Coconut Resource Assessment Using Pan-Sharpened QuickBird Image Data and Field Inventory Sample Plots

Pohnpei Island

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Pan-Sharpened QuickBird Image Data of Pohnpei States

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1 Introduction

1.1 Background
The coconut resource inventory for the Federated States of Micronesia started with an e-mail from Rupeni Mario (North Pacific Regional Office in Pohnpei under SPC Economic Development Division) from 27th August 2012 stating that he has received a request received from Vital Energy, the FSM national state owned energy enterprise.

Sairusi Bulai Forest and Tree Programme of SPC Land Resource Division agreed that the coconut mapping specialist Kataebati Bataua stopped the mapping for Kiribati and concentrated on coconut stratification and mapping of very high resolution (VHR) image data available and partly new purchased from FSM.

A new coconut inventory field design incorporating VHR image data was developed and tested in Suva in late 2012. This was presented on the ACIAR SPC Pacific Coconut R&D Coconut Strategy Meeting.

The coconut cover for the first 7 islands was stratified into dense, semi dense and scattered coconut cover in February 2013. The corresponding areas have been mapped and the number of coconut palms per stratum has been counted as semi-automatic GIS procedure. The first test of field work was conducted between 6th and 13th of March 2013.

All mapping is based on visual interpretation at 1:5,000 working scale. The mapping is based on geo-coded very high resolution image data (pan-sharpened QuickBird).

There is no area subdivision for the Pohnpei Island. This will be done if the official boundaries are delivered by the Lands Department of the Federated States of Micronesia.

1.2 Executive Summary
The area of the island Pohnpei was mapped with very high resolution image data (VHR), which allows: a) a stratification of the coconut area into three different densities; and b) a counting of coconut palms from the image data.

This is very precise synoptic information and provides a clear picture of the area. There was cloud cover over about one third of the island preventing image analysis, however, this was mostly in the mountain region where coconut palms are not planted.

Forty two field inventory plots were established where the palms were counted, measured and yield and age was estimated. The result was that the age was very young and the productivity of coconuts per palm was less than FAO states as standard. This might be based on a biased selection of inventory plots. The team had to select plots where access was allowed as randomly distributed plots would have required more time for landowner permission.

The main factor that reduces the amount of harvestable coconut is the accessibility of the stands. With the available digital road network and the assumption at the manual carry of coconuts will not exceed 350 m in semi dense stands and not exceed 50 m, a GIS buffer zonation was conducted. Applying this, 90 % of dens coconut area and 20 % of semi dense coconut area fall out of production area. This situation has to be investigated further as stated in chapter 4.3.
2 The Satellite Image Data

The interpretation is based on pan-sharpened QuickBird image data providing 60 cm spatial resolution and colour. The image data arrived as band combination red, green, blue and as band combination green, red, infrared. So far only the natural colour combination of blue, green, red was utilised for the interpretation. It will be investigated if the infrared combination brings additional information to what is expected. The colour contrast enhancement is limited due to the merge process between colour and panchromatic image channels. The image data was recorded 25 January 2007 and delivered in eight different image tiles. The image data set was purchased as geo-coded in UTM WGS84 Zone 57 North.

Figure 2-01: Pan-Sharpened QuickBird Image Data of Pohnpei States

About one third of the landmass is covered by clouds. Majority of the area is mountainous area where coconuts are normally not planted. However, also this area will be classified as soon as image data is available.

3 Area Analysis of Land Cover Types

The area analysis was carried out in Access as area database. The actual area calculation for every polygon was performed in GIS environment and afterwards the MapInfo table was copied to Access.

About 37,863 hectares or 62 % of Pohnpei States are covered by vegetation where 21.4 % is coconut cover and out of this 18.0 % or 4195 hectare are dense stands, which are the areas economical to harvest.

Furthermore, 38 % or 14,526 hectares of Pohnpei States have non vegetation cover where 60 hectares or 0.4 % is water bodies.

<table>
<thead>
<tr>
<th>Class</th>
<th>Area [HA]</th>
<th>% of Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Forest</td>
<td>11,720</td>
<td>50.2 % of 23337</td>
</tr>
<tr>
<td>02 Mangrove</td>
<td>5,711</td>
<td>24.5 % of 23337</td>
</tr>
<tr>
<td>03 Dense coconut</td>
<td>4,195</td>
<td>18.0 % of 23337</td>
</tr>
<tr>
<td>04 Medium dense coconut</td>
<td>285</td>
<td>1.2 % of 23337</td>
</tr>
<tr>
<td>05 Scattered coconut</td>
<td>509</td>
<td>2.2 % of 23337</td>
</tr>
<tr>
<td>06 Shrub</td>
<td>917</td>
<td>3.9 % of 23337</td>
</tr>
<tr>
<td><strong>Sum Vegetation</strong></td>
<td><strong>23,337</strong></td>
<td><strong>62 % of 37,863</strong></td>
</tr>
<tr>
<td>07 Settlement</td>
<td>1,888</td>
<td>13.0 % of 14526</td>
</tr>
<tr>
<td>08 Bare land</td>
<td>518</td>
<td>3.6 % of 14526</td>
</tr>
<tr>
<td>09 Water body</td>
<td>60</td>
<td>0.4 % of 14526</td>
</tr>
<tr>
<td>10 Unclear (clouds)</td>
<td>12,060</td>
<td>83.0 % of 14526</td>
</tr>
<tr>
<td><strong>Sum Non Vegetation</strong></td>
<td><strong>14,526</strong></td>
<td><strong>38 % of 37,863</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>37,863</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 3-01: Land cover summary of Pohnpei Island
Within the settlement area (75 m buffer zone around houses visible in the image data) coconut cover distributes into the three strata as shown in table 3-02.

<table>
<thead>
<tr>
<th>Class</th>
<th>Area [HA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Dense coconut</td>
<td>381</td>
</tr>
<tr>
<td>02 Medium dense coconut</td>
<td>26</td>
</tr>
<tr>
<td>03 Scattered coconut</td>
<td>167</td>
</tr>
</tbody>
</table>

Table 3-02: Coconut cover in settlement areas

4 The Coconut Resource

The coconut resource can provide coconuts usable for different purposes such as virgin coconut oil, biodiesel, charcoal, etc. The trunk of old coconuts can be used as timber.

The resource has a current status where the area, number of palms and accessibility indicate how much can be utilised. However, there are also parameters such as coconut age, insect damage, density and amount of hybrids which can be changed to optimise the production. Also the accessibility can be changed by additional tracks.

4.1 Number of Coconut Palms

The coconut palm cover was stratified into three different densities for which the number of coconut palms were counted in image sample plots as described in appendix 1.

4.1.1 Dense Coconut Palms

For 30 plots of 50 x 50, metres the coconut palms were counted in the stratum "Dense Coconut" on the satellite image data. This represents an area of 75,360 square metres as in GIS environment 50 x 50 m represents 2,512 square metres which is half a percent more than the cartesian area of only 2,500 m². The stratum "Dense Coconut" covers 38,140,230 m² and theoretically 15,256 plots could have been analysed instead of only 30. The number of palms varies from 39 (min) to 68 (max) which represents 155 or 271 palms per hectare (palms/ha) with an average of 210 palms/ha with a standard deviation of ±34 palms/ha. The question for dense coconut cover is how far the counting of palms really represents the reality as the young palms are normally not visible in the image data. The relation between number of palms in the image data and reality has to be established in plots exactly located in the images and on the ground. This was not feasible due to missing accurate GPS units¹.

4.1.2 Medium Dense Coconut

For 30 plots of 50 x 50 metres, the coconut palms were counted in the stratum "Medium Dense Coconut" on the satellite image data. This represents an area of 75,360 m². This stratum covers 2,591,819 m² and theoretically 1,037 plots could have been analysed instead of 30. The number of palms varies from 18 (min) to 37 (max) which represents 72 to 147 palms/ha with an average of 96 palms/ha with a standard deviation of ±17 palms/ha.

4.1.3 Scattered Coconut

For 15 plots of 50 x 50 metres the coconut palms were counted in the stratum "Scattered Coconut" on the satellite image data. This represents an area of 37,680 m². This stratum covers 3,417,488 m² and theoretically 1,367 plots could have been analysed instead of 15. The number of palms varies from 5 (min) to 12 (max) which represents 20 or 48 palms/ha with an average of 31 palms/ha with a standard deviation of ±8 palms/ha.

¹ SOPAC is currently purchasing a sub-metre accurate GPS unit. Using this unit the location of individual palms as well as the exact plot location can be documented. This allows establishing a correlation between palms visible in image data and palms standing on the ground.
4.1.4 Sum Available Coconut Palms

Table 4-01 displays the estimated coconut palm resource available in Pohnpei Island. These figures are based on the average number of palms visible in the plots established in the image data not in the field. The number of palms per hectare in dense stands counted from image data only is under represented.

<table>
<thead>
<tr>
<th>Class</th>
<th>Area [HA]</th>
<th>Palms/HA</th>
<th>Palms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense coconut</td>
<td>4,195</td>
<td>210</td>
<td>880,950</td>
</tr>
<tr>
<td>Medium dense coconut</td>
<td>285</td>
<td>96</td>
<td>27,360</td>
</tr>
<tr>
<td>Scattered coconut</td>
<td>509</td>
<td>31</td>
<td>15,779</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>924,089</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 4-01: Estimated coconut resource Pohnpei Island without settlement areas*

4.2 Coconut Production

Normally healthy coconut production ranges between 70 and 100 nuts per year and per palm (FAO). During the first field plots in Pohnpei the production was measured. The nuts on the three oldest branches were counted divided by three and multiplied by 12^2.

<table>
<thead>
<tr>
<th>Coconut Stratum</th>
<th># Plots</th>
<th>Min</th>
<th>Max</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense coconuts</td>
<td>8</td>
<td>23</td>
<td>41</td>
<td>31</td>
</tr>
<tr>
<td>Semi dense coconuts</td>
<td>30</td>
<td>17</td>
<td>60</td>
<td>37</td>
</tr>
<tr>
<td>Scattered coconuts</td>
<td>4</td>
<td>44</td>
<td>49</td>
<td>47</td>
</tr>
</tbody>
</table>

*Table 4-03: Estimated coconut production per palm in Pohnpei*

The yield in dense coconut stands (> 150 palms/ha) is naturally less than in semi dense stands (51 – 150 palms/ha) as the palms have nutrition competition. Assuming an average weight of 1.5 kg per nut and 30% of this weight is copra, the potential yield can be calculated. However, this would include the complete area covered by coconut in Pohnpei. This is an unrealistic figure as explained in the next chapter.

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Hectare</th>
<th>Palms/ha</th>
<th>Palms</th>
<th>Nuts</th>
<th>Copra [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Coconut</td>
<td>4,195</td>
<td>210</td>
<td>880,950</td>
<td>27,309,450</td>
<td>13,654,725</td>
</tr>
<tr>
<td>Semi dense coconut</td>
<td>285</td>
<td>96</td>
<td>27,360</td>
<td>10,123,20</td>
<td>506,160</td>
</tr>
<tr>
<td>Scattered coconut</td>
<td>509</td>
<td>31</td>
<td>15,779</td>
<td>741,613</td>
<td>370,807</td>
</tr>
</tbody>
</table>

*Table 4-04: Estimated potential copra yield assuming 1.5 kg average weight per nut and copra as 30 % of the weight (area without settlement area).*

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Hectare</th>
<th>Palms/ha</th>
<th>Palms</th>
<th>Nuts</th>
<th>Copra [Kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Coconut</td>
<td>381</td>
<td>210</td>
<td>80,010</td>
<td>2,480,310</td>
<td>1,240,155</td>
</tr>
<tr>
<td>Semi dense coconut</td>
<td>26</td>
<td>96</td>
<td>2,496</td>
<td>92,352</td>
<td>46,176</td>
</tr>
<tr>
<td>Scattered coconut</td>
<td>167</td>
<td>31</td>
<td>5,177</td>
<td>243,319</td>
<td>121,660</td>
</tr>
</tbody>
</table>

*Table 4-05: Estimated potential copra yield assuming 1.5 kg average weight per nut and copra as 30 % of the weight (settlement area).*

\(^2\) See report “Outline of Coconut Resource Inventory”
4.3 Harvestable Coconut resource

The accessibility of the coconut resource is a factor which is often overlooked. It is not economical to search for every coconut on the ground and stands less than 50 palms per hectare (scattered coconut) are not suitable for coconut harvest based on experience in Rotuma, Fiji. If the one collecting the coconuts has to search for each nut the collection time in proportion to the collected nuts is too high and the collection is uneconomic. Coconuts are normally carried in self-made baskets to the next track and left there until a vehicle picks them up. It is not economical to manually carry these baskets more than 350 metres as the time for transport reduces the number of collected nuts per hour. In dense coconut stands which normally have young palms in the undergrowth the economic transport distance shrinks to 50 metres. Both figures are based on experience in Rotuma and Kiribati.

GIS allows to semi-automatically drawing lines in 50 and 350 metres to both sides of every road and track which then can be converted to an area. These so called buffer zones can be overlaid with the semi dense and dense coconut palm stands. They then indicating areas in which coconut harvesting is economic. Figure 4-01 and figure 4-02 show the buffer zonation of 50 and of 350 metres. Figure 4-02 shows (only a small subset) clearly that many areas are not economically accessible for coconut collection.

Settlements (areas 75 metre buffer around houses) were treated as special class because of strong human influence on the vegetation. Patches covered by palms are now added to the palm area (red colour in figure 4-02).

The area from where coconuts can be collected economically reduces the total area of table 4-03 to figures shown in table 4-04. The area left is 12 % for dense coconuts and 79 % for semi dense coconut.

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3 Both figures are based on experience in Rotuma and Kiribati.
<table>
<thead>
<tr>
<th>Stratum</th>
<th>Area [ha]</th>
<th>Palms/ha</th>
<th>Palms</th>
<th>Nuts</th>
<th>Copra [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense coconut</td>
<td>458</td>
<td>210</td>
<td>96,180</td>
<td>2,981,580</td>
<td>1,490,790</td>
</tr>
<tr>
<td>Semi dense coconut</td>
<td>204</td>
<td>96</td>
<td>19,584</td>
<td>724,608</td>
<td>362,304</td>
</tr>
<tr>
<td>Sum</td>
<td>662</td>
<td>306</td>
<td>115,764</td>
<td>3,706,188</td>
<td>1,853,094</td>
</tr>
</tbody>
</table>

Table 4-06: Harvestable coconut per year in Pohnpei; the area is heavily reduced especially for dense coconut stands. The copra production in kg is based on assumption: 1.5 Kg weight per nut and 1/3 of the weight is copra⁴.

It is assumed that coconuts of all strata dense, semi dense and scattered can be collected in settlement areas so that the 2,815,981 or 1,407,991 Kg copra from table 4-04 has to be added to the amount of harvestable coconut, which results in 3,792,169 nut or 3,261,085 Kg copra.

Two conditions have to be investigated:

a) The road network available for the GIS: It is possible that not all road and tracks accessible for trucks are shown as digital information and the real road network is more dense than shown⁵.

b) The condition of dense coconut stands. It is possible that for example the undergrowth and regeneration is less dense than normal and the stands are more accessible than just for 50 metres. If stands of 210 palms per hectare (average) are properly managed coconuts can be economically transported for more than 50 metres. The “economic transport distance” can only be estimated by interviewing coconut farmers. This figure also will vary from island to island.

The current road network as digital layer does not fully fit onto the road network visible in the image data. The figure of harvestable coconut calculated with the currently available road network has definitely an error. The digital road network layer has to be adjusted to the image data, which estimated as one week of GIS work.

### 4.4 Coconut Palm Age

In Pohnpei coconut palms were already actively planted when the island was a German colony. There must be many old palms. This was not reflected in the plots measured in March. The age was noted in the inventory plots. Therefore the length of 11 leave scars were measured from 1.5 metres onwards. The total length of the trunk was divided by this length and a factor of 5 was added. This age estimation is the praxis of LRD Division of SPC⁶. The age estimation has to be calibrated at a later stage. Therefore palm stands, where the farmer still exactly knows the year of planting, have to be measured and age calculation has to be compared with the real age.

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⁴ Coconut production figures in terms of harvest of nuts per person per day and copra content of average nut have to be established for every island. See “Biofuel from Coconut in Rotuma” 2007, Zieroth, Gaunavinaka, Forstreuter.

⁵ If the digital road network is not showing all tracks, additional tracks can be easily conducted with a differential GPS mounted on a truck.

⁶ For further information see Tevita Kete, SPC-LRD or “Outline of Coconut Resource Inventory, Pohnpei” Forstreuter, Bataua, Wortel.
In dense stands, the coconut production normally can be increased by removing old unproductive palms (50 years and older) which reduces the nutrition competition and opens the stands at the same time. If such a thinning is planned the palms have to be removed to avoid insect breeding ground.

4.5 Palm Timber Volume

The diameter at breast height (1.3 metre) and the length of the palm trunk was measured for every palm in the inventory plots. Also the form factor of 0.71 was estimated from one palm (see “Outline of Coconut Resource Inventory, Pohnpei”). This allows a calculation of the available timber volume. For dense stands, this varies between 100 m$^3$/ha to 250 m$^3$/ha with an average of 162 m$^3$/ha. For semi dense stands, the volume varies from 17 m$^3$/ha to 173 m$^3$/ha with an average of 53 m$^3$/ha. This refers to the standing volume from which a part has to be removed. The usable timber volume is much less (see “Outline of Coconut Resource Inventory, Pohnpei”). It is assumed that the timber will be utilised with a transportable sawmill or special chainsaw setups to pay for the removal from the stands.

![Figure 4-03: Number of palms (y-axis) in Pohnpei plots over age groups (x-axis). The peak is in the age group 15 to 20 years, where the production just starts.](image-url)
5 Appendix 1 Interpretation of Land Cover Classes

The stratification and delineation of the land cover classes is based on on-screen visual interpretation.

5.1 The Visual Interpretation

The Digitising was performed with a zoom factor of 500 m where 1 cm screen distance represented 10 m in the filed. The Zoom factor of 500 m was the optimal display to separate coconut palm from other vegetation types. The smallest unit for indicated as own vegetation class was 25 x 25 metres for the complete area.

5.2 The Land Cover Classes

This chapter describes the land cover and the interpretation key.

5.2.1 Dense Palms

Dense coconut stands have a palm density of more than 150 palms per hectare. The number of palms per hectare cannot be counted on the images as this typically leads to an underestimation because the palms in the understory are not visible. Field sample plots have to be analysed to create a correlation between visible and actual number of palms per hectare. In opposite to forest vegetation the smaller and invisible palms are important as they are more productive than the tall and old palms. In cases the vegetation is too dense coconut harvest is sometime difficult.

Figure 5-01: Dense coconut stands on Pan-Sharpened image data in Pohnpei States
5.2.2 Shrub

Shrub is vegetation under 5 meters in height. The vegetation type “shrub” looks green but does not show the coconut palm texture or the texture of planting rows. The surface appears smoother than coconut stands.

5.2.3 Settlements

The visibility of house or huts on the pan images indicates settlements. Within a distance of about 75 metres to settlements human influence changes the natural species composition. Therefore the area is delineated as a 75m buffer to both sides of the road and houses. If the high water mark is closer than 75m to the road the high water mark is the boundary.

At a later stage vegetation patches within settlement areas will be stratified into palm and other vegetation where "other vegetation" will be statistical stratified into breadfruit and pandanas through field visits as a separation is currently difficult with the available image data only.
5.2.4 Forest
The vegetation type “Forest” in the Pan-sharpened image data is visible as a green texture but does not show the coconut palms texture. However vegetation type “forest” it is higher than all palms.

5.2.1 Bare Land
Bare land is considered as areas without or marginal vegetation. This land cover type is visible as brown to yellow and white in the pan sharpened GeoEye image with homogeneous flat texture.
5.2.2 Water Bodies

Any form of inland water is classified as "water body". The plain dark surface without any texture identifies it. These can be ponds, lakes and swamps.

![Figure 5-06: Water body on Pan-Sharpened image data in Pohnpei States](image)

5.2.3 Mangrove

Mangroves live at the edge of the land and grow at sea level. They can be identified by their texture like a woollen carpet. It appears darker and dark green than closed by vegetation. Sometimes mangroves have two types of texture like in water is darker and inland it appears dark green. Mangroves grow normally at the beach and in low lying parts of islands with salt water infiltration also inland.

![Figure 5-07: Mangrove on Pan-Sharpened image data in Pohnpei States](image)
Figure 5-08: Land cover type map Pohnpei States.
Figure 5-09: Land cover type map Pohnpei North.

Figure 5-10: Land cover type map Pohnpei South.
# Appendix 2 Abbreviations

Table of class names

<table>
<thead>
<tr>
<th>Land Cover Classes</th>
<th>Abbreviation of Land cover Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST</td>
<td>Settlement</td>
</tr>
<tr>
<td>Shrub</td>
<td>Shrub</td>
</tr>
<tr>
<td>SCO</td>
<td>Scattered Coconut</td>
</tr>
<tr>
<td>CP</td>
<td>Coconut Plantation</td>
</tr>
<tr>
<td>DCO</td>
<td>Dense Coconut</td>
</tr>
<tr>
<td>WB</td>
<td>Water Body</td>
</tr>
<tr>
<td>BL</td>
<td>Bare Land</td>
</tr>
<tr>
<td>Notclear</td>
<td>Not clear</td>
</tr>
<tr>
<td>MG</td>
<td>Mangrove</td>
</tr>
<tr>
<td>FOR</td>
<td>Forest</td>
</tr>
</tbody>
</table>
Appendix 3 Data Storage

Data

Server GISdata

Countries

FSM

Pohnpei States

IMG

VegMapping

AccessData

Report

VectorVegClasses
Appendix 4 Counting Coconut Palms Utilising MapInfo and Access

8.1 Introduction
This instruction paper explains how the features of MapInfo can be utilised to assist the counting of coconut palms. The operator does not have to count he can concentrate on image interpretation or more particular in the identification of individual coconut palms. The counting is then conducted by MapInfo and Access.

8.2 Coconut Palm Stratification
The coconut palm cover is stratified with sub-metre resolution image data into three categories:

1) dense coconut palms [150 to 300 and more palms per hectare],
2) semi dense coconut palms (also named coconut plantation) [50 to 150 palms per hectare] and
3) scattered coconuts [less or equal than 50 palms per hectare].

This stratification might be revised after more accurate data is available. For the time being visual impression is used to delineate the coconut cover into the three density classes where areas below ¼ hectare (50 x 50m) is the normally smallest mapping unit.

8.3 Image Sample Plot Establishment
Sample plots will be established on the images to count the number of coconut palms within a defined area.

8.3.1 Creating Thematic Map
One of the classes at the time will be displayed in colour all other classes with transparent coding. The palms therefore are not visible.

In MapInfo software the function "Create Thematic Map" is used where polygons are coded individual by default and the style is revised to transparent or full colour following the wizard instruction.

8.3.2 Grid Establishment
A grid has to be overlaid to be able to count the number of palms per hectare with sample plots of defined size.

The MapInfo grid function is used to create a 50 x 50m grid following the UTM projection. The grid must have polygons instead of poly lines. The grid acts as own layer with linked table. The table has to be changed through "Table Maintenance" instruction where a new one digit text field “Inside” is added. Then a default “N” is added through "Update Table" instruction

8.3.3 Grid Cell Selection
As a next for all grid cells which are fully inside the stratum a “Y” is stored in the field "Inside" through the MapInfo "I" instruction. Grid cells which are partly outside the stratum area keep their “N” in the field “Inside”.

7 For very small islands 25 x 25 m
After finishing this step all polygons containing a "Y" in the field "Inside" are selected and the selection is saved as new table "PotentialPlots_Stratum" where stratum can be dense, semi dense or scattered.

For the new table "PotentialPlots_Stratum" a new 7 digits text field is added “PlotNo". Through the MapBasic program "Add unique ID" this field is filled with a unique ID IN_0001 to IN_x. It is also possible to use the MapInfo grid code as unique ID (see figure 08-2).

From this grid cells 10 - 20% are randomly selected. Therefore paper chips have to be produced the numbers printed on it. These are put in bag and someone gets 10 - 20% out of the bag. For small islands all plots fully covered by only one class are selected. In extreme situations of very small vegetation pattern 25 x 25 grid cells have to be utilised.

Another 1 digit text field “Selected” has to be added to the table "PotentialPlots_Stratum". This has to be filled with "N". Then the "N" is converted to "Y" for all selected plots.

The selection of the table has to be copied to a new table "Plots_Stratum".

8.4 Counting of Palms per Hectare
This chapter describes how the counting is conducted by MapInfo and Access.

8.4.1 Counting Palms per Plot
A new layer has to be established “Palms_Stratum". The layer has to be editable and a red dot has to be placed on every visible palm in the selected sample plots. The interpreter concentrates on the identification of individual palms. He does not have to count and if he marks a palm outside the plot it will not change the figures as the program only recognises the palms inside the selected plots, see figure 08-1.

Then the layer Plots_Stratum and the layer Palms_Stratum have be overlaid and the number of palms “within” will be counted by MapInfo for every grid cell and stored in a new table through a SQL command:

```
SELECT TableName.UniqueID, count(*)
FROM TableName(GridTable), TableName(CoconutSymbolTable)
```

Figure 8-01: Selected grid cells with marked palms in dense coconut, Pohnpei States
WHERE TableName(GridTable) contains TableName(CoconutSymbolTable)

GROUPED BY TableName.UniqueID

INTO NewTable

The layer with the stored number of palms per grid cell has to be exported to access, where all parameters such as range, statistical mean and standard deviation will be calculated (see figure 08-2).

In Access the variation coefficient can be calculated which should give 95% confidence. If this is not the case additional plots have to be selected and procedure has to be repeated. If the confidence is reached the number will be multiplied by 4 to display the number of palm per hectare.

Figure 8-02: Access form for dense coconut