places a dot on top of every visible palm within the selected grid cells. In "boundary situations" at the grid cell edge he does not concentrate if the palm is still in or already outside the grid cell; he places the dot, everything else would be very time consuming. The software will only count the dots that definitely inside the grid cell.
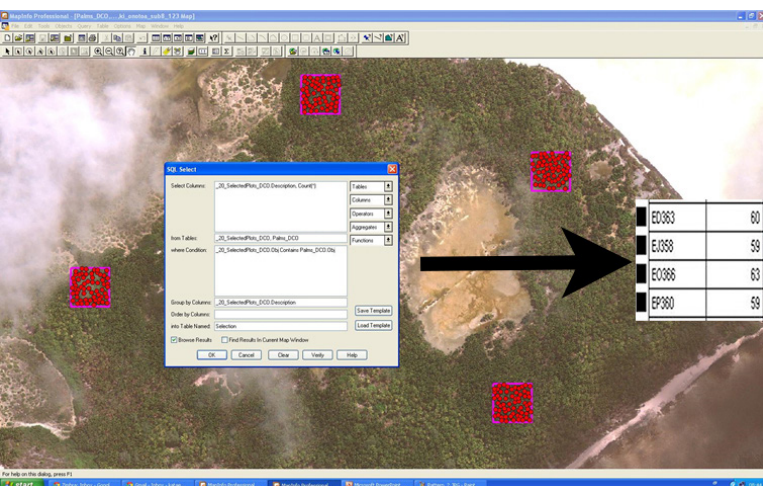

Figure 02: Semi automatic coconut palm counting, the software counts the dots placed on all visible palms and stores the results for every grid cell in a table which is exported to a database

As a final step the GIS operator runs a query which counts all dots symbolising a palm for the selected grid cells. The produced information for all selected grid cells is: (I) the grid cell ID and (ii) number of palms. The software transfers this information to a relational database. The database allows to calculate for each of the three strata: (i) the average number of palms per hectare, (ii) the variance between the plots and the (iii) standard error percent indicating the accuracy of counting.

This type of palm counting has limitations as the operator cannot see all palms in the understory especially in dense palm stands. However, general adjustment factors can be applied for medium

dense and dense stands. For scattered coconut stands this is not necessary as explained in the article "Accuracy Assessment of Coconut Palm Counting with Very High Resolution Image Data" in this newsletter. For larger inventories the local adjustment factors can also be calculated.

Sample Plot Identification and Establishment in the Field

Normally 10 % [4] of the image sample plots should be visited in the field. To find the plots the corner coordinates are stored as waypoint in the GIS. These waypoints guide the team to the location. However, technically this only leads to a rough position of the selected sample plot. To compare the number of palms on the ground with the number of palms recognised in the image data the position of the four plot coordinates have to be recorded by GPS and afterwards the palm counting has to be repeated in the image data within the slightly shifted plot.

It is important that the plot boundaries are marked with a line clearly showing which palm is inside and which is outside the plot.
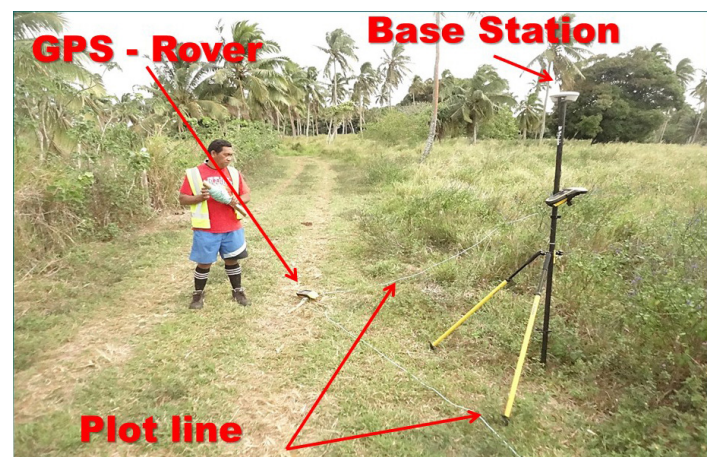

Figure 03: Plot establishment in the field with high resolution GNSS, the boundary is marked with a line.

Collecting Palm Related Information in the Field

Similar to forest inventories it cost already essential money to bring a team to the plot. Once a team is out a maximum usable parameter should be collected. The following lists the parameters normally recorded:

Palm Type

Everywhere in the Pacific it is possible to find hybrids between the normal local palms. If hybrids can be recognised by stem form or shorter height it has to be recorded, as other production figures apply. It is also possible that there are other plants inside a plot of coconut palms (cocos nucifera) such as ivory nut (Phytelephas aequatorialis) or other type of palms. This has to be noted as these will be counted as palms during the image interpretation and a factor has to be established reducing the calculated number of palms per hectare.

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[1]   Semi automatic palm recognition is in investigation and seems to work with oil palms, however, not in Pacific natural coconut stands yet.

[2]   In the grid cells he sees the according number of palms for ¼ of a hectare.

[3]   Before a random selection was performed, due to the advise from biometric specialists this has changed to systematic.

[4]   The percentage of plots to be visited in the field depends on the required accuracy of the coconut palm estimation.

Trunk Height

The trunk height is an important parameter to calculate the age and the timber volume of a palm. It is normally measured with a clinometer where the angle to the bottom of the trunk and the angle to the top of the trunk is measured plus the distance from the observer to the palm, see figure figure 04. This measurement can be replaced with modern electronic forest measurement equipment if funds are available. So far this forestry method with clinometer provided a reliable and accurate solution.
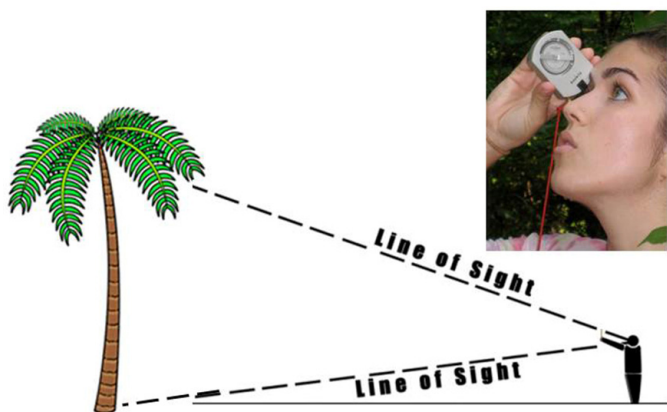

Figure 04: Measuring palm trunk height

Palm Diameter

The palm diameter is measured at "breast height" which is a worldwide forest term and can be translated with diameter measurement at 1.30 m height. This measurement is an input for the trunk volume calculation as well as other forest parameters such as basal area per hectare.

Fertility

To have an indicator of palm fertility or production the number of coconuts from the three oldest branches are counted and the average calculated[5]. It proved to be essential to utilised a binocular. Without there is an underestimation of 10 to 20 % as coconuts are difficult to count with naked eye.

Figure 05: Counting coconuts of the 3 oldest branches.

Age Measurement Input

To get an indicator of palm age the length of 11 leave scars is measured from 1.5 metre onwards. This length in relation to the trunk height is the input to the age calculation, see article "Age Estimation of Coconut Palms" in this newsletter.

Biotic Disturbance

So far, only the number of leaves affected by rhinoceros beetle and by stick insect are counted for every palm. The database uses this to calculate the infection rate per hectare.

Other Plot Parameters

To have an indicator of coconut palm management the number of dead trunks are counted which are lying within the plot. They indicate the potential danger of rhinoceros beetle infection. Furthermore the number of palm seedlings is counted to have an indication of regeneration potential.

Database Management

All parameters recorded are evaluated in a relational database and not calculated in the field. The field forms are directly transferred into an entry table keeping all counting and measurement per palm. A further table keeps all plot related parameters such as regeneration and dead palm trunks. From the entry table a palm value table is calculated keeping the parameters per palm such as volume, fertility, height, age, etc. Finally a table is calculated summarising all palm related information per plots to values per hectare such as number of palms per hectare, coconut production per hectare, timber volume per hectare, etc.

A database also allows input control through logical check. Reports of plot related information can be generated semi automatically.

Linking Database to GIS Coconut Palm Layers

The main GIS layer is the stratified coconut palm area. The second important layer keeps the plot locations. If the database is linked to the spatial layer of plot locations the hectare values such as number of palms per hectare, coconut production per hectare, etc. can be displayed by clicking on the plot symbol. More important is the link between plots and area. A new average of values can be calculated with a subgroup of plots only available within a sub-area.

A typical sub-area can be created if the total coconut palm area is reduced to the "harvestable" coconut palm area, which has to be explained: For example in semi dense palm stands normally people do not carry coconuts further than 300 to 350 metres as the work becomes uneconomic. The same applies for with 50 metres in dense palm stands. This means after a buffer zone creation of 300 metres to both side of the roads in semi dense palm stands shows the area, where coconuts can be forwarded by hand to the road. This is the area, where coconut will be harvested.

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[5]   This method was proposed by Tevita Kete, but never checked in a scientific way. However, it definitely is an indicator within a palm population.

[6]   So far Microsoft Access is utilised allowing a standalone database with a direct link to MapInfo whenever required. Investigation with PostgreSQL and QGIS is ongoing.

Summary

SPC-GEM together with SPC-LRD provide the tools to conduct a statistical sound coconut resource assessment of large areas with optimal integration of very high resolution satellite image data, GIS, GPS and database management reducing expensive field work to the minimum necessary amount. The system is flexible and can incorporate new measurement instruments, new analysis methods for example semi automatic coconut palm mapping and subsequent stratification. All parts can be handled by Pacific islanders without outsourcing parts of the workflow to institutions outside the Pacific.

Accuracy Assessment of Coconut Palm Counting with Very High Resolution Image Data

- Kataebati Bataua SPC-GEM and Wolf Forstreuter SPC-GEM

Coconut resource inventories are essential to estimate the availability and condition of the Pacific coconut resource. One part of the mapping side of the inventories is the stratification of the coconut palm layer, where the density indicator is the number of coconut palms per hectare.

This paper explains the accuracy of counting coconut palms with very high resolution (VHR) image data. The interpretation is still visual but the counting of coconuts palms is a semi-automatic process based on the number of palms visible and displayed in the image data.

Figure 02: The palms in the field plots (green) had to be counted again in the image data as the field plots did not match the image plots.

The next step is the counting of palms which was conducted through a statistical sound number of randomly selected image plots .

The interpreter marks all visible palms with a plot with a dot and a GIS program does the counting. The result is stored in a database which calculates the average number of palms per stratum.

The Limits of Palm Counting

Palm counting in the described way refers to the palms in the top canopy. In dense and partly in semi dense smaller palms below the canopy cannot be counted with image data (see figure 01). The counting therefore leads to an under representation of the real number of palms per hectare. The relation between counting in image data and field has to be established to have an accurate number of palms per hectare.

Figure 01: Dense coconut stands with palms underneath the canopy. These are not visible during image interpretation.

The first step of a coconut resource inventory is the mapping of the land cover with focus on coconut palm stands[7]. The coconut area is stratified into three categories (i) dense coconut (more than150 palms per hectare), (ii) semi dense (50 to 150 palms per hectare) and (iii) scattered coconut (25 to 50 palms per hectare). All mapping is based on visual interpretation at 1:5,000 working scale of geo-coded VHR image data. The mapping was carried out as on screen delineation. The result of this step is the layer showing the area stocked with coconut stratified into three densities.

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[7]   This is now replaced by systematic sampling.

[8]   The team used Trimble 6000 Series with an own base station providing accuracy of 80 cm, GPS is now called GNSS as the equipment also receives others than US operated satellites.

Comparison of Image Interpretation and Field Reality

The image plots have a size of 50 x 50 metres representing ¼ of hectare. High resolution GPS[8] allows to mark 50 x 50 m plots exactly on the ground. The plots of the image plot selection were visited in the field and all palms measured during the inventory. This establishes also the exact number of palms per hectare. It was not possible to locate exactly the satellite interpretation plot as the GPS guidance to the plots location does not have the required accuracy (see figure 02). Therefore as a second step the exact outline of the field plot were displayed in the image data and the visible palms were counted again. This results that the plots do not fit exactly on the UTM grid.

Result

20 plots were compared for dense coconut palms where the lowest difference was 2 palms but the highest 20 palms more in the reality than visible in the satellite image plots with an average of 10.2. For semi dense stands also 20 plots have been compared where the lowest difference was -2 palms and the highest 6 palms with an average of 0.95 more palms in the field compared with satellite image interpretation. Negative values indicate that the counting in the satellite images resulted to more than found in the field. This is possible as the image data were recorded three years before the field measurements took place. For scattered palms the difference was below 1 % and was not further followed up.

The analysis led to a correction factor of 36,8 % for dense coconut stands which has to be added to the image counting to have the correct figure of standing palms. For semi dense stands 4.6 % had to be added to the figure derived from image interpretation.

Recommendation

For larger coconut resource inventories it is recommended to establish this correlation for the country or region again and adjust the given figures to the local conditions. To do this high resolution GPS should be part of the inventory equipment. For general mapping the given adjustment figures provide the best available in Pacific Island Countries.

	No. Plots	Avg Image	Avg Field	Min Dif.	Max Dif.	Avg Dif.	% of Image
Dense Coconut	20.00	27.70	37.90	2.00	20.00	10.20	36.80
Medium Dense Coconut	20.00	20.50	21.50	-2.00	6.00	0.95	4.60
Scattered Coconut	20.00	8.50	8.50	-2.00	2.00	0.00	0.00

Table 01: Comparison between palm counting in satellite image plots and field plots. The average difference in 50 x 50 m size plots is 10.2 palms for dense and 0.95 for semi dense plots. This is 36.8 or 4.6 % more in the field than counted in the satellite image data

Age Estimation of Coconut Palms
-Wolf Forstreuter, SPC-GEM Division

Pacific coconut palms are an essential contribution to food security and family income through copra selling. In outer islands there are not to many alternative than utilising the existing resource. The production figures of the copra processing facilities show a declining production. The coconut palm area is shrinking in size; however, it is unclear how far the age structure contributes too due to too many senile palms which cannot produce. The Geoniformatics Unit of SPC-GEM was asked to assess the coconut resource in the Vava'u Group in Tonga to find out the reason for declining coconut production. The inventory provided a picture of the age structure of standing coconut palms.

Figure 01: Felled coconut palms allowed a proper measurement of leave scars.

There is not much literature showing methods of age determination for coconut palms. Trees have two parameters, which are directly correlated with age (i) the tree height and (ii) secondary diameter growth. The palm height apparently is only usable during the first 25 years and the secondary diameter definitely cannot be utilised[9].

One usable parameter a coconut palm trunk has: this are leave scars, which stay on the trunk after the leaves fall of. This parameter was consulted by Land Resource Division of SPC[10]. Coconut was calculated from the number of leave scars on the trunk assuming that after the first five years a coconut palm produces 11 leaves every year. The height of the trunk divided by the length of 11 leave scars plus 5 is the calculated age. Figure 02 shows the measurement of the length of 11 leave scars starting at 1.5 meter. The height of the trunk is measured with clinometer following forest measurement instruction.

Figure 02: Measuring the length of 11 leave scars from 1.5 metre upward.

The assumption that a coconut palm produces 11 leaves within one year might be varying depending on water supply, palm variety or soil, but it is an indicator of age and will be the same or very similar within one population of palms. The age then can be calibrated. Tonga provided the opportunity that palms were freshly felled as the government enhanced the road network in the agriculture area. 62 palms were investigated by counting the number of leave scars for every metre. For a statistical sound figure at least 60 palms have to be investigated, which was the case in Tonga. Counting of leave scares per metre showed that this calculation has to be adjusted as the number of leave scars per meter increases significantly towards the top of the trunk. The old method ignores that the trunk of a palm grows not only have secondary diameter growth but also increases the distance of the leave scars.

Figure 03: Old age calculation (blue), "real age" (red) and new calculated age (yellow)

For the 62 palms the length of the trunk for 11 scars was measured as well as the total number of leave scars. So the total number of leave scars divided by 11 as "real age" and the calculated age could be compared.

Figure 03 shows the comparison between age calculated by the old formula: [Age = length trunk / length 11 leave scars + 5] and the "real" age number of counted leave scares divided by 11 + 5.

A new formula was calculated:

Age = (length trunk / length 11 leave scars + 5) + ((length trunk / length 11 leave scars +5) / 2.06)

This is represented by the yellow line in figure 03, which acts like factor/offset.

The result of the investigation is that setting the length of 11 palm scars in relation to the number of scars per trunk works. The method has to be further calibrated, however, for the time being it is a valid method to show the age distribution of a palm population.

Applying this new formula in Vava'u Group in Tonga showed that existing senile palms have to be removed and also young palms were missing. Even if the absolute age calculated has to be calibrated differently the formula allows to provide an age profile of the coconut palm population.

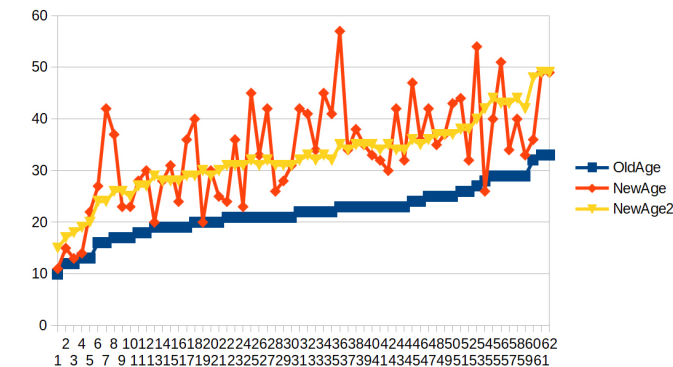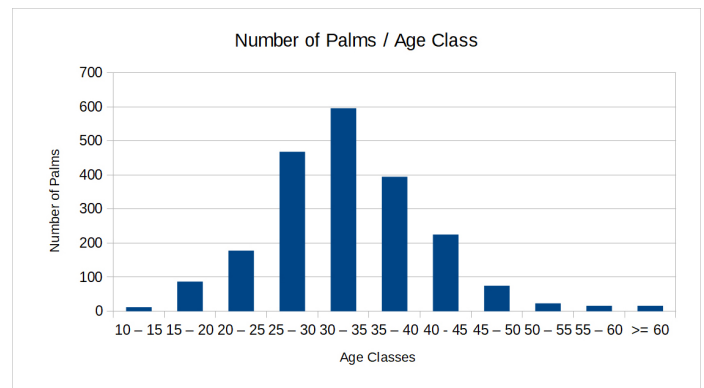Figure 04 shows that there not sufficient young palms.

Figure 04: Age distribution of palm population in Vauva'u Group in Tonga

9   See article "Form Factor Calculation of Coconut Palms Vava'u Group in Tonga" in this newsletter.

10   Age calculation of Tevita Kete

Form Factor Calculation of Coconut Palms Vava'u Group in Tonga

- Wolf Forstreuter SPC-GEM
- Tevita Faka`osi, Head of Forestry Division, Tonga

Pacific coconut palms are called "the tree of life" as they produce what villages in outer islands need for income and living. Since soya been oil was promoted and produced in large farms in US the copra market broke down and the coconut resource was neglected. However, it is one of the Pacific natural resources on land and using very high resolution image data the amount can be economically estimated[11].

Today most Pacific coconut stands are overage as replanting programs stopped decades ago. This also results in a growing part of senile palms population. The GIS&RS Unit of SPC-GSD was asked to assess the coconut resource in the Vava'u Group in Tonga to find out the reason for declining coconut production. The inventory provided a clear picture of the available coconut palm area, the palms per hectare, the palm age, the health condition, the nut production and several other figures.

Figure 01: Felled coconut palms allowed a proper measurement of the trunk form.

If senile palms have to be removed the trunk has to be transported out of the area otherwise the rotting trunk creates a breeding ground for an important biotic coconut pest, the rhinoceros beetle. For planning the removal of senile palms the timber volume is an important planning figure.

Although a coconut palm is a grass and not a tree, tree measurement procedures are applied whenever the trunk volume is calculated. The volume is estimated by measuring the total height of the trunk and the diameter at 1.3 metre. Both figures were captured with forest measurement instruments[12]. This two figures allow to calculate a cylinder (see figure 02). Similar to a tree the palm trunk is tapered towards the top and the volume of the cylinder has to be reduced accordingly. The ration of the volume of a cylinder and the volume of the trunk is called the form factor.
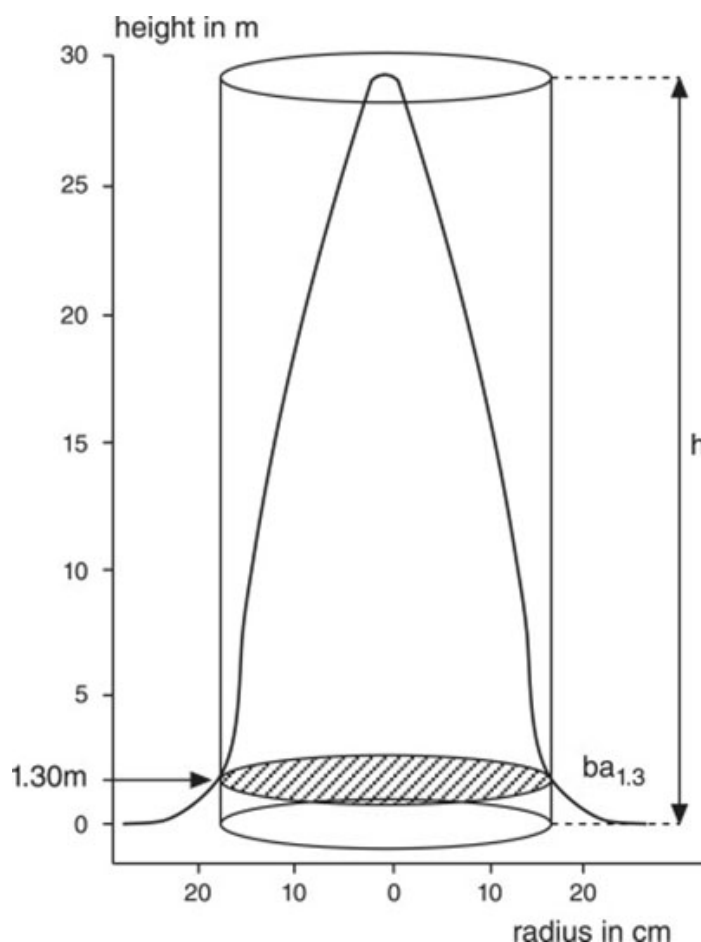
Figure 02: Cylinder and trunk

To establish form factor someone would have to climb the trunk and measure the diameter in regular intervals. As for a statistical sound figure at least 60 palms have to be measured, such an approach makes this task to an exhausting exercise. Tonga provided the opportunity that palms were freshly felled as the government enhanced the road network in the agriculture area (see figure 01). For 62 palms the diameter of the trunks were measured every metre. In some cases holes had to be dug under the trunk to enable the diameter to be measured.

The form factor measurements showed that coconut palm trunks do not have a form like a tree which tapers permanently with the height. It was expected that palms either have a strait, convex or concave form, but that the trunk tapers continuously towards the top (see figure 03). The measurements showed that

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[11] See Wolf Forstreuter, Coconut Resource Inventories in Pacific Island Countries.

[12] Measurement of palm height and diameter see Coconut Resource Inventories in Pacific Island Countries

98% of the coconut trunks had a form where the trunk did not permanently decrease in diameter. Mostly the diameter even increased somewhere at the trunk.

Palm Trunk Form

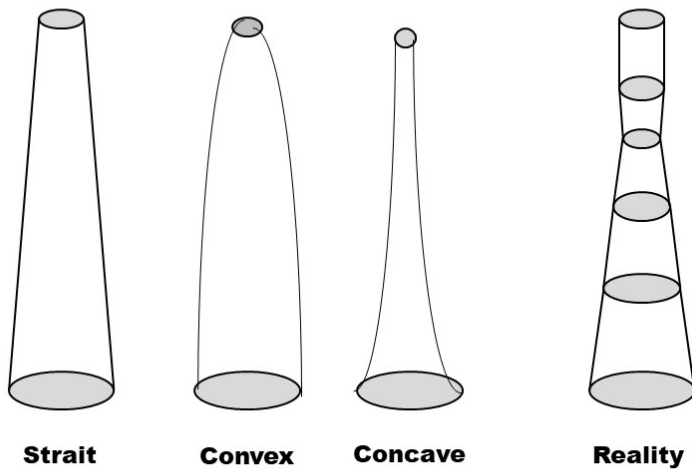**Strait**   **Convex**   **Concave**   **Reality**

Figure 03: The form of a palm trunk does not taper continuously to the top.

For every metre section the volume was calculated with the formula of the truncated cone[13] and added to volume of the trunk. This volume value was set into relation of the cylinder volume calculated from height of trunk and diameter at breast height (1.3 m). The resulting form factor varied from 0.56 to 0.91 with an average of 0.74, a standard deviation of 0.09 and a standard error of 0.01.

Figure 04: Abnormal palm trunk form in Tarawa, Kiribati

The form factor of 0.74 can be used for volume calculation as long as there are no other figures available. For larger coconut resource inventories an own form factor should be established. For trees the form factor can vary related to stand density and partly site. In the Pacific it is expected that site has an influence. In Tarawa trunks of abnormal form were noted on very shallow soil over salt water (see figure 04).

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[13]   Volume = 1/3 Pi (r12 + r1 x r2+ r22) x height

Pacific Flying Lab - Amrita Lal, University of the South Pacific

The Pacific Flying Lab is part of the growing network of flying labs all over the globe which focuses on local capacity building in the UAV and technology sector. Apart from the 14 established labs in countries like Nepal, Tanzania and Peru, new labs are coming up in places like India and Japan by the end of this month.

The Pacific Flying Lab, situated at the Lower Campus in Laucala, was established by WeRobotics and the University of the South Pacific in November 2017. Headed by local coordinator Amrita Lal under

the supervision of Associate Professor Dr. Nicholas Rollings, the lab has managed to run workshops and a conference this year with funding from the Rockefeller Foundation and Department of Foreign Affairs and Trade.

Pacific Flying Lab has partnered with organizations like the Fiji Red Cross for post natural disaster response missions after Tropical Cyclone Keni devastated the island of Kadavu in April, 2018. We have participated in community outreach programs for informal settlements and created baseline data by mapping some villages which had not been mapped before. We have also managed to successfully secure Phase Two Funding from Department of Foreign Affairs and Trade which will further help us in our mission for local capacity building in terms of hiring and training youths, creating opportunity for others and acquiring hardware and software. The Lab currently has a few fixed wing drones, remotely operated underwater vehicles and a wide range of multirotor drones but in the future, we will be looking into the effectiveness of bathymetry study with surface water vehicles.

Fig 1. Aftermath of TC Keni on Kadavu Island

Under the Pacific Flying Labs banner in November, five local youths also successfully completed their CASA certified drone training in Suva. Youths who participated in this training consisted of 2 male and 2 female Fijians and 1 Vanuatu student currently enrolled in the Geospatial Science program at the University of the South Pacific. They were trained for handling not only small and medium weight multirotor but also fixed wing drones. The Remote Pilot License training was provided by experienced individuals from AviAssist and Hover, which are both based in Australia. Apart from basic training on how to use these technologies effectively, participants were also versed on conducting proper risk assessments and other methods of documentation for safety purposes.
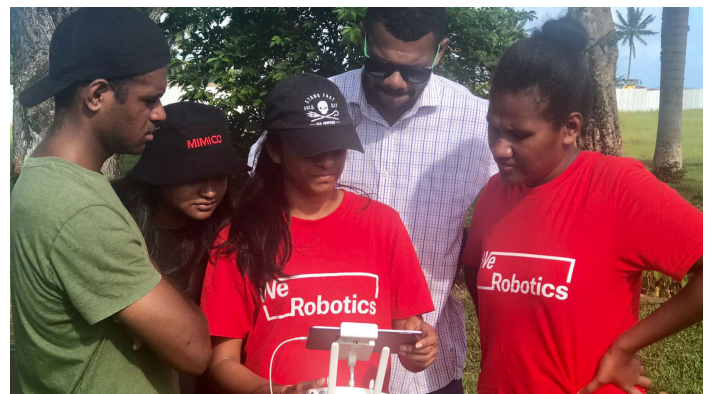

Fig 2. Participants of the CASA certified training in November

In 2019, Pacific Flying Lab is looking forward to partnering with interested individuals and organizations by funding projects which are centred around the use of Unmanned Aerial Vehicles. We will be focusing on projects which aim to solve or explore both environmental and humanitarian issues in the Pacific region. We are also keen on setting up a new Flying Labs node in Vanuatu and further training locals to take on projects which has so far been done by outsiders.

Multi-copter based coastal erosion assessment and monitoring on Kiribati outer islands – First experiences and conclusions : Mission framework and facts - Gilbert Kattenborn, GeoCopter, Germany

In the framework of the EU-giz "Adapting to Climate Change and Sustainable Energy (ACSE)" programme directed by Dr. W. Killmann the "Land Use and Coastal Areas Vulnerability and Adaption Assessment" project aims to have strengthened capacities and an enabling environment for land use and coastal vulnerability assessment empowering stakeholders at all levels on disaster risk reduction and climate change adaptations through enhanced skills and knowledge with information generation data management.

To this end, an UAV mission was conducted by Dr. G. Kattenborn, GeoCopterTM, Germany and supported by K. Bataua, SPC GeoScience Division, Fiji and T. Tofinga, Ministry of Environment and Agriculture Development, on Tabiteuea North, Kiribati and neighbor outer islands. For assessment and monitoring of coastal erosion and vulnerability UAV imagery has been acquired on seven critical coastal areas with a DJI Phantom 4 between the 21.04. and 26.04.2018, five on Tabiteuea North, and one each on Aiwa and Tenatorua.

Prior to the flight operations a ground team distributed checkerboard plates as Ground Control Points (GCP) according to operational surveying standards and measured their coordinates with a terrestrial differential GPS (Trimble GeoExplorer). These serve in a later step of the data processing to enhance the georeferencing of the UAV based photogrammetric products, which would otherwise solely rely on the logged meta data of Phantom 4 imagery.

The UAV was operated at a constant altitude of 100m above ground as a compromise between precision of the resulting RGB orthomosaics as well as digital surface models (DSM) and necessary efforts in terms of flight endurance i.e. battery supply. This resulted in an effective ground resolution of 4.2 cm (pixel size).

The areas covered during the 7 flights varied between 20 and 40 ha. To this end, batteries had to be changed once or twice during one photo flight. Under outer island conditions, and considering that power supply for recharging was only guaranteed during day time, it can be stated that this was a reasonable planning size.

The acquired amount of around 5000 aerial images i.e. 21 GB of data requires enormous processing time for the photogrammetric workflow i.e. orthophoto mosaic and digital surface model generation. As power supply was limited on the outer islands, data end product generation was finished in Bairiki, Kiribati and at SPC offices, Fiji.

Experiences from field operations

Since power supply during field work on Tabiteuea atoll was only available during day time synchronization of flight operations and hardware maintenance e.g. battery recharging was demanding. In addition web access was very limited, thus making online flight planning almost impossible. This could be mainly overcome using offline maps downloaded already in Germany in preparation of the mission but in a coarser resolution.

A main concern prior to the UAV mission were wind conditions during day time, since preferred operation time with view on shadowing in the acquired aerial images was between 10.00am and 15.00pm local time. It turned out that with the prevailing steady winds - mainly from the East and not too gusty - flying up to a wind speed of 7m/sec was possible without any problems in terms of endurance i.e. power consumption, taking into account also steering and correction movements of the UAV platform. Preparing field tests have shown that flying with and against the prevailing wind direction - compared to flights perpendicular to the wind direction - caused a minimum of autonomous steering and correction efforts for autonomous navigation system of the Phantom 4, i.e. less power consumption.

Another experience of the flight planning was that the larger field of view of the Phantom 4 Sony camera compared to the Phantom 4 Pro camera – also a Sony but with the technical advantage of a mechanical shutter - allowed larger forward and side overlaps for the 3D photo flights. I.e. the slightly higher image quality of the Phantom 4 Pro camera is balanced by a significant gain in endurance respectively gain in overlap of the aerial imagery.

At no time prevailing air temperatures of 29-31 C° caused any problems neither with the long time running engines nor with the inner battery temperatures. Cooling by the steady air stream during flights and probably also the white coating of the Phantom 4 guaranteed a safe flight operation at any time according to the steady stream of respective telemetry data.

Lessons learned and outcome

i) It can be stated, that the financial efforts made by engaging a professional UAV team namely GeoCopterTM,Germany paid off. The profound experience of GeoCopterTM in various countries and regions of the globe including the South Pacific, covering broad ranges of remote sensing tasks - from platform/sensor selection and preparation, designing the remote sensing approach from flight planning with respect to environmental conditions as sun illumination/geometry, wind, temperature, to flight performance and data quality management, as well as the following orthophoto mosaicing and 3D reconstruction - in one hand guaranteed a successful progress of the mission

In addition necessary field work was performed by SPC/Kiribati staff acquainted with local environmental conditions and logistical capacities.

This approach can be considered as a process of know how transfer from a highly specialized European team to Kiribati officials. It was also augmented in form of education and training sessions for further Kiribati officials of different administrations

With this cooperation arrangement, costs for an otherwise necessary Kiribati national UAV unit including personal and maintenance are more than balanced.

ii) With respect to available UAV platform technology a copter type drone approved to be superior to a fixed wing system under given circumstances and environmental conditions considering its pronounced flexibility (e.g. vertically takeoff - landing) especially when working on small islands and atolls. According to our local experience there would have been hardly sufficient space for starting and landing state of the art fixed wing systems. Also manoeuvring and hovering capabilities of such a system allow close look imagery and can guarantee the necessary precision in high front and side overlaps of the data takes for 3D reconstruction of the coastal areas under investigation. This can be especially important under the prevailing windy conditions on Kiribati islands with sometimes strong gusts occurring.

iii) In comparison to other remote sensing approaches for coastal erosion processes assessment e.g. high resolution satellite data, the advantages of UAV missions are convincing i.e. spatial resolution and precision of orthophoto maps and 3D data, the incorporation of oblique view data whenever necessary, as well as the timely flexibility with view on different acquisition conditions as illumination geometry and cloud cover.

Vertical take-off and landing (VTOL) UAV systems come of age - Richard Russell, Drone Services Fiji

Drone use for data collection is becoming more popular and routine through-out our Pacific Community and the demand to map larger area's and longer coastlines and corridors from universities, government, business and the general community is increasing.
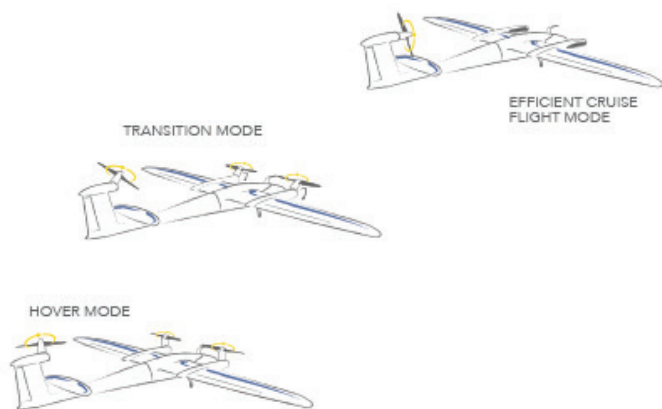
In the Pacific these is a multitude of small area (< 100 ha) examples of drone aerial imagery being collected from a plethora of RGB, NVDI, Thermal remote sensors on small multi-rotor drones including the DJ Phantom 4, Matrice 200, Parrot Bebop and custom solutions.

For larger areas (100 – 500 ha) and extended coastlines (5-10 km) the SenseFly eBee and Trimble UX-5 delta wing platforms have achieved some popularity due to their ease of use and versatility, however they are restricted to areas where landing can be completed on a runway or large open flat and clean space via a belly or steep stall landing of the drone.

Demand for large area mapping of forests, rugged vegetated areas, rugged rocky areas, coastline, road corridors and dense urban environments is increasing where drone endurance and suitable launch and landing sites are problematic.

The merging of multi-rotor drones and fixed wing systems to develop a Vertical Take-off and Landing UAV or hybrid system has been a recent industry focus and VTOL systems are now readily available to address the constraints of limited endurance and being able to launch and land a drone system where no runways or flat areas exist.

Graphic 1: Hybrid VTOL system – hover, transition and cruise modes

The Trinity and Trion VTOL drones from Quantum Systems of Germany represent the next generation of hybrid UAV systems. Designed for ease of use with intuitive software and capable of carrying a multitude of payloads including RGB, multi-spectral cameras and LiDAR for mapping large areas, coastlines, corridors and engineering and construction applications.

Both models share a common flight controller, long flight times, high speeds and flexible payload options.

At a list price of €12,900 the Trinity F9 is a compelling solution, with a 550 g (1.2 lbs) payload capacity, and 60-minute flight time enables a 70km range or 500ha area coverage (at 100m AGL). The F9 is designed for integration with manned aircraft, air traffic safety and BVLOS applications with anti-collision strobe lights and ADS-B live air traffic information provided to the Remote Pilot operating its ground base station.

To enable survey grade mapping the F9 is equipped with a PPK GNSS and a base station which provide X-Y accuracies of 20mm and Z accuracy of 50mm.

Sensors available include a Sony UMC-R10 20MP RGB camera for mapping and surveying, and dual RGB and MicaSense RedEdge-M for Agricultural applications. User customisable payloads can also be integrated.

Graphic 2: area coverage at various heights Above Ground Level (AGL)

The Tron is available where heavier payloads such as LiDAR and gimballed surveillance cameras, are required. The Tron carries up to 2 kg (4.4 lbs) payloads and flies for up to 90 minutes which provides and area coverage of up to 11 km2 11,000 ha at 100 m (328 ft) AGL.

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Look at PGRSC website to see the history of the newsletter and the history of GIS&RS in the Pacific.

http://www.picgisrs.org/gis-remote-sensing-newsletter/

For more Information

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