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

December 2011

SOPAC TECHNICAL NOTE (PR132)
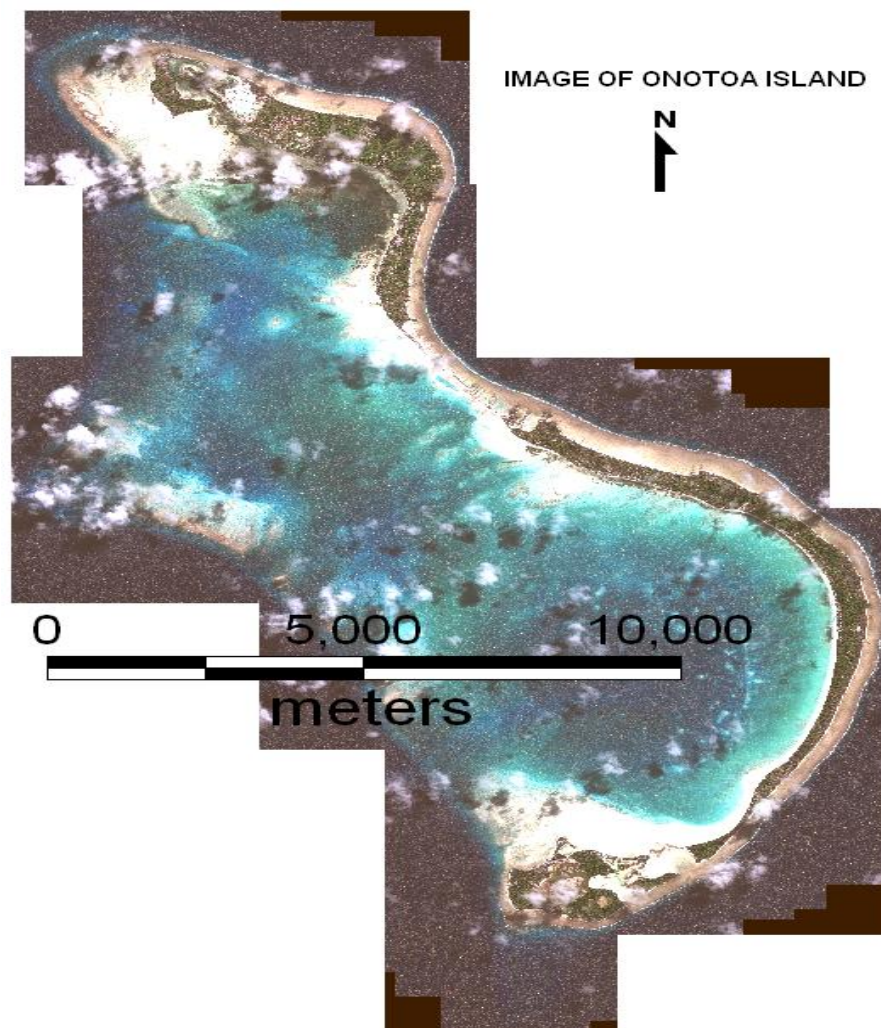
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Revised Land Cover Type Mapping Utilising GeoEye Image Data
ONOTOA ISLAND

IMAGE OF ONOTOA ISLAND

N

0   5,000   10,000
meters

GeoEye image data of Onotoa Island

For further Information

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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 Onotoa Island. This will be done if the official boundaries are delivered by the Lands Department in Kiribati.

2 The Satellite Image Data
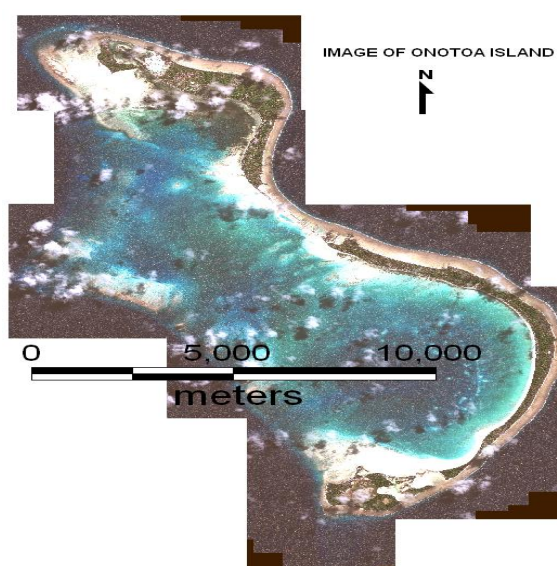
The interpretation is based on GeoEye image data providing 50 cm spatial resolution and colour. The image data arrived as band combination blue, green, red and as band combination green, red, infrared. So far only the natural colour combination of blue, green, red was utilised for the interpretation. 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 eight 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.

Figure 01: GeoEye image data of Onotoa Island.

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.

902 hectares or 67 % of Onotoa Island are covered by vegetation where 85 % is coconut cover and out of this 67 % or 601 hectare are dense or semi dense ("plantation") stands, which are the areas economically to harvest.

33 % or 440 hectares of Onotoa Island have non-vegetation cover where 168 hectares or 38 % are water bodies.

Table 01: Land cover summary of Onotoa Island.

Class	Area (ha)	% of Sum
01 Forest	1	0.11 % of 902
02 Mangrove	43	4.8 % of 902
03 Dense coconut	329	36.5 % of 902
04 Medium dense coconut	272	30.2 % of 902
05 Scattered coconut	165	18.3 % of 902
06 Shrub	92	10.2 % of 902
Sum Vegetation	**902**	**67 % of 1,342**
07 Settlement	159	36.1 % of 440
08 Bare land	59	13.4 % of 440
09 Water body	168	38.2 % of 440
10 Unclear (clouds)	54	12.3 % of 440
Sum Non-Vegetation	**440**	**33% of 1,342**
Total	**1,342**	

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 50,220 square metres as in GIS environment 50 x 50 m represents 2,511 square metres which is half a percent more than the cartesian area of only 2,500 m^2. The stratum "Dense Coconut" covers 3,292,383 m^2 and theoretically 1311 plots could have been analysed instead of only 20. The number of palms varies from 58 (min) to 71 (max) which represents 231 or 283 palms per hectare (palms/ha) with an *average of 241 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 50,220. This stratum covers 2,715,685 m^2 and theoretically 1082 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 26 (min) to 49 (max) which represents 104 or 195 palms/ha with an *average of 147 palms/ha* with a standard deviation of +23 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 50,220 m^2. This stratum covers 1,647,440 m^2 and theoretically 656 plots could have been analysed instead of 20. The number of palms varies from 9 (min) to 15 (max) which represents 36 or 60 palms/ha with an *average of 49 palms/ha* with a standard deviation of +7 palms/ha.

4.4   Sum Available Coconut

Table 02: Estimated coconut resource Onotoa Island.

Class	Area (ha)	Palms/ha	Palms
Dense coconut	329	241	79,289
Medium dense coconut	272	147	39,984
Scattered coconut	165	49	8,085
Sum			**127,358**

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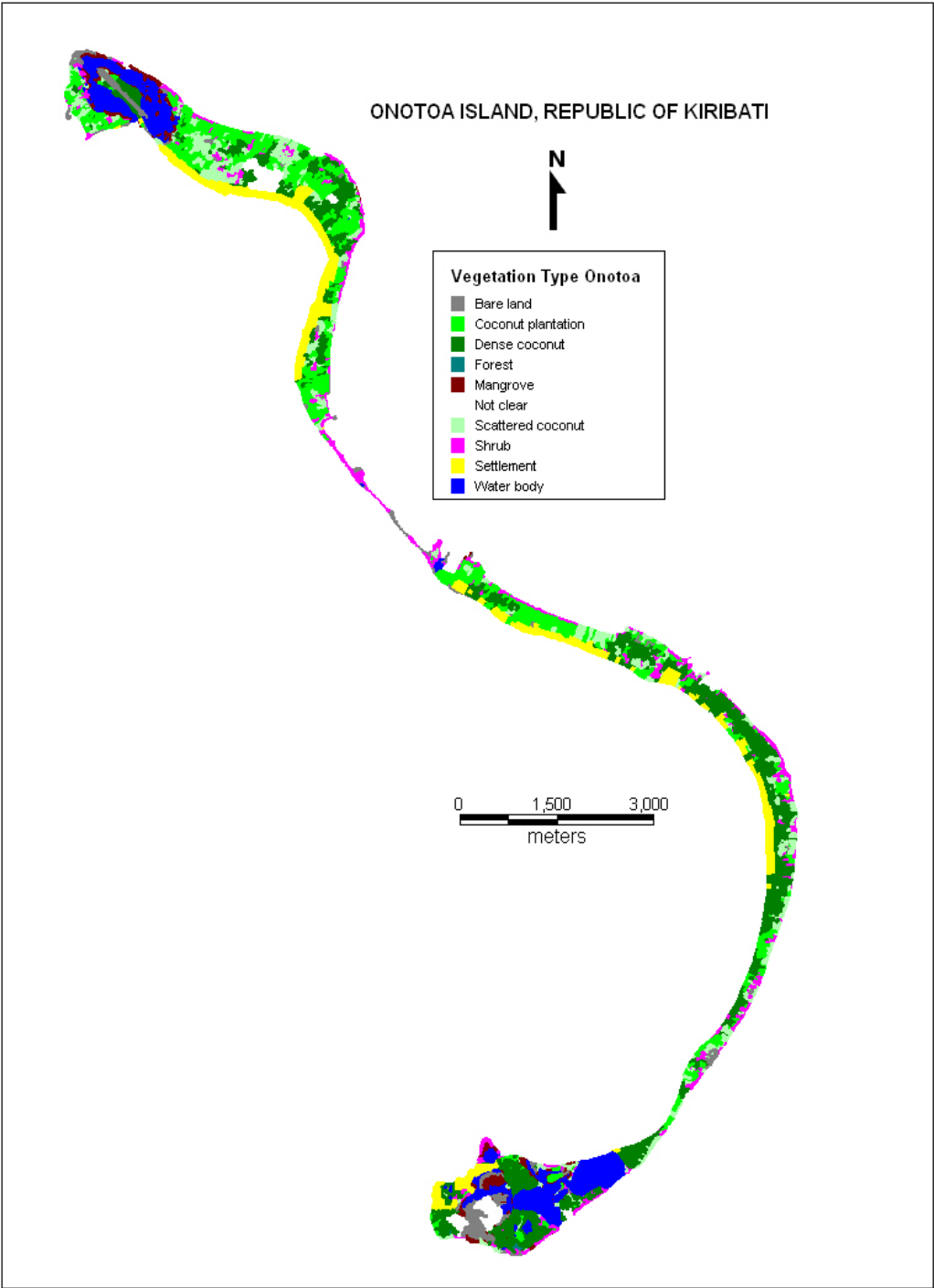

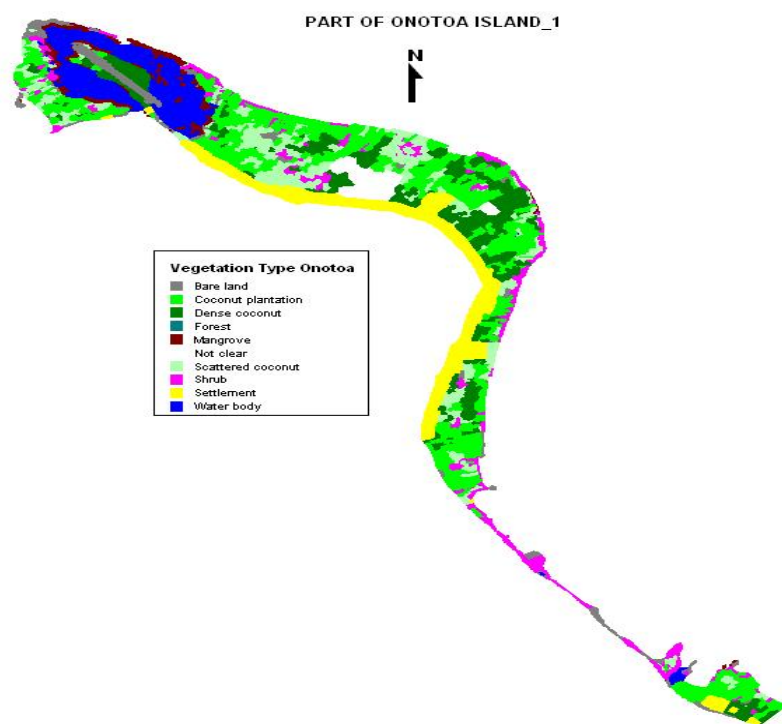*Figure 02:* Land cover type map Onotoa Island.

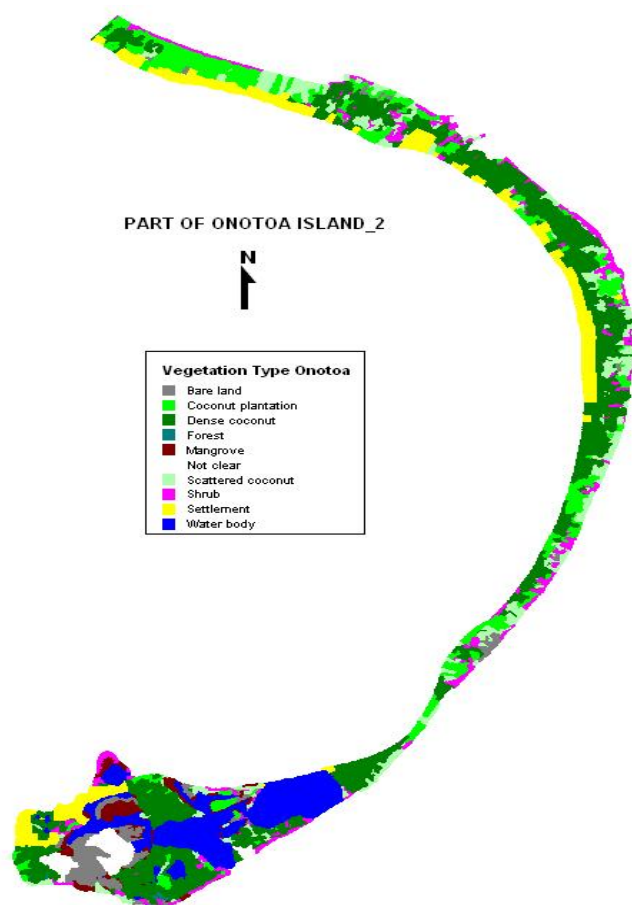*Figure 03:* Land cover type map Onotoa_1.

Figure 04: Land cover type map Onotoa_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
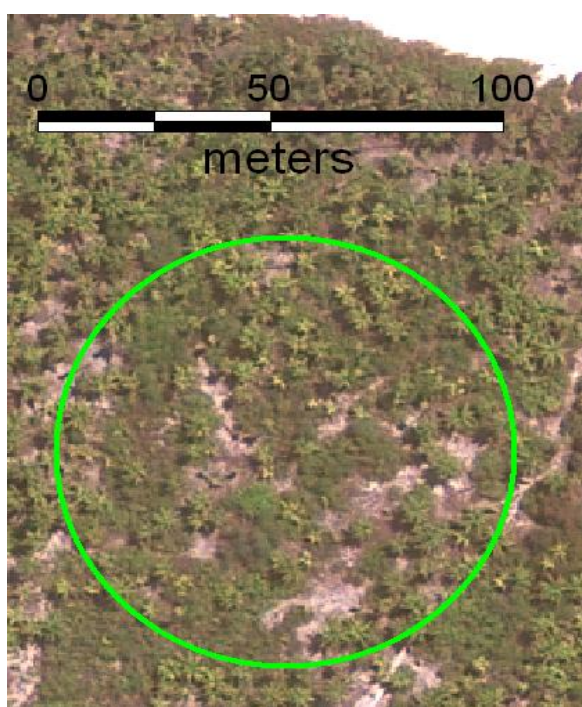
Coconut palms have a typical star like shape and this texture allows a separation from other vegetation even if the colour is similar. Figure 05 shows scattered coconut palms within shrub vegetation. Coconut harvest is normally uneconomical in scattered coconut stands. Scattered palm stands have less or equal than 50 coconut palms per hectar. The number of palms per hectare can be counted on VHR image data with sub-metre resolution such like this GeoEye image.

Figure 05: Scattered coconut GeoEye image data Onotoa Island.
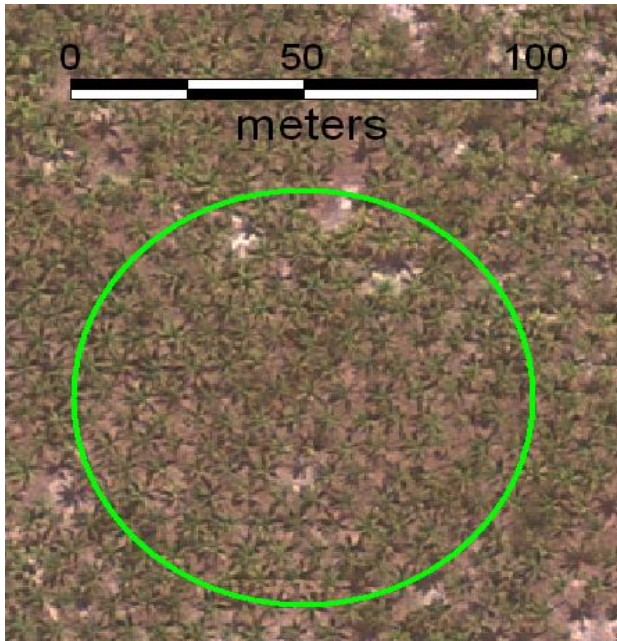
5.2.2 Palm Plantation

Figure 06: Palm plantations or semi dense coconut stands on GeoEye image data in Onotoa 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 the 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
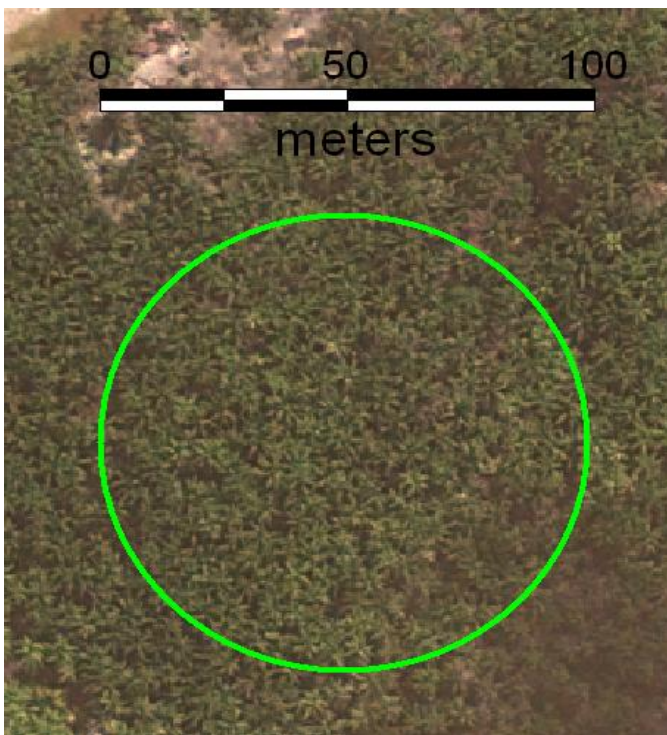
Figure 07: Dense coconut stands on GeoEye image data in Onotoa Island.

Dense coconut stands have a palm density of 150 to 300 palms per hectare. The number of palms per hectare cannot be counted with 1005 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
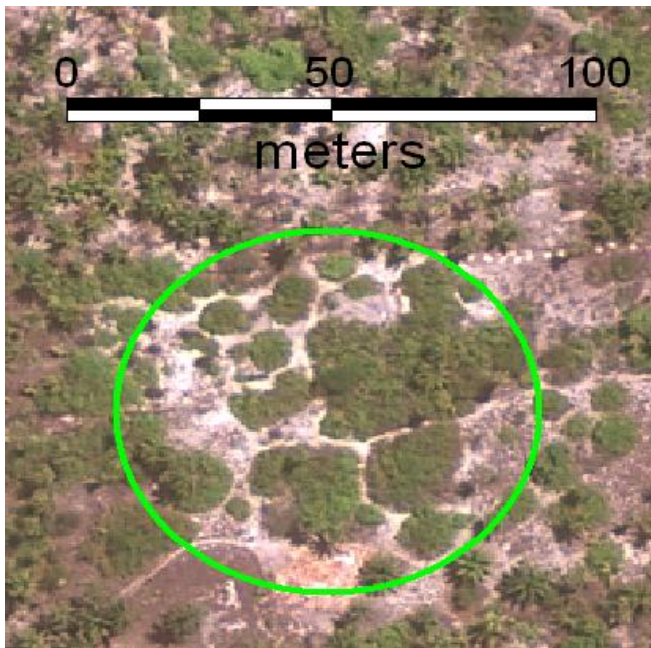
Shrub is vegetation under 5 meters in height. The vegetation type "shrub" looks green but does not show the coconut palm texture or the texture of planting rows. The surface appears smoother than coconut stands.

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

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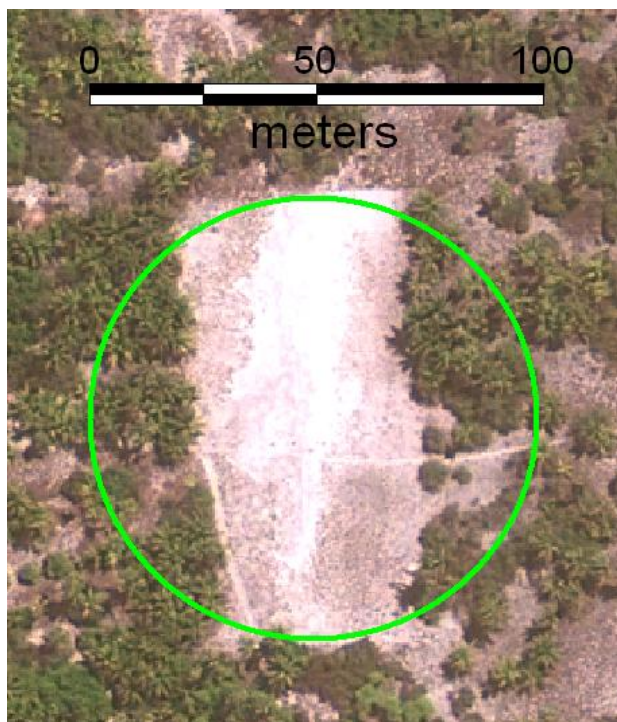
Bare land is considered as areas without or marginal vegetation. This land cover type is visible as brown to yellow and white in the GeoEye image with homogeneous flat texture.

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

5.2.6   Settlements

Figure 10: Settlement GeoEye image data Onotoa 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.
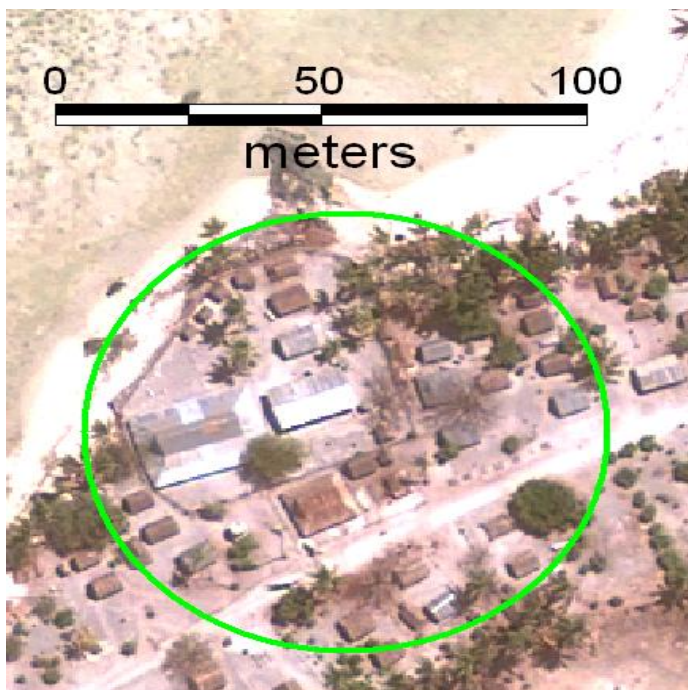
At a later stage vegetation patches within settlement areas will be stratified into palm and other vegetation where "other vegetation" will be statistically stratified into breadfruit and pandanas through field visits as a separation is currently difficult with the available image data only.

5.2.7   Water Bodies

Figure 11: Water body on image data Onotoa Island.

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.
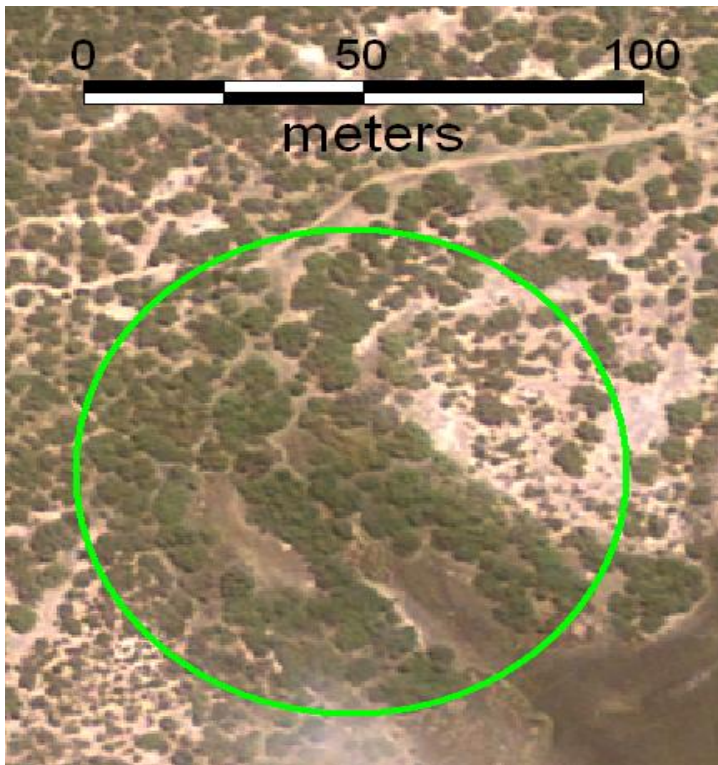
5.2.8   Mangrove

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 has two types of texture, like in water is darker and inland appears dark green. Mangroves grow normally at the beach and in low lying parts of islands with salt water infiltration also inland.

Figure 13: Mangrove on image data Onotoa Island.

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

Server GISdata

Data
- Countries
  - KI
    - Maiana
    - Beru
    - Onotoa
      - IMG
      - VegMapping
        - AccessData
        - Report
        - VectorVegClasses
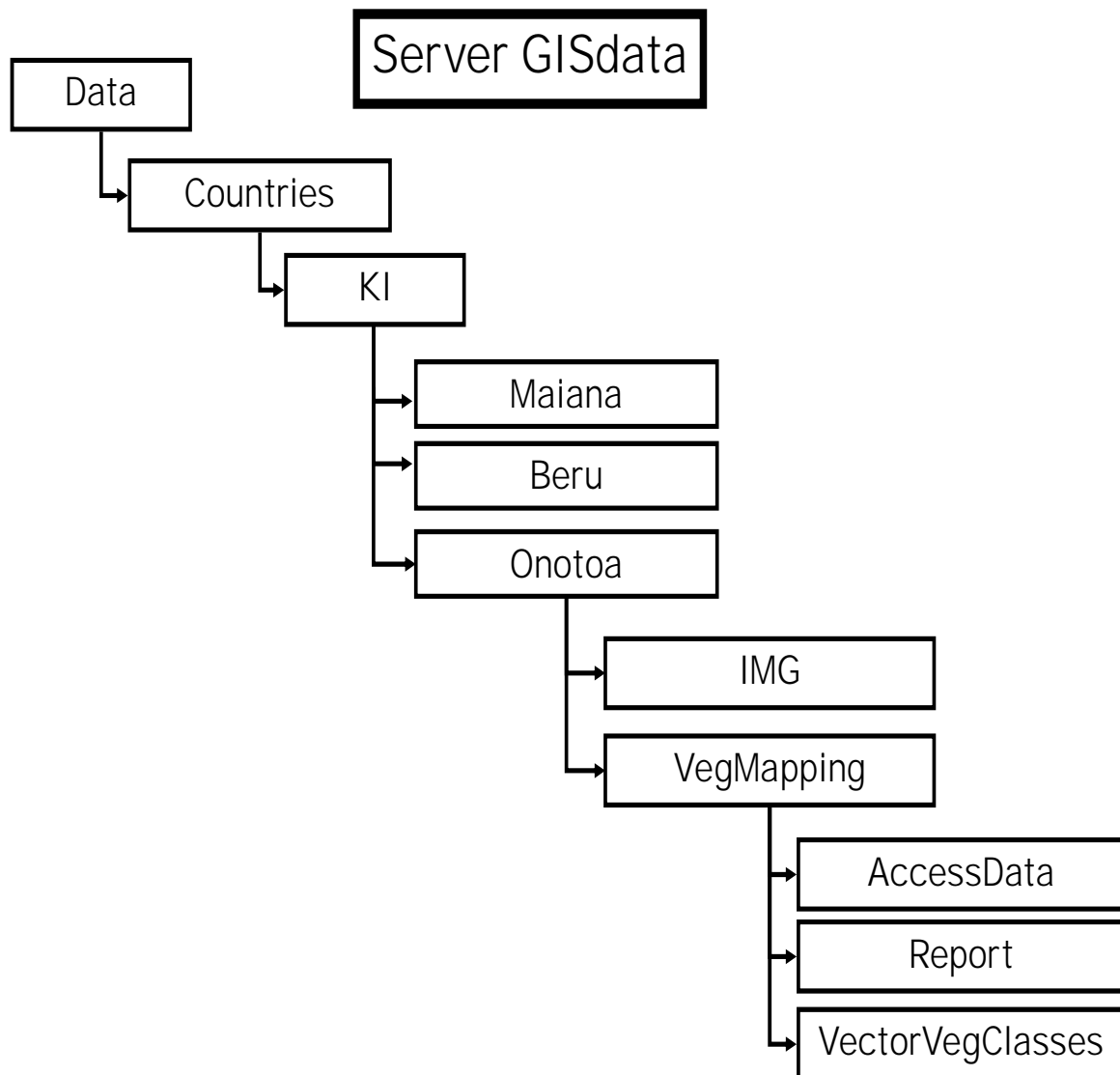
C Counting Coconut Palms Utilising MapInfo and Access

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 unit[1].

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.

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[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 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.

Chr_Veg_Cover			

Palms per Hectare Scattered Coconut

Sum Palms	361 Plot	1,444	Hectare
Min Palms	12 Plot	48	Hectare
Max Palms	24 Plot	96	Hectare
Mean Palms	Plot	72	Hectare
Standard Dev Palms	Plot	15	Hectare
Number of Plots	20		
Area all Plots m2	50,220		
Area Coco SDense m2	1,647,440		

Plot ID	Area [m2]	Palms/Plot	Palms/Ha
AO30	2,511	20	80
AQ35	2,511	24	96
AS45	2,511	21	84
AW40	2,511	21	84
BA44	2,511	14	56
BO39	2,511	12	48
BQ45	2,511	21	84
BZ112	2,511	20	80
BZ52	2,511	17	68
BZ98	2,511	16	64
DK160	2,511	14	56
E24	2,511	14	56
ED369	2,511	23	92
FK185	2,511	23	92

Record: [◄◄] [◄] 1 [►] [►►] [►*] of 20

Figure B: Access form for scattered coconut.