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Applied Geoscience and Technology Division (SOPAC)

Technical Note – Land cover change for Nanumaga, Tuvalu between 1969 to 2005

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SOPAC TECHNICAL NOTE (PR160)

Dolores Leneuoti, Kataebati Bataua & Wolf Forstreuter

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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: SOPACDirector@spc.int
Web site: http://www.sopac.org

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1 SUMMARY

Figure 01: Pan-sharpened QuickBird image of Nanumaga recorded 01/07/05.

The total area of all land cover types on Nanumaga Island in 2005 has increased by 6 hectares compared to 1969. That does not mean that this is a visible sea-level rise as this comparison of land cover types do not include change of beach and reef. The main change is the conversion of 9.1%. from dry land vegetation to settlement area 1.7 % of dry land vegetation was converted to seawater or beach (light blue in the change detection image). Mangrove areas have a slight increase.

2 INTRODUCTION

Figure 02: Map of Nanumaga drawn from aerial photographs recorded in 1969.

The area of Nanumaga Island was mapped with pan-sharpened QuickBird satellite data recorded in 01st July, 2005. The image data displayed the recent vegetation cover. For this island, a map was also used based on aerial photography recorded in 1969. This map was scanned and the resulting image of the map was geometrically corrected to fit with a linear shift to the projection of the pan-sharpened QuickBird images, which is UTM WGS84 Zone 60 South. Then the change of vegetation was analysed through an overlay procedure which visualises the change and provides quantitative data of vegetation change.

3 CHANGE DETECTION

Both vegetation delineations (the 1969 map and the 2005 image data) were rasterised and imported through ArcGIS into ERDAS Imagine. The classes of the image data interpretation were summarised to the classes shown in the historical vegetation map. Palm vegetation and shrub are not separated as both are in the same class "dry land vegetation". Bare land and mangrove classes were left and not summarised as they were clearly shown on the historical map.

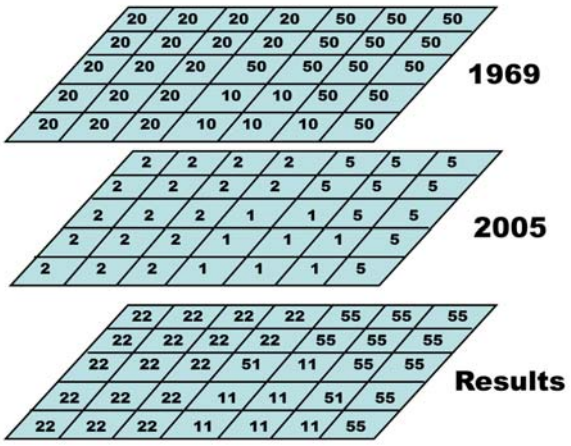

Figure 03: Overlay in raster data environment. The pixel values of the 2005 layer are multiplied by 10 before the values of both layers are added and stored in layer Result. 5 = Mangrove; and 1 = Water; 51 (in Result layer) = New Mangrove.

Then the raster data from both interpretations were combined by an overlay process where the values of picture elements (pixels) of the 1969 layer were multiplied by ten before the value of the corresponding pixel of the 2005 layer was added for a new output layer. For example the mangrove class has the value 5, therefore it has the value 5 in the 2005 layer and 50 in the 1969 layer and the value in the output layer is 55. Value 5 in the output layer shows that in the 2005 layer this pixel indicates mangrove and in the 1969 layer this pixel indicates seawater (0). A value 50 indicates the mangrove was cut as the pixel in the 2005 layer indicates seawater (0) where there was mangrove (5) in the 1969 layer.

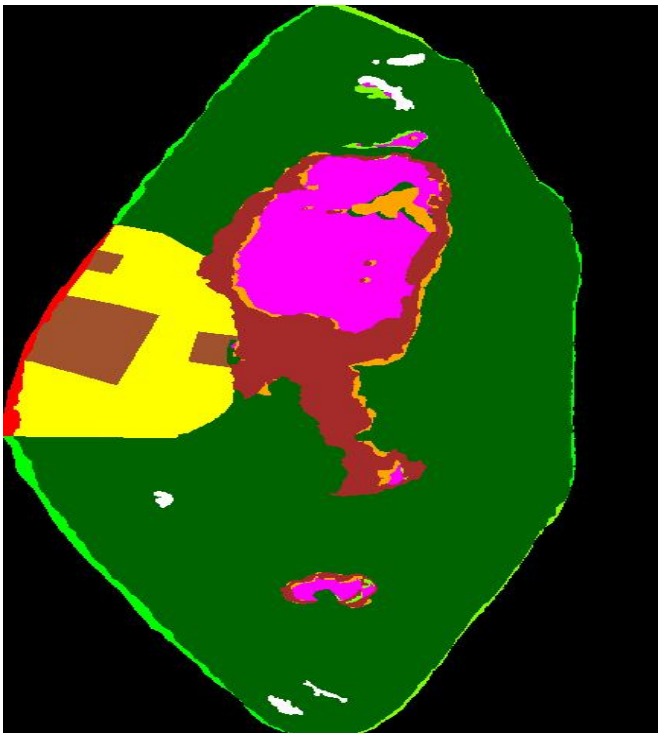

Figure 04: Change detection map of Nanumaga Island.

Knowing that every pixel covers one square metre[1] it is easy to calculate the area by counting the pixels of each class. Table 01 shows the results of the change detection area analysis. Most area was dry land vegetation in 1969 and 2005. There is a significant change in dry land vegetation to bare land and vice versa, and there is more area converted from bare land to dry land vegetation than deforested. The following section describes the changes in more detail.

[1] 1 m resolution is related to the rasterised vegetation layers utilised for the overlay analysis; the image data has 0.5 m resolution.

Table 01: Change detection summary of Nanumaga Island. The percentage figure is based on 297 hectares (2,948,306 pixels) of non-water area in 1969 including dry land vegetation, mangrove, settlement and bare land.

ID	Class Name	Number of Pixels	Hectare	%Sum
00	Seawater2005 and Seawater1969	1434977	143	
20	Settlemenet2005 and Seawater1969	19128	2	0.7
40	Dry Land2005 and Seawater1969	49325	5	1.7
10	Seawater2005 and WaterBody1969	2	0	0.0
11	WaterBody2005 and WaterBody1969	256606	26	8.8
14	Dry Land2005 and WaterBody1969	5990	1	0.3
15	Mangrove2005 and WaterBody1969	15688	2	0.7
21	WaterBody2005 and Settlement1969	268	0	0.0
22	Settlement2005 and Settlement196	95130	10	3.4
24	Dry Land2005 and Settlement1969	1436	0	0.0
25	Mangrove2005 and Settlement1969	72	0	0.0
31	WaterBody2005 and Bareland1969	742	0	0.0
34	Dry Land2005 and Bareland1969	17744	2	0.7
40	Seawater2005 and Dry Land1969	14988	1	0.3
41	WaterBody2005 and Dry Land1969	7290	1	0.3
42	Settlement2005 and Dry Land1969	268429	27	9.1
44	Dry Land2005 and Dry Land1969	1986615	199	67.0
45	Mangrove2005 and Dry Land1969	36159	4	1.3
50	Seawater2005 and Mangrove1969	2	0	0.0
51	WaterBody2005 and Mangrove1969	16635	2	0.7
54	Dry Land2005 and Mangrove1969	29549	3	1.0
55	Mangrove2005 and Mangrove1969	194961	19	6.4
		3016759	**304**	

Table 02: Pixel values indicating land cover types 1969 and 2005 and area comparison. Water = inland water body as opposite to seawater.

ID	Land Cover 1969	Hectares	ID	Land Cover 2005	Hectares
0	Seawater	0	0	Seawater	0
10	Water	29	1	Water	29
20	Settlement	10	2	Settlement	39
30	Bare land	2	3	Bare land	0
40	Dry land vegetation	233	4	Dry land vegetation	210
50	Mangrove	24	5	Mangrove	25
	Sum	**297**		**Sum**	**303**

4 CHANGE OF LAND COVER CLASSES

This section describes the changes between 2005 and 1969 in Nanumaga Island. The classes 55, 44, 33, 22 and 11 are stable classes where no change of land cover was noted.

4.1 Dry Land Vegetation

Dry land vegetation is palm cover of all densities, shrub vegetation and left over forest cover. The classes in the 2005 layer were combined accordingly. 67.0 % (199 hectare) of Nanumaga area was dry land vegetation in 1969 and it remains dry land vegetation in 2005 (the dark green coloured area in Figure 05). Light green = dry land vegetation in 2005 and was bare land 2005. Light blue = dry land vegetation in 1969 and seawater or beach in 2005.

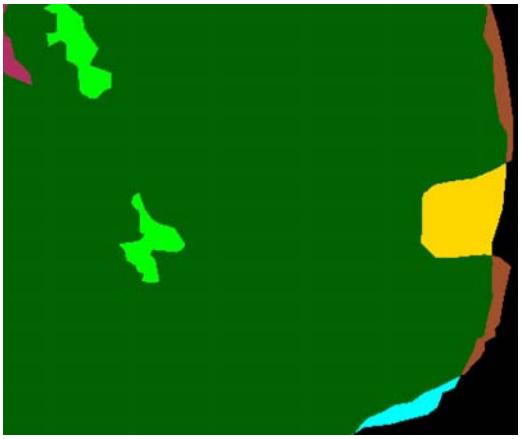

Figure 05: Dry land vegetation in Nanumaga. Dark green no change, light green area was bare land in 1969 and is now dry land vegetation.

4.2 Dry Land Vegetation to Bare Land and Vice Versa

Bare land is land without vegetation or with grass vegetation only.

0.7 % (2 hectares) of the vegetation cover today was bare land in 1969 (light green). 0.0 % (0 hectare) was converted to bare land which was covered with vegetation in 1969 (white). 0.0 % or 0 hectare of bare land in 1969 remained bare land in 2005.

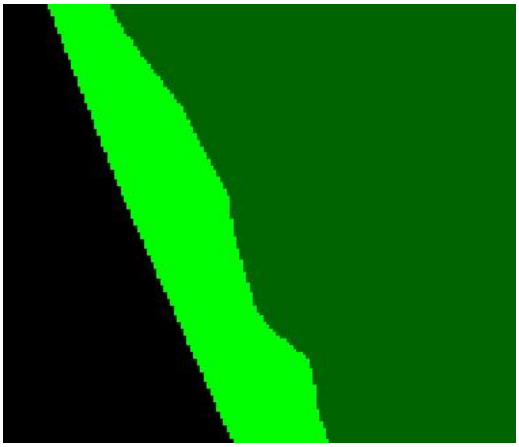

Figure 05: Dark green vegetation at both times and light green areas converted from bare land to vegetation.

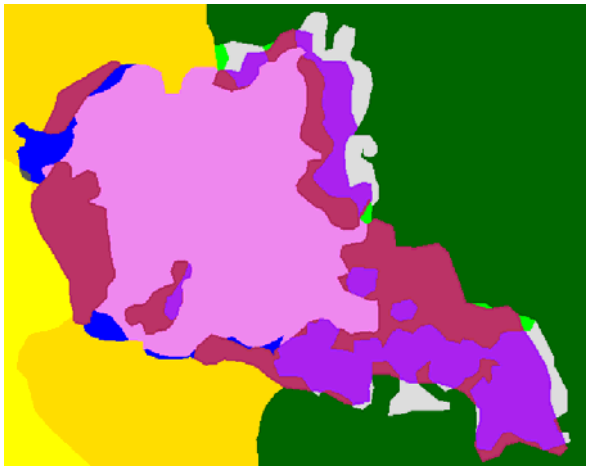

Figure 07: Pink coloured area represents water 2005 and the maroon coloured area is water body 1969 converted to mangroves.

4.3 Vegetation and Water Change

Inland water bodies are areas on the island covered by water or swamps.

0.3 % or 1 hectare was water bodies in 1969 and covered by vegetation today. The area of 1 hectare or 0.3 % dry land vegetation is now seen as inland water body.

4.4 Increased Settlement Areas

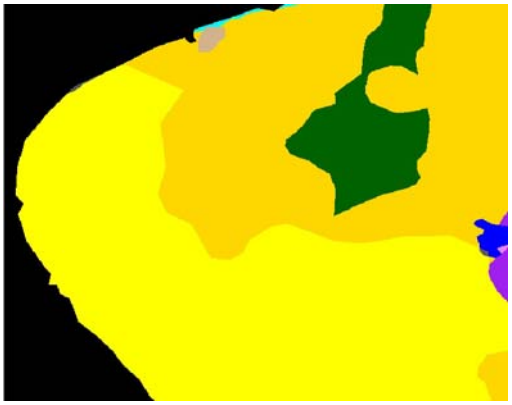

Figure 08: Change from vegetation to settlement.

27 hectares or 9.1% is counted as settlement areas today which were covered by vegetation in 1969 (darker yellow portion in Figure 08). Settlement "influenced area" is the area with a buffer of 75 metres around visible houses, where the vegetation is strongly influenced by humans. There is still vegetation and the change is partly misleading as the historical map only shows houses. The analysis will be defined at a later time. However, it is apparent that there are more locations of settlements in 2005 which indicates an increase.

4.5 Change of Mangrove Areas

Figure 09: The figure shows new mangrove in 2005 (maroon).

A portion of the total area of 19 hectares or 6.4 % of new mangroves is visible in Figure 09 as the maroon coloured area. This area of 4 hectares represents both the dry land vegetation and water body converted over time (1969-2005) to mangroves. However out of the total mangrove area, a portion of 3 hectares disappeared and the area is now covered with vegetation (gray coloured area in Figure 09).

4.6 Examples of Change

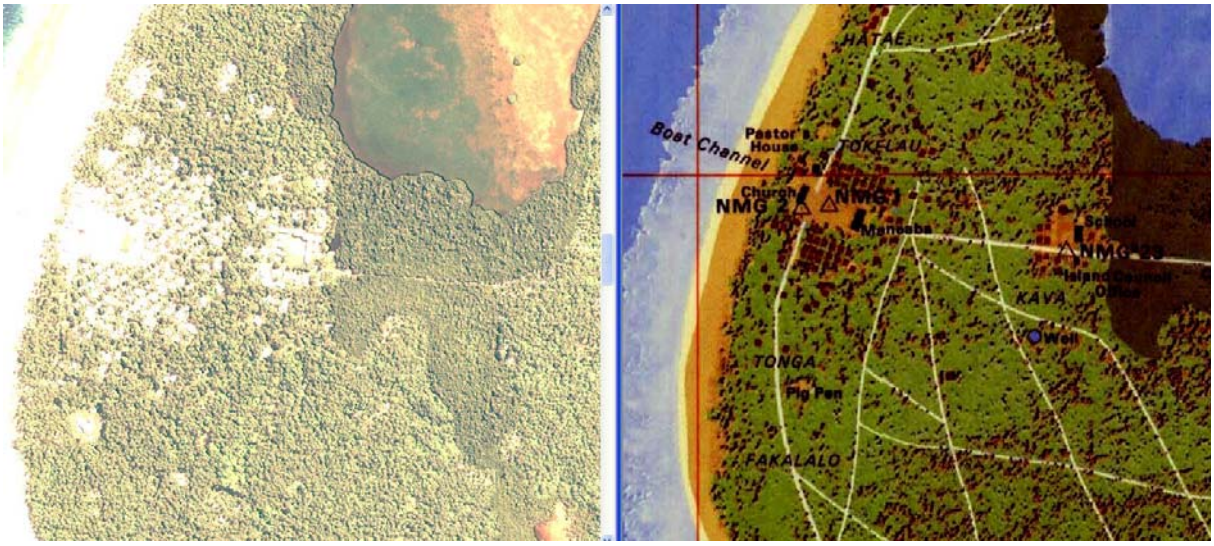

Figure 13: Land cover change zooming into settlement area in 1969 (left) & 2005 (right).

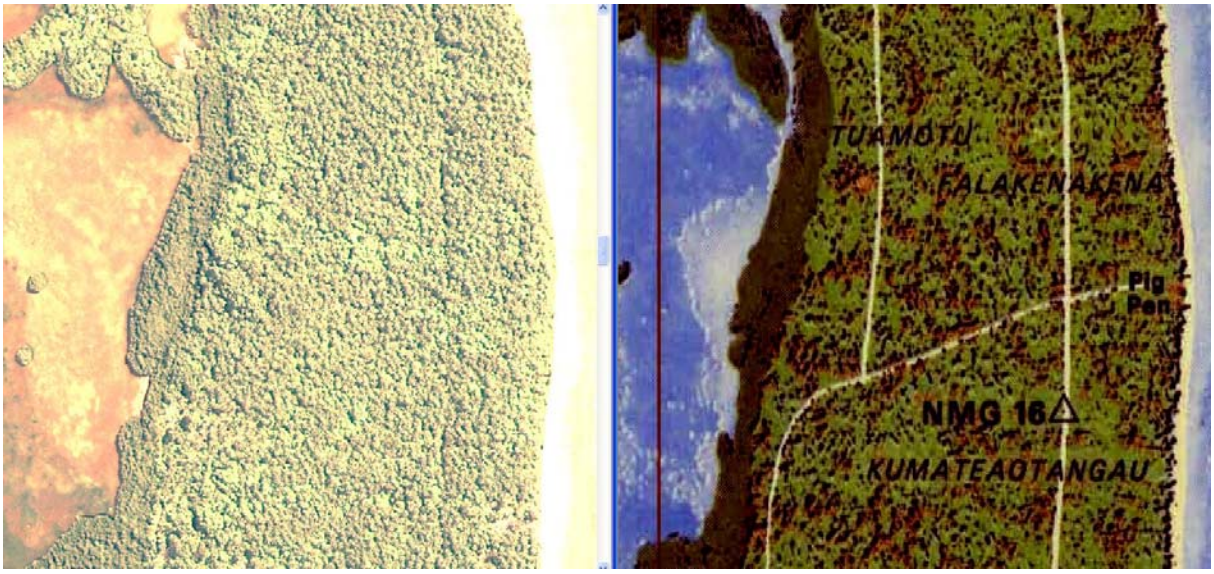

Figure 14: Land cover change on Nanumaga, zooming into dry land areas for 1969 (left) and 2005 (right).

4.7 Formulas to Calculate Change Detection Layer

Layer A = EITHER 50 IF ($n1_nanu_1969 == 3) OR
(EITHER 40 IF ($n1_nanu_1969 == 2) OR
(EITHER 30 IF ($n1_ nanu _1969 == 4) OR
(EITHER 20 IF ($n1_ nanu _1969 == 0) OR
(EITHER 10 IF ($n1_ nanu _1969 == 1) OR 0
OTHERWISE) OTHERWISE) OTHERWISE) OTHERWISE) OTHERWISE

Layer B = EITHER 5 IF ($n2_nanu_2005 == 2) OR
(EITHER 4 IF ($n2_ nanu _2005 == 1) OR
(EITHER 3 IF ($n2_ nanu _2005 == 0) OR
(EITHER 2 IF ($n2_ nanu _2005 == 3) OR
(EITHER 1 IF ($n2_ nanu _2005 == 4) OR 0
OTHERWISE) OTHERWISE) OTHERWISE) OTHERWISE) OTHERWISE

Result C = $n3_recode_1969_x_10 + $n4_recode_2005

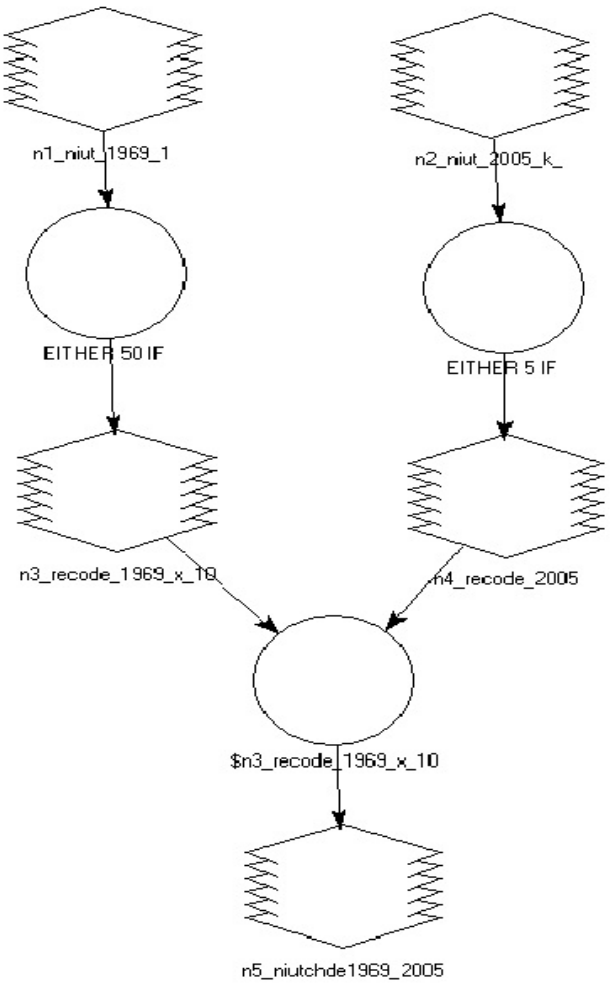

Figure 16: The diagram above describes the recoding of both 2005 and 1969 layers and the overlay procedure, where the values of the 1969 layer are multiplied by 10 before the value of the 2005 layer is added.