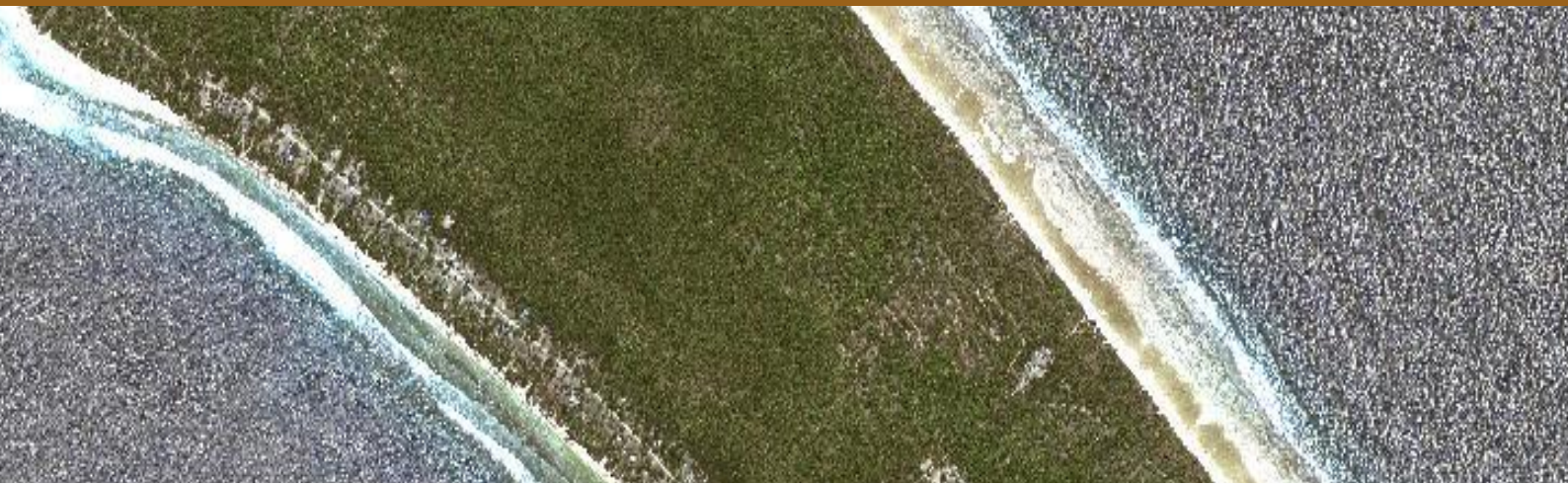


Technical Note – Revised land cover type mapping utilising GeoEye image data, Tamana Island, Republic of Kiribati



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Wolf Forstreuter¹, Kataebati Bataua²

¹GIS & Remote Sensing Section, Technical Support Services, ²Republic of Kiribati

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Applied Geoscience and Technology Division (SOPAC)
Private Mail Bag
GPO Suva
Fiji Islands
Telephone: (679) 338 1377
Fax: (679) 337 0040
E-mail: director@sopac.org
Web site: <http://www.sopac.org>

Revised Land Cover Type Mapping Utilising GeoEye Image Data TAMANA ISLAND



GeoEye image data of Tamana Island

For further Information

Wolf Forstreuter, SOPAC, wforstreuter@yahoo.co.uk

Kataebati Bataua, SOPAC, kataebati@sopac.org

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1 Introduction

The vegetation mapping for low lying islands started at SPC/SOPAC as a initiative related to the FAO programme **M**onitoring **A**ssessing and **R**eporting (MAR) in Tuvalu. In 2009 a monitoring system was established in the Agriculture Department in Kiribati and initial training was provided through SPC/SOPAC. The Agriculture Department worked together with the Department of Environment and the Lands Department on the vegetation mapping task. Kiribati – like Tuvalu at a later stage – expressed additional reasons to map the vegetation of their outer islands. They explained the importance of mapping the coconut resource because accurate figures are required to attract bio fuel related projects. Spatial and statistical information of the coconut resource is also required to be able to start regeneration activities as most coconut palm stands are getting senile. Another important reason to map the vegetation is the food security of low lying islands where the Agriculture Department needs to know the available amount and condition of pandanas, coconut and bread fruit to support management of this natural resource. Finally, the vegetation cover is supposed to be documented to be able to record any changes through a re-mapping at a later stage. It is presumed that the impact of climate change will be visible through vegetation changes which refer especially to mangrove vegetation.

SPC Forest and Trees finances one position at SPC-SOPAC's GIS&RS section currently filled by Kataebati Bataua from Kiribati who continues the vegetation mapping to support the mapping in Kiribati's Environment, Lands Department and Agriculture Department.

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 (GeoEye). The geo-location accuracy is about 5 metres for GeoEye image data.

The coconut cover is stratified into three density classes. These classes might be revised after establishing sample plots within the image data to count the number of palms per hectare.

Currently there is no area subdivision of Tamana Island. This will be done if the official boundaries are delivered by the Lands Department in Kiribati.

2 The Satellite Image Data

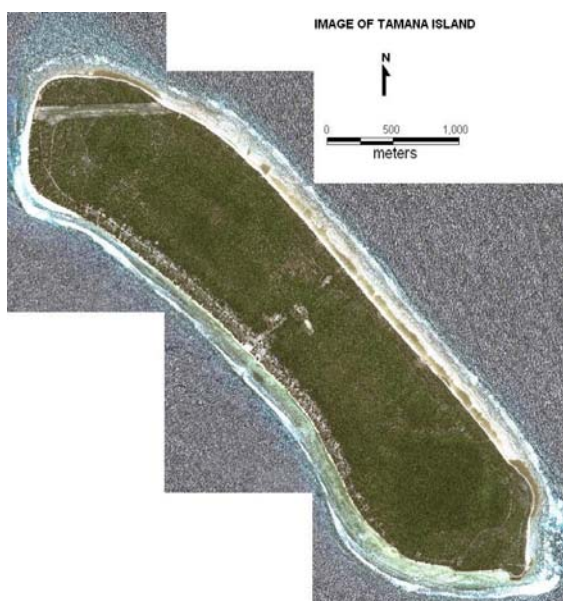


Figure 01: GeoEye image data of Tamana Island.

The interpretation is based on GeoEye image data providing 50 cm spatial resolution and colour. The image data arrived as band combination blue, green, red 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 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 04 April 2011 as two tiles. The image data set was purchased as geo-coded in UTM WGS84 Zone 60. A possible shift is marginal due to the high geo-accuracy of about 5 metres.

3 Area Analysis

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.

375 hectares or 81 % of Tamana Island are covered by vegetation where 92 % is coconut cover and out of this 77 % or 288 hectare are dense or semi dense ("plantation") stands, which are the areas economically to harvest.

19 % or 86 hectares of Tamana Island have non-vegetation cover where 0 hectares or 0 % is water bodies. Currently no water bodies in Tamana Island.

Table 01: Land cover summary of Tamana Island.

Class	Area (ha)	% of Sum
01 Forest	0	0 % of 375
02 Mangrove	0	0% of 375
03 Dense coconut	197	52.5 % of 375
04 Medium dense coconut	91	24.3 % of 375
05 Scattered coconut	58	15.5 % of 375
06 Shrub	29	7.7 % of 375
Sum Vegetation	375	81 % of 461
07 Settlement	75	87.2 % of 86
08 Bare land	11	12.8 % of 86
09 Water body	0	0% of 86
10 Unclear (clouds)	0	0 % of 86

Sum Non-Vegetation	86	19% of 461
Total	461	

4 The Coconut Resource

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 C. However, this does not mean that the complete area is harvestable as the distance to the next transport line (track) has to be estimated through buffer zone analysis. Normally 300 to 350 metres is the maximum distance coconuts will be carried by hand.

The coconut production also depends on age of the palms, the soil and the amount of hybrids in the coconut stands, which only can be determined by field sample plots.

4.1 Dense Coconut Palms

For 20 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 50,260 square metres as in GIS environment 50 x 50 m represents 2,513 square metres which is half a percent more than the cartesian area of only 2,500 m². The stratum "Dense Coconut" covers 1,972,209 m² and theoretically 785 plots could have been analysed instead of only 20. The number of palms varies from 59 (min) to 74 (max) which represents 235 or 294 palms per hectare (palms/ha) with an **average of 258 palms/ha** with a standard deviation of only +16 palms/ha. The question for dense coconut cover is, how far the counting of palms really represents the reality as the young palms are often not visible in the image data. Field samples have to create a correction factor between image interpretation and field reality.

4.2 Medium Dense Coconut

For 20 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 50,260. This stratum covers 913,882 m² and theoretically 364 plots could have been analysed instead of 20. Although 20 plots are nearly the half of the possible plot quantity the number of palms varies from 25 (min) to 44 (max) which represents 99 or 175 palms/ha with an **average of 130 palms/ha** with a standard deviation of +25 palms/ha.

4.3 Scattered Coconut

For 20 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 50,260 m². This stratum covers 578,090 m² and theoretically 230 plots could have been analysed instead of 20. The number of palms varies from 10 (min) to 16 (max) which represents 40 or 64 palms/ha with an **average of 50 palms/ha** with a standard deviation of +8 palms/ha.

4.4 Sum Available Coconut

Table 02 displays the estimated coconut palm resource available in Tamana Island. As mentioned before the age and amount of hybrids are influencing the production. The average

Table 02: Estimated coconut resource Tamana Island.

Class	Area (ha)	Palms/ha	Palms
Dense coconut	197	258	50,826
Medium dense coconut	91	130	11,830
Scattered coconut	58	50	2,900
Sum			65,556

production per coconut palm has to be elaborated for each islands. There are several ways to do this but this will be postponed to a later stage. It was mentioned above that available coconut resource is not the same figure as harvestable coconut resources as the transport by hand to

the next road where a truck can pick up the coconuts is critical.

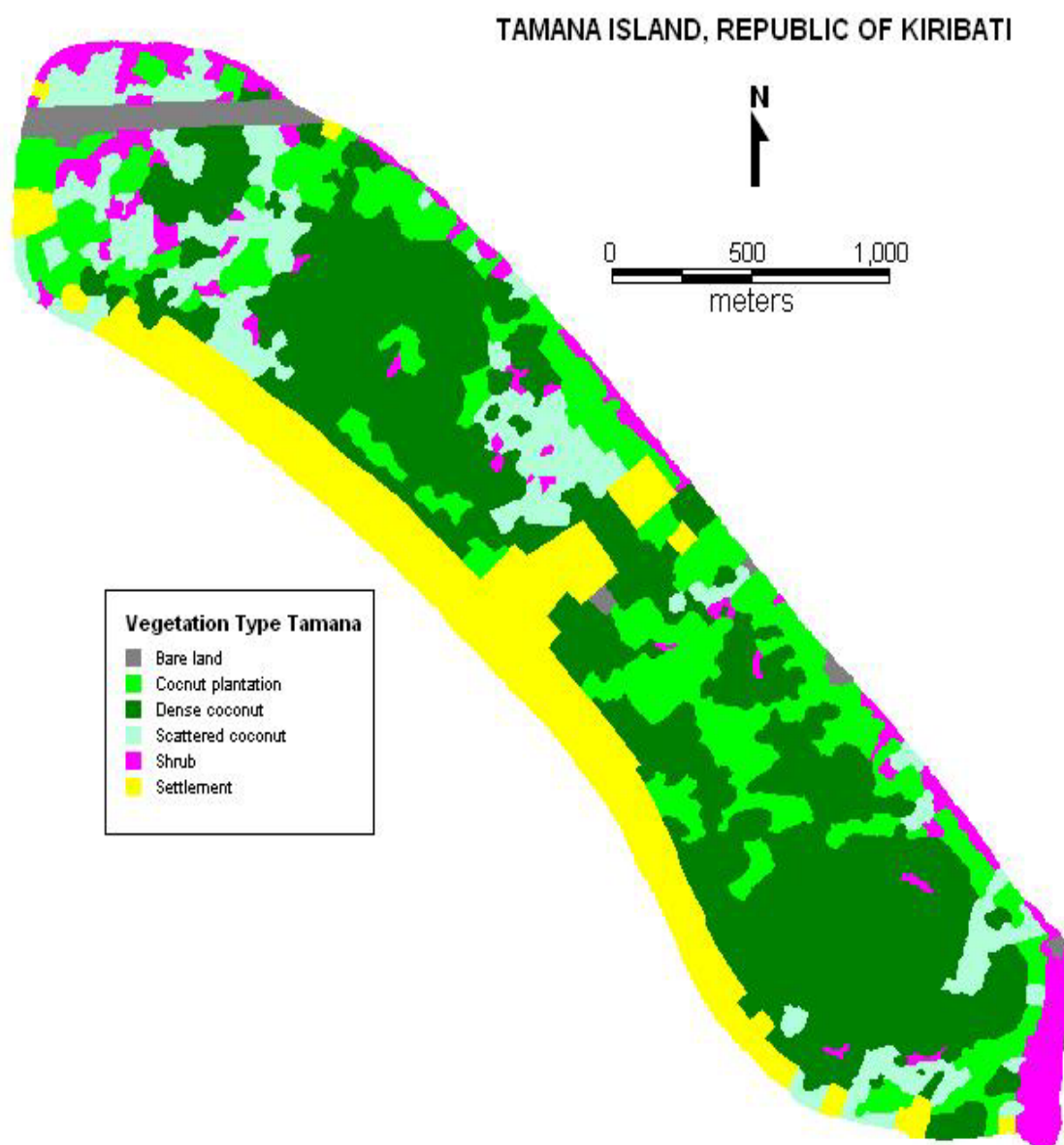


Figure 02: Land cover type map Tamana Island.

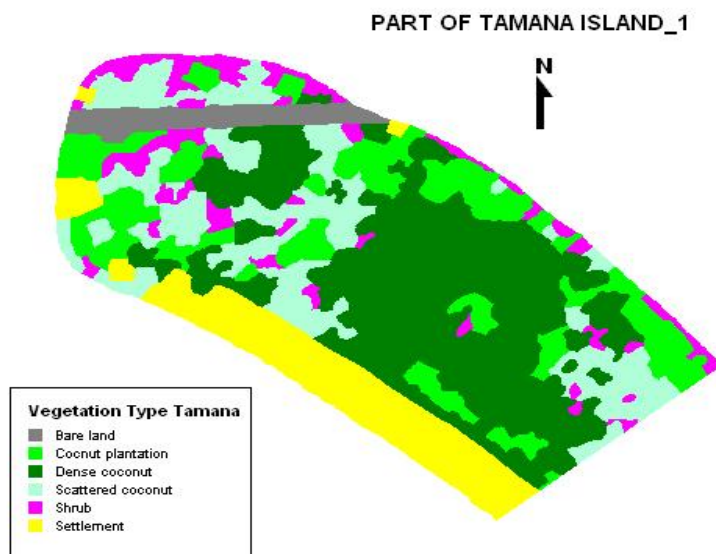


Figure 03: Land cover type map Tamana_1.

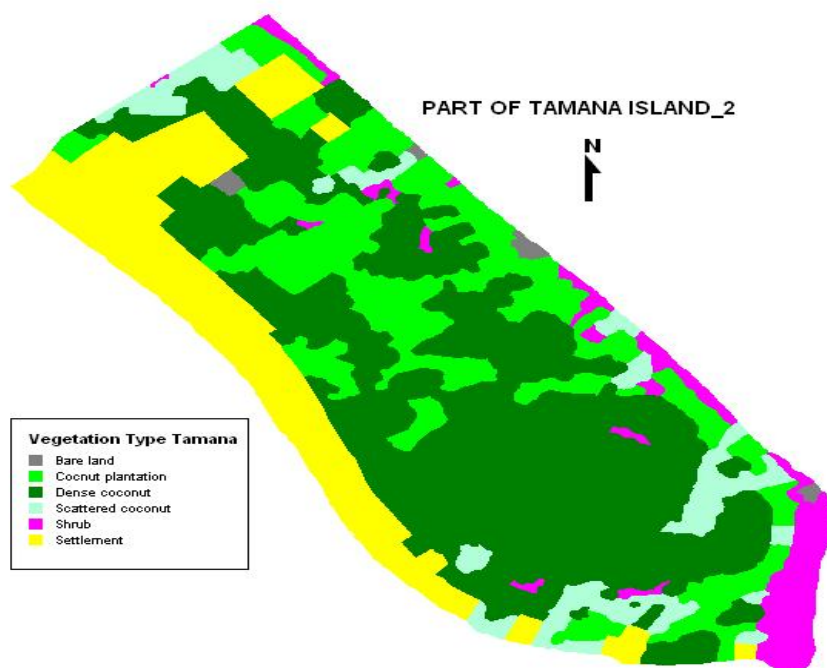


Figure 04: Land cover type map Tamana_2.

5 Interpretation of Land Cover Classes

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

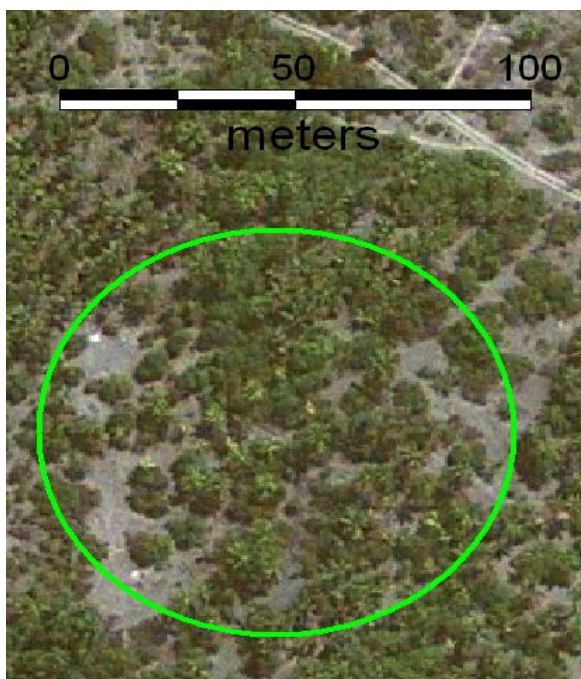
5.1 The Visual Interpretation

The digitising was performed with a zoom factor of 500 m where 1 cm screen distance represented 10 m in the field. The zoom factor of 500 m was the optimal display to separate coconut palm from over 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 Scattered Palm



Coconut palms have a typical star like shape and this texture allows a separation from other vegetation even if the colour is similar. Figure 05 shows scattered coconut palms within shrub vegetation. Coconut harvest is normally uneconomic in scattered coconut stands. Scattered palm stands have less or equal than 50 coconut palms per hectare. The number of palms per hectare can be counted on VHR image data with sub-metre resolution such like this GeoEye images.

Figure 05: Scattered coconut GeoEye image data Tamana Island.

5.2.2 Palm Plantation

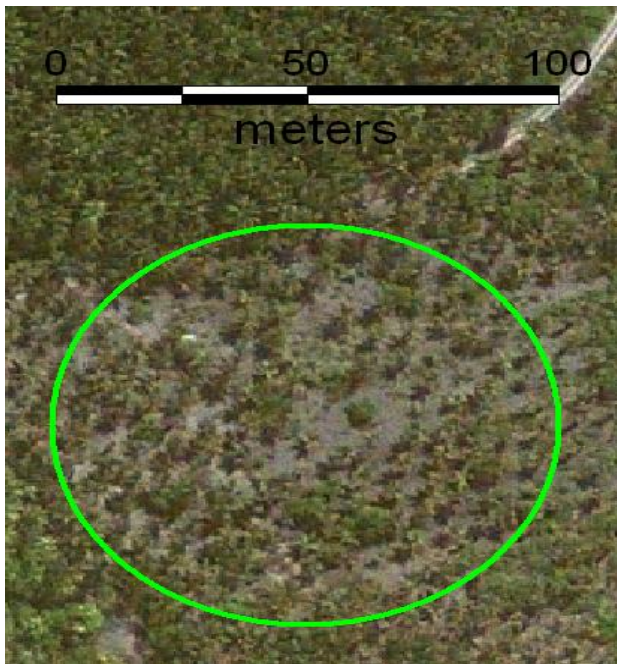


Figure 06: Palm plantations or semi dense coconut stands on GeoEye image data in Tamana Island.

The class “Palm Plantation” reflects a density typical in coconut plantations of 50 to 150 palms per hectare. The class name does not indicate that there are actual plantations on the ground. It is possible that the plantations are not maintained anymore or that by coincidence such a palm density is mapped. Again the texture allows a separation of palms from other vegetation. In addition, planting rows are clearly visible and make the separation from other vegetation easy even if there is an understory of shrub vegetation. Sample plots within the image data allow an estimation of palms per hectare with 100 % accuracy in sub-metre resolution image data.

Semi dense coconut stands are ideal for coconut harvest as the collector has sufficient coconuts per hectare to collect (in opposite to scattered coconuts) and he can easily move in the area (in opposite to some dense coconut stands).

5.2.3 Dense Palms

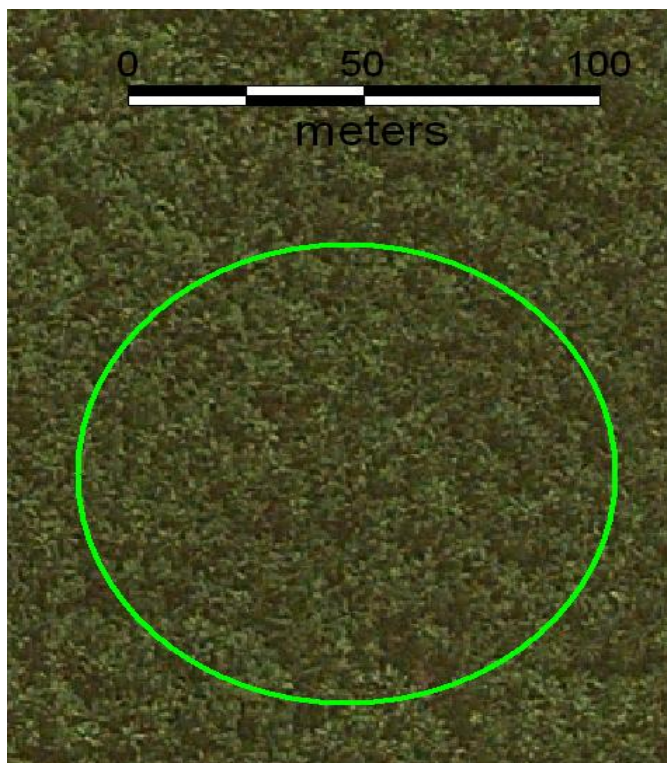
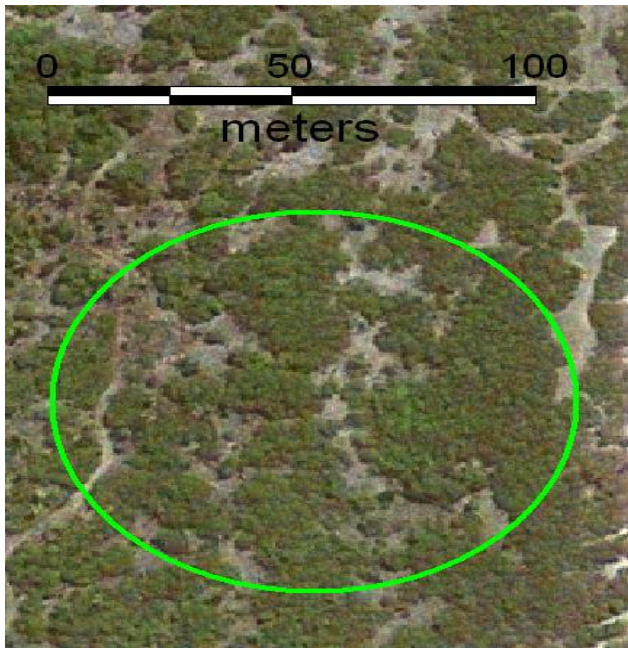


Figure 07: Dense coconut stands on GeoEye image data in Tamana Island.

Dense coconut stands have a palm density of 150 to 300 palms per hectare. The number of palms per hectare cannot be counted with 100% accuracy 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 sometimes difficult.

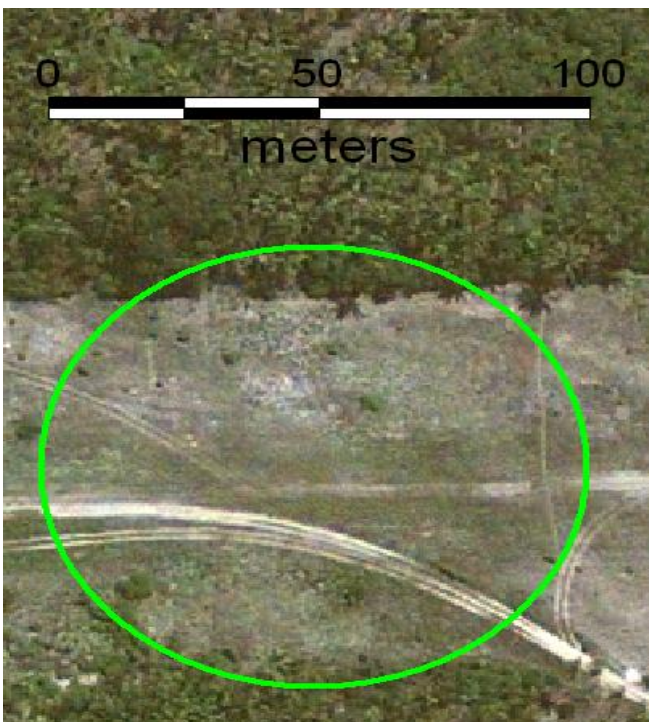
5.2.4 Shrub



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.

Figure 08: Shrub vegetation on GeoEye images data, Tamana Island.

5.2.5 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 GeoEye image with homogeneous flat texture.

Figure 09: Bare land on GeoEye image data Tamana Island.

5.2.6 Settlements

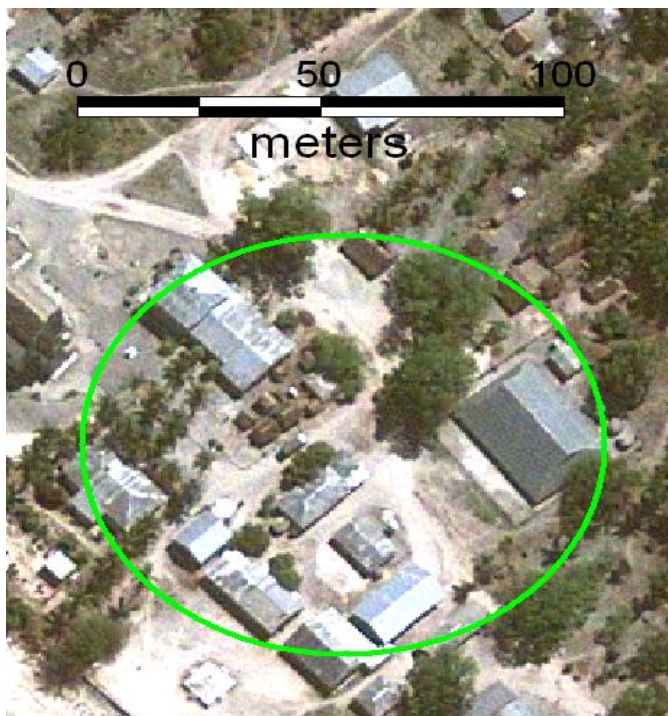


Figure 12: Settlement GeoEye image data Tamana Island.

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 75 m buffer to both sides of the road and houses. If the high water mark is closer than 75 m 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 statistically stratified into breadfruit and pandanas through field visits as a separation is currently difficult with the available image data only.

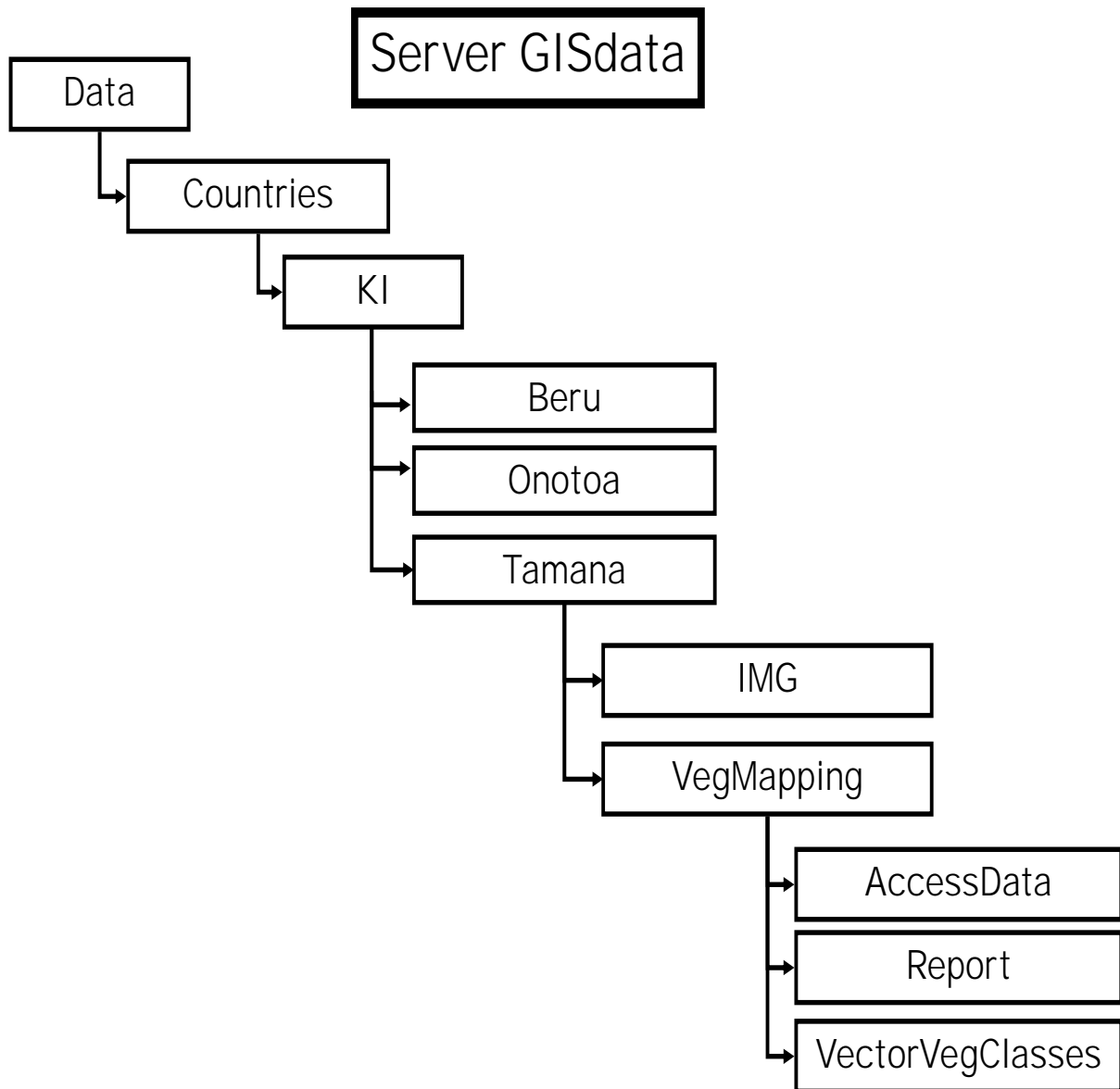
6 Appendices

A Abbreviations

Table of class names

Land Cover Classes	Abbreviation of Land Cover Classes
ST	Settlement
Shrub	Shrub
SCO	Scattered Coconut
CP	Coconut Plantation
DCO	Dense Coconut
WB	Water Body
BL	Bare Land
Notclear	Not clear
MG	Mangrove
FOR	Forest

B Data Storage



C Counting Coconut Palms Utilising MapInfo and Access

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.

2 Coconut Palm Stratification

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

- a) Dense coconut palms [150 to 300 and more palms per hectare];
- b) semi dense coconut palms (also named coconut plantation) [50 to 150 palms per hectare] and;
- c) 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 50 m) is the normally smallest mapping unit¹.

3 Sample Plot Establishment

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

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.

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 50 m 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.

¹ For very small islands 25 x 25 m

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*".

After finishing this step all polygons containing a "Y" in the field "Inside" are selected and the selection is save 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 an unique ID IN_0001 to IN_x. It is also possible to use the MapInfo grid code as unique ID (see Figure B).

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'".



Figure A: Selected grid cells with marked palms in dense coconut.

4 Counting of Palms per Hectare

This chapter describes how the counting is conducted by MapInfo and Access.

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 A.

Then the layer Plots_Stratum and the layer Palms_Stratum have to 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)  
  
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 B).

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.

Sum Palms	279	Plot	1,116	Hectare
Min Palms	10	Plot	40	Hectare
Max Palms	19	Plot	76	Hectare
Mean Palms		Plot	56	Hectare
Standard Dev Palms		Plot	11	Hectare
Number of Plots	20			
Area all Plots m2	50,260			
Area Coco SDense m2	578,090			

Plot ID	Area [m2]	Palms/Plot	Palms/Ha
AL25	2,513	19	76
AM31	2,513	16	64
AO27	2,513	13	52
AP29	2,513	11	44
AQ28	2,513	14	56
BL67	2,513	16	64
BN68	2,513	14	56
BS61	2,513	14	56
BT59	2,513	18	72
E12	2,513	12	48
F5	2,513	13	52
H4	2,513	12	48
I15	2,513	11	44
K14	2,513	12	48

Figure B: Access form for scattered coconut.