Report Status of Activities and Results of USAID Funded Food Security Activities

Draft

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SPC-SOPAC GIS&RS Unit

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1   <u>Introduction</u>

This report lists and explains all tasks of the GIS&RS Unit which are contributing to food security and climate change adaptation in the target countries of the USAID food security and climate change adaptation project. This does not mean that the activities are fully or financed by this current USAID project. It is not always possible to separate how far activities are financed by different donors, however, activities in countries not covered by the project are not listed. The other funding sources besides USAID are GIZ, Forest and Trees Programme at SPC-LRD, FAO and UNDP. Task results and outputs often benefit the objectives of two or several donors.

The GIS&RS Unit is based in SPC-SOPAC and has to service other units at SPC and parallel to this, the unit has to service GIS&RS users in the Pacific states directly where the latter creates the main part of workload.

This reports lists all tasks which somehow contribute to food security and climate change adaptation and take substantial time within the work programme even small tasks for example transferring data from ERDAS software to Access database.

Nearly all tasks are reflected in own reports and for the mapping tasks reports are available (mostly in the virtual library) for every atoll or island.

2   <u>Mapping and Inventory Activities</u>

This chapter lists and explains all tasks which are related to actual mapping. Forest or coconut inventories require a mapping as well and are therefore also listed in this chapter.

2.1 Land Cover Mapping Fiji (1:10,000)

It is planned to map the land cover for Fiji at 1:10,000 Scale; such a map was never produced for Fiji. Forestry needs the map for planning and management at operational scale and Agriculture requires it for farming assistance and planning.

2.1.1 Expected Outcome
The outcome of the map will be a more focused forest and agriculture planning and management. Another outcome will be that the digital maps will be the basis for a future recording of carbon change.

2.1.2 Expected Output
The output will be a digital map where (first time in Fiji) the forest to non-forest boundary is agreed between Forestry and Agriculture. This digital layer allows the precise area calculation of currently 4 forest classes and a minimum of 8 agriculture land cover classes including non-agriculture classes like settlements.

2.1.3 Activities
The image data had to be purchased, enhanced (including haze removal, atmospheric correction, ortho-correction, etc.) and converted GIS image backdrops. Then, image data are pre-classified through image segmentation software which superimposes vector boundaries

over the images. Visual interpretation by field experienced agriculture and forestry officers confirm or correct these boundaries.

The accepted polygons showing the boundaries between the different land cover classes are rasterised on map section level (10 x 10 km). Finally the area statistic is calculated showing the area of each land cover class on map section level.

2.1.4 Results
40 % of the area is mapped by forestry staff and agriculture staff during the last year. The remaining 60% of the area will be mapped faster as (i) the method is known and (ii) new image segmentation software is working faster than the old one.

One map sheet is transformed from vector to raster and the area analysis is carried out. This took long time as it required method development for (i) FMG to UTM conversion at 1:10,000 scale and (ii) vector to raster conversion for large files (~ 115 GB). Both problems have been solved recently.

2.2 Land Cover Mapping Fiji (1:50,000)

There was never an agriculture map for Fiji and the agriculture census was based on statistical selected 10 x 10 km map sections, which were mapped from historical and not up-to-date aerial photographs. For agriculture management it is essential to have a agriculture map. Therefore multi-spectral image data[1] recorded in 2007 was used to create a land cover map for Viti Levu and Vanua Levu (including Taveuni). This was performed with officers from Agriculture as the forest layer had been mapped already using this data source.

The image data covers also the outer islands Kadavu, Beqa, Koro and Gau. The forest mapping is performed but for agriculture interpretation was no time as image delineation at 1:10,000 scale with up-to-date image data has priority. If time allows the agriculture interpretation for these four islands will be performed.

2.3 Land Cover Mapping Solomon Islands 1:50,000

During a meeting in 2012 in Honiara with Solomon Island Government, IUCN and UNDP it was decided to map the areas at 1:50,000 first and perform mapping at 1:10,000 scale level at a later stage for selected areas.

2.3.1 Outcome
Statistic and map will be utilised for enhanced land use planning and protection of left forest cover. This is not performed to full extent, now.

2.3.2 Output
The output is a land cover map layer showing the different types of agriculture areas are and different main forest types[2]. Furthermore, a combined area statistic was produced telling how much forest, mangroves, pasture lands, etc. is available.

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[1] ALOS image data, four spectral bands 10 m spatial resolution.
[2] The main four types are shown (i) natural rain forest, (ii) mangroves, (iii) pine plantation and (iv) hardwood plantation. Different forest types such as dry forest, highland forest, etc. are not shown.

2.3.3 Activities

After image data purchase and pre-processing the interpretation was performed. GIS officer from Lands Department, Agriculture and Forestry Department were jointly carried out the image interpretation and returned with their data and gained practice of image interpretation and delineation.

For selected areas maps were also printed.

2.3.4 Results

The map layers are available in Forestry, Agriculture, Lands Department and Department of Environment. Also the cooperation between the different departments improved after carrying out the task jointly. The map layers are completed for 4/5 of the area.

2.3.5 Problems

(i) The area analysis is not performed yet due to missing time capacity in the GIS&RS unit as well as missing time allocation in Honiara.

(ii) The image data recording is not performed for the western province where the image selling company[3] claims the cloud cover is the reason.

2.4 Land Cover Mapping Solomon Islands 1:10,000

Land cover mapping at 1:10,000 scale is planned for Solomon Islands for two islands: (i) Choiseul and (ii) Rennell. For these islands land cover mapping was supposed to be carried out at this scale in addition to 1:50,000 scale. So far only very limited amount of image data has been captured due to permanent cloud cover.

2.5 Land Cover Mapping Espiritu Santo

For the forest inventory of Espiritu Santo the land cover was mapped into several classes such as: (i) three densities of forest, (ii) coconut palm cover, (iii) forest plantations, (iv) thickets, (v) mangrove, (vi) shrub, (vi) grass land, (vii) bare land, (viii) settlement areas and (ix) inland water bodies. This is a by-product of the forest cover stratification but it is available as separate land cover layer for Vanuatu and will be delivered once a spatial database is established for the country.

2.6 Land Cover Mapping in Kiribati 1:10,000

Land cover mapping for Kiribati was carried out at 1:10,000 scale and was completed in 2012. During the last months the team mapped the vegetation around settlement areas which before was mapped as "special vegetation of settlements" and not stratified into coconut, shrub, etc. The reason for the Kiribati Agriculture Division requesting SOPAC mapping assistance was directly food security. There is a need to keep breadfruit and panadanas alive to immediately put into production in case rice import stops.

2.6.1 Outcome

The agriculture department is using maps and reports to quantify the coconut area, which possibly attracts donors to invest in alternative use of copra. The map display layers are

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[3] In this case GISTDA, a Thailand based company marketing the Thailand owned satellite Theos.

installed at lands Department and at Agriculture Department and demonstrated outsiders. Lands Department utilising the map layers to further stratify the mangrove areas through a SPREP based project.

2.6.2 Output
Through the mapping activities staff at Lands Department and Agriculture Department is trained. The map layers are established. Reports for every islands are available to be downloaded from SOPAC virtual library.

2.6.3 Activities
The mapping was carried out before June 2013, however, vegetation around settlements had to be stratified[4]. Now the settlement area is stratified like the area outside settlements but at 1:5,000 scale interpretation level.

2.6.4 Results
The maps are updated as well as the area database; both are available at Agriculture Division and Lands Department. Map layers and database will be permanently updated.

2.7 Land Cover Change Mapping in Kiribati 1:10,000

In opposite to land cover mapping[5] land cover *change* mapping shows the difference between two periods and indicates where area and at which amount has been converted from one land cover type to another land cover type.

2.7.1 Outcome
The output might have stimulated investigation on international level. So far there is not reaction noticeable in Kiribati.

2.7.2 Output
It is the first time that quantitative data[6] is available how far vegetation has changed. In overall the vegetation of islands in Kiribati does not shrink, in opposite palm cover and mangrove cover is growing in most places during the last 40 years. The increase of coconut palm area is explainable as there have been coconut rehabilitation programs in the eighties. The increase of mangrove are might be caused by human influenced change of beach front and reduced water turbulence.

2.7.3 Activities
Vegetation maps created 1972 using aerial photographs recorded in 1969 have been scanned. The vegetation maps created from recent VHR satellite image data have been overlaid and the difference was mapped. The task was conducted with financed from SPC-

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[4] The area around settlements is different from the rest of the islands as heavily influenced by humans. Therefore it was classified as "settlement area" only hoping to analyse the spectral signatures further to be able to stratify bread fruit, pandanas, other trees, shrub and coconut. This research work is carried out by a USP student, now.
[5] Land cover mapping and land use mapping is often used as synonym. In this report land use mapping indicates the supposed use of the land for example "mahogany plantation" = an area leased for mahogany plantation and land cover = the actual stocking of the area, for example the mahogany plantation can be still stocked with natural forest.
[6] There are descriptive reports available but no analysis providing numerical figures of change.

LRD and partly also from the USAID project, where two GIS officers from Kiribati were carrying out the job under guidance at SOPAC.

2.7.4 Results

This type of change detection was carried out for 19 islands. Not for all islands historical vegetation maps are available but 13 more island could be analysed. For more details see Appendix 4

2.8 Mangrove Mapping and Change Detection in Fiji

Forest cover change detection was conducted in Fiji for the periods 1991 to 2001 and 2001 to 2007. The MESCAL project required quantitative data of mangrove change only. When extracting the mangrove from other forest it was visible that there was an interference of inland mangrove areas along the rivers with forest patches. This was corrected by visual interpretation.

2.8.1 Outcome

The mangrove change results were needed by the Fiji department of Environment. Digital map layers as well as the corresponding statistic of change were handed over to the department and are used as basis for political action. A mangrove action plan is on the way.

2.8.2 Output

The areas of mangrove deforestation and also a few parts of mangrove growth are mapped and an area statistic was produced[7]. This was the first time that such results were available for Fiji. For details see appendix 2.

2.8.3 Activities

All areas of interference were mangrove change to forest and vice versa were digitally highlighted. Then map layers were created for image data 1991, 2001 and 2007 were the contrast between rain forest and mangrove was enhanced. As next step the patches of mangrove and rain forest were corrected. Finally the digital overlay process had to run again and a new area statistic of change was produced.

2.9 Coconut Resource Inventory Tarawa and Abaiang, Kiribati

Coconut is not only a food resource, especially in Kiribati it creates work income for people in outer islands which otherwise would migrate to the already overpopulated Tarawa.

All coconut areas in Kiribati are mapped and the palms per hectare are counted from VHR image data in a statistically sound way. However, field work is required to estimate the coconut production per palm where age, general fertility, amount of hybrids, level of disease or beetle attack and other factors have to be measured. Besides the coconut production the amount of timber volume is of vital interest[8].

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[7] See appendix 2 Mangrove Area Change
[8] Dead trunks in the stands are breeding ground for rhinoceros beetle the major coconut palm pest. FAO is planning a transportable sawmill to remove dead or senile palms in an economic sound way, however, the Agriculture Division Kiribati has to know how much timber volume is available and the age structure of the stands.

2.9.1 Outcome

The inventory results are utilised by the Agriculture Division and by FAO.

2.9.2 Output

The productivity, age structure and timber volume is known for the coconut stands in Tarawa and Abaiang. Two people in the Division of Agriculture are trained to establish and measure the palms in coconut sample plots. For details see related reports.

2.9.3 Activities

A number of plots were selected for Tarawa in dense coconut stands, medium dense stands and scattered coconut stands. Four plots were measured in dense, 12 in semi dense and 2 plots in scattered stands. For Abaiang the activities were conducted in the same way.

A database was established analysing the field data.

2.9.4 Results

Stratum	Hectare	Palms/ha	Palms	Nuts/Year	Copra [kg]
Dense coconut	695	258	179,310	6,275,850	2,091,950
Semi dense coconut	104	146	15,184	409,968	136,656
Scattered coconut	288	49	14,112	522,144	174,048
Dense coconut SA*	303	258	78,174	2,736,090	912,030
Semi dense coconut SA*	6	146	876	23,652	7,884
Scattered coconut SA*	169	49	8,281	306,397	102,132
Sum:					**3,424,700**

Table 01: *Estimated potential yield of coconuts per year in Tarawa in open areas and settlement environment (SA* = settlement area). Estimated potential copra yield assuming 1.5 kg average weight per nut and copra as 30 % of the weight*

Stratum	Hectare	Palms/ha	Palms	Nuts	Copra [kg]
Dense Coconut	409	237	96,933	19,968,198	9,984,099
Semi dense coconut	215	131	28,165	2,478,520	1,239.260
Scattered coconut	430	50	21,500	946,000	473,000
Dense Coconut SA*	185	237	43,845	9,032,070	4,516,035
Semi dense coconut SA*	0	131	0	0	0
Scattered coconut SA*	68	50	3,400	149,600	748,000
Summary:				**30,095,868**	**15,721,134**

Table 02: *Estimated potential yield of coconuts per year in Abaiang in open areas and settlement environment (SA* = settlement area). Estimated potential copra yield assuming 1.5 kg average weight per nut and copra as 30 % of the weight*

2.10 Coconut Palm Counting for Kiribati

VHR satellite image data allow the identification of individual palms and this enables an interpreter to count the palms on a per hectare level. This is performed in sample plots of 50

x 50 m superimposed on the image data. These plots are randomly selected to create information in a statistically sound way. The analysis of palms per hectare is performed semi-automatically.

2.10.1 Activities (per island)

The coconut palm area is first stratified into three densities. A grid overlay of 50 x 50 m size is superimposed over the image data to help the interpreter in the decision between the three densities (i) scattered coconut palms (25 – 50 palms / ha) (ii) medium dense coconut palms (51 – 150 palms / ha) and dense coconut palm stands (>150 palms / ha).

The area is analysed in an area database and a number of plots is selected for every stratum following the method parts proportional to size.

Randomly plots are chosen and the number of palms is semi-automatically counted and stored in a database. For details see appendix 3.

2.10.2 Output

The figures palms per island stratified into three densities is documented in reports for every islands in Kiribati and most of the islands in Tuvalu and several islands in Federated States of Micronesia.

For counted coconut palms in Kiribati see Appendix 3

2.10.3 Outcome

These figures are utilised by FAO, Kiribati Agriculture Division and NGOs to estimate the potential coconut production. The countries utilise the mapping to get biofuel related projects.

2.11 Forest Inventory Santo

As a contribution to REDD+ preparation of Vanuatu the forest of Santo will be inventoried. This will create the link between standing forest timber volume and amount of carbon per hectare.

2.11.1 Expected Outcome

It is expected that the activities and inventory results will stimulate Vanuatu to carry out inventories for other islands, so that statistically sound quantitative data about forest carbon will be available for the country. This will strongly contribute to participate in REDD+ activities.

2.11.2 Expected Output

The output will be: (i) a digital map stratifying the forest of Santo into three different densities, (ii) statistically sound data of standing and dead timber volume which can be converted to carbon per hectare, (iii) statistically sound data about litter, (iv) statistically sound data about available regeneration, (v) statistically sound data about the species composition which is related to biodiversity. Finally (vi) a group of foresters trained to conduct further forest/carbon inventories.

2.11.3 Activities

The satellite image data (8 band bundle WorldView-2) was purchase and pre-processed. The ortho-correction created difficulties, however, problems were resolved.

The image was interpreted and a land cover layer produced. Rain forest was stratified into three different densities besides forest plantations and mangroves.

The area database was established in Access.

2.11.4 Results so far

A land cover map was produced and the area database showing the area size in hectare for all 13 land cover classes.

For the forest inventory an inventory design is established and discussed.

2.12 Establishing Soil Layer for Solomon Islands

Partly soil maps are available as printed maps which have to be digitised. Partly they are available as spatial layers where sometimes the format has to be changed. Soil information seems to be essential to stratify coconut palm cover as fertility is directly related to soil. The GIS&RS unit therefore tries to store soil layers for every country.

1.1.1 Activities

The soil map of Solomon Islands is available in printed form. For GIS overlay analysis and for fast access these printed maps have to be converted into digital GIS layers. All existing soil maps of Solomon Islands have been digitised, cleaned and rasterised.

The soil annotation information of Solomon Islands (soil classification, description) is printed in a report. The reports have been scanned and are available as records in a soil database, now. This database is linked to the spatial layers. A customised GIS display allowing GIS untrained persons to access the information.

2.12.1 Output

The output is the availability of the digital soil layer. This layer can be incorporated into GIS planning and analysis, now.

2.12.2 Outcome

The outcome requires that there is a land potential analysis or any planning. This is currently not the case at the scale the soil map is available which is 1:250,000. However, the soil information will be required soon.

2.13 Storing Soil Map Vanuatu

The digital soil layer of Vanuatu at 1:50,000 scale has been copied and is available at SPC-SOPAC backup hard drives. It is available for further GIS work.

2.14 DSM Creation for Protected Forest Areas

FAO requested SPC-SOPAC to create a digital surface model for the declared forest protection areas. It was decided to cover one area first check the usability and proceed with

the other areas afterwards. The area selected is Delakoro in Vanua Levu with a size of 494 square km.

2.14.1 Activities
The stereo image data has been ordered.

2.14.2 Expected Output
A 3D image of the surface overlaid with recent satellite image data in natural colours.

2.14.3 Expected Outcome
It is assumed that villagers have better understanding of image interpretation if the display is incorporating the third dimension. The image data is supposed to be utilised to protect the forest cover where the 3D images will be used to mark observations.

3   Information Dissemination

Pacific island GIS&RS users are often working in isolated environment. It is essential for the GIS&RS development and even to keep the status quo that users are informed about new developments, regarding hardware, software, data and application methods. It is also important to recognise Pacific applications performed in the different Pacific states.

To disseminate information the GIS&RS Unit several vehicles can be utilised: (i) there is the Pacific Islands GIS&RS User Conference, (ii) the e-mail distribution list GIS-PacNet, (iii) different websites, (iv) the Pacific Islands GIS&RS Newsletter and local (v) GIS&RS User groups. The GIS&RS Unit manages or contributes to all of them. A noticeable amount of working time has to be allocated to do this.

3.1   Pacific Islands GIS&RS User Conference

The Pacific Islands GIS&RS Conference is with 200 to 300 participants the largest GIS&RS conference in the Pacific where Pacific Island Countries participate[9]. Since the inception of the GIS/RS User Conference in 1999, this annual event has attracted a lot of participants from as far as the America and Europe to come to Fiji. Each year the range of GIS/RS technologies presented cover an array of applications including the management of resources of the small island Pacific nations. Also remote sensing data providers, software and hardware sellers find this conference the most important one as they directly reach the users of the Pacific states.

3.1.1   Activities
The conference was held in Novotel with participants from 20 countries. 60 power point presentations were presented during the four days of the conference, where most of them were related to food security and climate change adaptation.

A number of organisations had representatives at the Conference or presented through others. These included regional agencies Secretariat of the Pacific Community (SPC), South Pacific Regional Environment Programme (SPREP), Pacific Islands Chapter of the Internet Society (PICISOC) and University of the South Pacific (USP). The national agencies were

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[9] There are GIS&RS conferences in Australia, New Zealand and Hawaii, however, these conferences have very little participation of Pacific states.

Native Land Trust Board (TLTB), World Conservation Society (WCS), Fiji Sugar Corporation (FSC), Telecom Fiji Limited (TFL), Airport Fiji Limited (AFL), Biosecurity Authority Fiji. Regional and international companies and agencies were present or presented: Electric Power Corporation of Samoa (EPC) and DigitalGlobe International. Software and hardware companies presented and displayed their products and services included Eagle Technology (ESRI), Geosystems NZ Ltd, Lukemine Enterprises.

The conference for 2014 is announced in event calendars of 12 different international journals and newsletters. This year's theme is Mapping Pacific Resources. The new USP facilities are booked for five days where the conference itself will run from 25th to 27th November with parallel sessions on 26Th of November. Monday 24th is reserved for the ESRI user conference and Friday is reserved for workshops, where already three different workshops are in preparation. An important part besides presentations is a discussion about topics where methods have to be adapted to Pacific standards. There is also an exhibition room where data provider and hardware and software dealer present their products, something Pacific islanders have seldom in their countries.

3.1.2 Results

The website http://picgisrs.appspot.com/ reports about the presentations and other results of the 2013 conference.

3.1.3 Output

The years before a report and CD was produced and send to countries. Today this is all handled through the conference website. From the website the presentations can be downloaded as well as audio files which were captured during the presentation.

3.1.4 Outcome

Participants are stimulated to move towards new RS and GIS applications in their countries. Hardware, software and image data seller understand the Pacific needs and have developed already several Pacific solutions.

3.2 The Pacific Islands GIS&RS Newsletter

The Pacific Islands GIS&RS Newsletter has a history dated back to 1993. It is the only publication where Pacific GIS or RS officers publish their application. In its best time more than 400 prints have been produced, however, in Pacific Island Countries the number of readers was much higher as the newsletter handed to others.

The newsletter is produced again in new design, however, due to missing funds only in digital version. On the other hand the access to Internet has improved in the Pacific and printing might not be that necessary like it was before.

3.2.1 Outcome

The outcome is stimulation for Pacific islanders to invest in new remote sensing and GIS application. The other outcome is the news of new data, software and hardware incorporated in the daily work.

3.2.2 Output

Last year two issues of the GIS&RS newsletter have been released.

3.2.3 Activities

Three staffs are involved in compiling and editing the newsletter. Currently articles are collected from the last GIS&RS User Conference.

3.3 Maintain the e-mail List GIS-PacNet

Since mid of the nineties the e-mail distribution list is available as a SOPAC help function for the Pacific. The original idea was mainly the support of GIS and RS related questions and problems.

3.3.1 Activities

It takes 5 to 10 minutes on a daily basis to screen messages and clean the list manually[10] from Spam, which is normally handled by the person also responsible for image data purchase. This year the list GIS-PacNet was continuously running and distributed information. The number of subscribers is currently growing.

3.3.2 Outcome

Pacific islands GIS&RS users are isolated. Through this distribution list the isolation is partly reduced and users are stimulated to carry on with their development.

3.3.3 Output

Several problems have been solved through question and answer using this platform. During the last months, even ISPRS and FIG are utilising this distribution list.

3.4 Maintain and Develop GIS and RS Related Websites

There are two websites, which are maintained by the GIS&RS Unit: a) web display of the forest change detection and b) the SOPAC own website. The SOPAC website had to be re-established after a major re-organisation. Following parts have to be re-built were the work is still ongoing:

- o Satellite image data available for Pacific Island Countries,
- o Instruction papers for GIS and RS applications,
- o Important articles describing methods or GIS, RS and GPS applications.

3.4.1 Activities

The forest change detection display is improving as one staff is working on it in regular intervals. The re-establishment of GIS&RS section of SOPAC's website is still pending.

3.5 Support GIS&RS User Group Meetings

The Fiji GIS&RS User Group started to meet in 1991 when the Fiji Forestry Department established their GIS and did not want to be isolated from other development. These meetings proved to be an essential tool to share knowledge between technicians and to avoid duplication of work. The meetings in Fiji also guide and stimulate decision makers, which leaded in Fiji to a meeting on decision maker lever always one day after the User Group Meeting. User group meetings are running in several other Pacific Island Countries.

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[10] Automatic Spam remover were tested but did not perform

3.5.1 Activities

The meetings have to be prepared and conducted. There is also a need to distribute the main topics and findings of the meetings through different vehicles such as GIS-PacNet e-mail list and GIS&RS Newsletter.

3.5.2 Output

The output is the summarised information of presentations, demonstrations and discussions.

3.5.3 Outcome

The most important outcome is the assistance between different users. The other outcome is the different level of decision making at upper administration level after information reaches this part of administration.

4 System Installation and Maintenance

The installation and maintenance of GIS units was a major part of the workload in times when GIS was introduced to the Pacific. Today only a minor part is dedicated to this task.

4.1 Biosecurity GIS Installation and Maintenance

Biosecurity is directly related to food security and required GIS installation and subsequent training to monitor the spread of pests.

4.1.1 Activities

MapInfo and open source QGIS software was installed tested and trained. A second training course was delivered to train database handling and link a relational database to GIS[11].

4.1.2 Output

The system is running and the staffs are able to handle the software.

4.1.3 Expected Outcome

The documentation of pests and the management to fight pests should improve.

4.2 Agriculture LRPD

Agriculture mapping activities were originally carried out in the Land Resource Planning Division (LRPD) until staff migrated to SPC. At this time the Economic Planning & Statistics Division of the Agriculture Department took over agriculture mapping. Through change of management in the Economic Division mapping interest has dropped. Staff moved to LRPD and the system was re-installed at LRPD.

4.2.1 Activities

There was already a running license of ArcGIS software. In addition, the GIS&RS Unit installed open source and therefore free QGIS software and ERDAS to carry out image rectification of aerial photographs. Training was provided which is explained in the chapter "Training". Two days every week two agriculture staffs come to SOPAC to run image segmentation and to adjust the agriculture to forest boundary. During this time the staff also receives hands-on-training.

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[11] These activities are listed under chapter training.

4.2.2 Results
The system is running and the staffs are able to operate the software.

4.2.3 Output
LRPD has an operational GIS system again which now even covers remote sensing tasks after ERDAS was installed.

4.2.4 Outcome
40 % of the agriculture area has been mapped and the digital layers are transferred to Agriculture and Forestry as reported in chapter Land Cover Mapping Fiji 1:10,000. The real outcome will be created when Agriculture management receives the rasterised map sheets with attached agriculture cover area statistics.

5   Developments

The GIS&RS Unit has to adjust methods of image processing, image interpretation or other GIS and RS applications to Pacific standards as sometimes methods, which are running well in USA or Europe, face difficulties in the Pacific. In addition, there are methods missing to handle Pacific demand..

5.1   Create Form Factor for Coconut Palms

When calculating the stem of a tree or in this case a coconut palm the basal area of the trunk at 1.30m is multiplied with the height of the trunk. However, this assumes that the trunk is a cylinder. The form factor reduces the volume of a cylinder to the real form and volume of the trunk of tree or coconut stem. The form factor varies between different tree species. It is not known for coconut palms in Tarawa. As a team with a transportable sawmill will utilise the timber palm trunks are easy to measure.

5.1.1 Expected Outcome
The form factor is incorporated into code of programs calculating the volume of coconut palm trunks.

5.1.2 Expected Output
A statistically sound form factor for coconut palms will be available for timber volume calculation in Tarawa. Possibly there will be different form factors for the "normal" coconut variety and for hybrids, which depends on the trunks which will be cut by the FAO financed team.

5.1.3 Activities
The GIS&RS unit team leader will go for one week to Tarawa and train the officers from the Agriculture Division (training-on-the-job) to measure and record the palm diameter every metre of the trunk.

Program code will be established to calculate the form factor from these measurements.

5.2   Separation of Forest Types and Densities in Fiji

The cover of natural rain forest was stratified into three densities for the inventory in 1991 and into two densities in 2006. However, the forest stratification was based on differences in

the satellite images. There was never an approach looking at the forest first and investigating how far the difference can be recognised with remote sensing data. This time the FAO density definition was used to select example areas and then investigate how far delineation is possible with image data. The delineation is not carried only visually but through the software eCognition which take radiometric content, texture and shape of the object into consideration.

5.2.1 Expected Outcome
The outcome will be that the developed method is utilised by Fiji Forestry Department and by SPC-SOPAC to stratify the density of Fiji natural forest cover.

5.2.2 Expected Output
The output will be a clear description of steps to undergo with eCognition software to stratify (i) non-forest and (ii) scattered forest and scattered forest and dense forest

5.2.3 Activities
Field sample plots were selected with scattered and dense forest in Viti Levu for which 8 band bundle WorlView 2 satellite image data is available.

The first step was the separation of scattered forest and non-forest.

The student is currently working on the separation of scattered forest and dense forest.

5.2.4 Results
The first results were presented, where scattered forest and non-forest were separated.

5.3 Transformation UTM to FMG

The transformation from FMG to UTM WGS84 is generally known, however, only at 1:50,000 scale level. At 1:10,000 scale level shift up to 20 metre is visible as the FMG is not based on WGS72 spheroid only, the Fiji Geodetic Datum has to be applied. This is misleading indicated on the Lands Department topographic map series 1:50,000. The mapping at 1:10,000 for the USAID food security project is currently based on UTM WGS84 and needs to be converted to FMG to follow the Lands Department topographic map outlay to be able to refer to 10 x 10 km map sub-sections. These are the common reference areas in Fiji.

5.3.1 Outcome
The transformation used by Lands Department and Forestry, as main user of FMG to UTM translation, will be the outcome. So far there is no statement from Lands Department.

5.3.2 Output
The output is the enhanced MapInfo projections file including Fiji Geodetic Datum.

5.3.3 Activities
Search for literature with clear indication of all parameters of Fiji Geodetic Datum. As next step implementation of Fiji Geodetic Datum in the MapInfo projection file was performed.

5.3.4 Results
Two ways were tested (i) to convert FMG to UTM using the International Terrestrial Reference Frame, where the publication of J. Dawson and G. Hu clearly describes the 7

parameters transformation and (ii) getting the 7 parameters from a paper of John Elliot (Anzeco Pty. Limited.). The first way failed and the second way seems to work as the output coordinates produce a map sheet of the correct size and overlay of features such as road, etc. fit reasonable.

There is still a test missing where survey coordinates are converted forward and backward.

5.4 Development of Spatial Data Storage and Management

The GIS&RS Unit itself urgently needs a data storage which is clearly structured, accessible and can be monitored with simple software. Tuvalu, Solomon Islands and Kiribati want to have the same system; due to urgency of data sharing, the Solomon Islands data set is structured first.

5.4.1 Expected Outcome

The outcome will be that government agencies structure their spatial data and access is easy without danger of overwriting or deleting data.

5.4.2 Expected Output

The output will be a clearly structured dataset for Solomon Island, Kiribati, Tuvalu and Fiji with an understandable user guide and simple software to monitor and upload and download data.

5.4.3 Activities

The first step was a plan of data structure and a naming convention for directories keeping different types of information. The second step was to store the data accordingly which is in progress for Solomon Islands spatial data. The third step was a data inventory of all directories and subdirectories. This is performed with simple code written in Access Basic, which extracts the file names into a database and reflects the structure of the original files stored on the corresponding drives.

The next step will be to develop appropriate search routines and copy routines where the search routines run in the database keeping only the file names.

5.4.4 Results

The Solomon Islands spatial dataset is 90% structured and first monitor codes are written. The Tuvalu spatial data was partly organised in 2013 and will be finalised in July 2014.

5.5 Developing Image Segmentation

Due to experience semi-automatic image classification during the national forest inventory 1991 and again 2006 image data have been visually interpreted since. This worked well at 1:50,000 scale. At 1:10,000, having image data of high spatial and increased radiometric content, the time for interpretation increased more than expected compared with the experience gained with the image interpretation for low lying islands.

Image segmentation is semi-automatic image classification software, which is in contrast to image classification before object and not pixel based. The software does not only utilise the radiometric information of the image like other image classification before but also the texture and shape of the objects. As output it provides vector layers which can be

superimposed over the image data, checked and either accepted or revised. This allows staying with the concept of visual interpretation without having to care of 80% routine delineation.

Image segmentation was already performed in the GIS&RS Unit with ERDAS add on module Objective, however, the performance was low. This was most probably due to the fact that the software was developed recently by ERDAS to have a competitive product to Trimble software eCognition. Remote sensing specialists from Waageningen University advised to switch to eCognition and GIZ financed the software after a test version has been compared with ERDAS software and showed the advantage in performance.

5.5.1 Outcome
It is expected that through the mapping performance increases through the new image segmentation software. It is also expected that there will be further forest stratification as the separation of scattered and dense forest is based on eCognition employment.

5.5.2 Output
Last week eCognition software was installed and is working.

5.5.3 Activities
The software was downloaded, installed and tested. A training course from Waageningen specialists was conducted as well as on-the-job training and assistance.

5.6 Revise Coconut Palm Age Estimation

The age of coconut was estimated in SPC-LRD through following procedure: measuring the length of 11 leave scars from 1.5 m onwards. Then, length of the palm trunk is divided the by this length. There seems to be a general underestimation of age and Tarawa for a series of plots the age was estimated to less than 50% of the real age.

5.6.1 Outcome
The outcome should be that the new age calculation will be implemented in the palm age calculation code in the inventory software. The software is used and produce realistic palm age estimation.

5.6.2 Output
There is no revised age calculation available yet. If so this will be the output.

5.6.3 Activities
In Tarawa for nine palms the leave scars were counted from 1.5 m onwards for every metre section of the trunk. The planting age for these palms was exactly known.

5.6.4 Results
The current formula assumes that the distance between leave scars is the same over the complete trunk, however, the conducted measurements show that the number of leave scares per metre of trunk more than doubles from bottom to top. Taking this increase into account the age calculation becomes realistic for these nine palms. However, (i) these nine palms are a statistical insufficient number, (ii) these nine palms are hybrids and not the "normal" Tarawa coconut palms and (iii) the more than 50 % age underestimation in some plots are apparently soil related.

5.7 Spectral Separation of Breadfruit, Pandanas and other

The area around villages is anthropogenic influenced and contains species such as bread fruit which is not much spread farer away from villages. The vegetation around village areas also contains a higher amount of pandanas the vegetation away from villages. The interpretation counted all area within a buffer of 75 around visible houses as settlement area. This is the reason not to stratify was the idea to estimate through field visits the percentage of the classes shrub, pandanas, bread fruit and also other trees. Palms can be separated through the texture.

The Agriculture Division of Kiribati wants to know the availability of bread fruit and pandanas as part of fruit security in case the rice import stops out of a reason not expected.

Now, a USP student under USP and GIS&RS Unit guidance is investigating how far a separation of (i) pandanas, (ii) bread fruit, (iii) shrubs and (iv) other trees (as summary class) can be separated with enhanced by colour and texture.

5.7.1 Expected Outcome
The outcome will be - in case separation is possible – that the village area is mapped again for all islands and that future mapping takes the separation into account. The amount of the available breadfruit and pandanas can be mapped and calculated.

5.7.2 Expected Output
The output will be either that these classes can be separated by image colour and texture or that this is not or only partly possible.

5.7.3 Activities
The activities have just started. A research proposal has been formulated and is discussed between GIS&RS Unit and USP.

5.8 Spectral Separation of Mangrove Associations in Fiji

Mangrove areas in Fiji, Solomon Islands, Kiribati, Tuvalu and other are delineated as such. So far no further stratification into mangrove species or mangrove associations has been undertaken on a nationwide level. To monitor mangrove development the stratification into mangrove associations is necessary to document the change within the mangrove area which reflects environmental change. For example if the salt to fresh water content changes then the mangrove area stays for a while but there will be a shift of species.

It is essential to stratify the mangrove area into the four Fiji main species or at least species associations[12].

5.8.1 Outcome
The outcome will be that mangrove areas are not only monitored regarding the size of overall cover but more sensitive monitoring performing a comparison of stratified maps showing the areas of different mangrove species or associations showing the area shift between the species or associations. This will allow a different impact to mangrove management and protection of the already starting mangrove management plan.

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[12] The term "mangrove associations" is used by specialist Dick Watling and indicates a mangrove species associated to a fixed percentage with other species such as coconut and trees.

5.8.2 Output

The output will be an instruction manual for object specific contrast enhancement of mangrove cover.

5.8.3 Activities

A student was identified by USP who does carry out the research as a PhD thesis. The student is Lanieta Veileqe Tokalauvere who has GIS experience in coastal work.

As a first step reference areas in different parts of Fiji have to be mapped by DGPS survey. These areas must be stocked with only one mangrove species. Then these areas have to be separated on satellite image data and spectral signatures have to be identified.

The spectral signatures have to be investigated to identify the origin of the reflection nature and ensure that it is related to the mangrove species only and that it is not seasonally different. There is also a possibility on dependency on mangrove age which has to be identified.

A final step is the application of the knowledge to improve the object specific image enhancement.

5.8.4 Results

There are no results so far the research work is still on at initial stage.

5.9 Spectral Separation of Sugar Cane Varieties

A request from the Sugar Ministry in Fiji asked for assistance to map (i) different sugar varieties and (ii) separate areas where the cane has be effected by biotic or abiotic stress. As the GIS&RS Unit does not have the resources to carry out such a research a student will work under guidance at SOPAC.

To cover task 1, the stratification of sugar cane area into areas of different varieties, requires (a) the selection of training areas for each variety covering different slopes and expositions. Then (b) a spectral analysis of atmospheric corrected VHR image data.

To cover task 2, the mapping of sugar cane under stress, less investigation is necessary. It is known that plant stress reduces the reflection in the near infrared which is visible in every vegetation index. The difficulty will be to have up-to-date image data covering the near infrared.

5.9.1 Activities

The activities will be training area selection and spectral analysis of the image data covering the training areas. The analysis will lead to an improved spectral enhancement of the image data enabling more accurate mapping.

5.9.2 Output

The output will be an instruction manual for object specific image enhancement based on the spectral analysis of reflection investigation of sugar cane.

5.9.3 Outcome

The outcome will be a more precise mapping and monitoring of sugar cane areas. This allows a more accurate harvest forecast which improves the marketing and leads to better pricing and therefor normally increased income for sugar can farmers.

5.10 UAV Employment for Coconut Palm Survey Assistance

The coconut palms are counted for all islands in Kiribati and for most islands in Tuvalu and for some islands in Federated States of Micronesia. The palm area is stratified into scattered, semi-dense and dense coconut palm stands. For the first two strata the number of palms per hectare is counted with about 90 % accuracy through randomly selected sample plots in the satellite images. Dense coconut stands do not allow palm counting with VHR satellite image data as the canopy covers the young and therefore very productive palms.

Employing a UAV allows looking into a plot in oblique view and might identify the number of smaller palms under the canopy of tall palms. This can be utilised to establish a factor which increases the number of palms visible in the satellite image to the real number of palms per hectare.

There are still field plots necessary where other parameters of palm stands such as height, age, volume, number of hybrids are collected, however, the UAV application would reduce the number of field sample plots and field sample plots are the most expensive part of an inventory.

5.10.1 Outcome

If it is more economical to employ the UAV the outcome could be more cost effective palm resource inventories which could lead into more inventories and better management of the palm resource.

5.10.2 Output

The output will be (i) a description and an example to count the small palms not visible in the satellite image data and (ii) an economic estimation if the employment of an UAV reduces the cost of field work. If the palm counting with UAV application has difficulties or is not economical to replace some field sample plots, the output is the knowledge not to employ UAV for this purpose.

5.10.3 Activities

The UAV was brought to Tarawa and tested in dense coconut stands.

5.10.4 Results

The recording of oblique images was possible and the palms under the main canopy are visible in the images.

The establishment of a 3D model allowing the counting of small palms is still ongoing.

5.11 UAV Application for Beach Profiles

Low lying Pacific islands are drifting most probably affected by el Niño and el Niña. This creates problems as productive areas of coconut production disappear or created newly. The exact amount of shift was not investigated yet as there were no tools to count the

amount of sand in m^3 eroded on one side of islands and built as beach on the other end. There were several attempts to monitor this such as linear beach profiling with survey methods or digital terrain model (DTM) creation with survey grade GPS. All these methods failed to a certain degree. There is another reason for have a DTMs for beaches which is the preparedness for sea level rise. There will be more storm related big waves which can affect the food production area and to know the beach profile helps to predict the possible damage.

5.11.1 Outcome
The outcome is already visible as Kiribati take the method on board and has asked SPC-SOPAC to create a DTM for the complete beaches of Christmas Islands.

5.11.2 Output
The output is a DTM for 100 m Nawerewere beach in Tarawa and the experience gained.

5.11.3 Activities
The copter type UAV was flown over a beach in Nawerewere, Tarawa of about 100 m length and 50 m depth where GPS points were 6 GPS surveyed ground control points were placed within this area.

The image data was analysed at a low resolution due to computer limits in Tarawa.

5.11.4 Results
Even with relatively low resolution (still in cm range) common points within the cloud of points have to be relatively big a DTM creation was possible. With higher resolution produced with computers in Germany more points can be identified on the relatively homogenous sand which will increase the accuracy of the DTM.

5.12 DSM Establishment from Stereo Image Data

The need for digital terrain models (DTM) and digital surface models (DSM) gains important as the mapping and working scale changes from 1:50,000 to 1:10,000. At 1:10,000 a DSM must provide in minimum 5 m contour lines which can be created from stereo satellite images. SPC-SOPAC also can access satellite image data for only USD 15 per square km, which is a very competitive price. SPC-SOPAC invested in Intergraph software which can handle this. However, the procedure has to be tested and the result has to be checked.

5.12.1 Expected Outcome
Agriculture planning, Airport Fiji Limited, Fiji Pine Limited, Sugar Ministry and many others need DSMs for proper planning. They will utilise it and management will improve.

5.12.2 Expected Output
The output will be: (i) the clearly documented method how to produce DSMs with available software and available satellite image data and (ii) the DSMs as such. SPC-SOPAC will continue to produce DSMs for Pacific Island Countries as this procedure cannot be installed and handled economically in the countries; SOPAC has to produce for the countries.

5.12.3 Activities
The software was purchased and installed. One staff member trained herself through manual and Internet conversation. For one area, Sabeto in western Viti Levu, a DSM was created from stereo WorldView-1 satellite data, however, there is still the absolute

orientation missing. The absolute orientation links the DSM to the WSG 84 spheroid and this requires survey grade resolution reference image points. Corresponding accurate GPS equipment was available but there was no permission to visit the area. This task will be performed soon and then the accuracy can be tested.

5.13 Establishing Semi-Automatic ERDAS to Database Transfer

ERDAS software calculates the number of picture elements (pixel) per unit e.g. forest of one map sheet which is equivalent to area as all pixels have the same give size. This information has to be summarised for all map sheets to have the forest area e.g. for one island. This is performed in a relational database as it allows the adding of annotation information.

Currently the transfer from ERDAS to relational database (normally Access) is either performed as copy and paste or export to an special Ascii file which is then converted to Excel and finally imported to Access.

To shortcut this the GIS&RS Unit is investigating in a way to transfer directly to Access, which all common GIS products can do.

5.13.1 Activities
Consultations with the software company in Australia did not bring convincing solutions and investigations continue.

6   Training Activities

During the last 10 years more than 80 "hands-on" GIS&RS training courses were delivered in in the area of GIS, RS and GPS for many Pacific Island Countries. The participants were limited to a number of maximal 12 and had to bring their own computer. Out of principle there was also no lunch provided, which reduced the participants to interested technical people. These trainings had the target to introduce GIS and VHR satellite image data and many GIS units started in Pacific Island Countries.

The GIS&RS Unit does not have the resources to provide this kind of training in the extent provided before. There is also more need to have selected GIS units where staff is trained through training on-the-job at SOPAC and follow up with these units.

6.1   GIS Training of Forestry and Agriculture Department Fiji

Forestry Department requested training of field officers in Labasa and Agriculture Department linked into this training. The field officers needed to be trained in GPS handling and rapid mapping to add spatial component to their field observations and reporting.

6.1.1   Activities
Two trainers (i) Vilisi Tokalauvere, GIS&RS Unit SOPAC and Diana Ralulu LRPD, Agriculture Department conducted the training for 9 participants (6 Forestry and 3 Agriculture Department). USAID supported the training.

6.1.2 Output

The training was conducted and training material delivered. Details see corresponding report[13].

6.1.3 Outcome

All field officers using GPS and import the GPS data into GIS.

6.2 GIS Training of Agriculture Staff

The GIS unit at LRPD (Land Resource Planning Division) of the Agriculture Department was re-started in April this year and there was a need to run a general GIS training to most of the staff in the mapping unit to be able to participate in the land cover mapping conducted jointly with forestry.

6.2.1 Activities

Training was delivered by four staff of the GIS&RS Unit, who trained the agriculture staff in their specific topics within a three days session. The training was delivered partly through power point presentations, however, the main part was hands-on-training. The task was supported by USAID.

6.2.2 Results

Training was delivered for 13 staff of the LRPD unit. They received training in following subjects: (i) Projection and scale, (ii) Relational database applications, (iii) Nature of satellite image data, (iv) GPS as mapping tool for GIS mapping, (v) Image pre-processing and (vi) Visual image interpretation and semi-automatic image analysis.

6.2.3 Output

The output was a training package including hands-on and theoretical training as well as training material, which enabled the staff to participate in the joint land cover mapping.

6.2.4 Outcome

The gained knowledge is utilised as the LRPD GIS actively performs in the land cover mapping. The progress is visible.

6.3 GPS Training of TLTB

TLTB purchased new GPS units, but the new staff cannot handle the units. There is a need to train the GPS instrument handling, the GPS data preparation, the post data capture data handling, the GIS data import and the first map editing. Such training was already delivered to at this time NLTB but staff has moved and GPS equipment reached the end of lifetime. TLTB went through the official channels and SPC-SOPAC has to act.

6.3.1 Outcome

If the trained field officers will get into the mapping duty the response time to map leases will be faster and agriculture lease can be transferred faster to residential lease. This creates life free of concerns for many Indian families who then can stay in their farm houses although their agriculture lease has expired.

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[13] Report file name: Training_Sep_13.pdf

6.3.2 Output
The output will be about 30 trained field officers, who then prepare better data in the field which leads to faster mapping and more accurate mapping.

6.3.3 Activities
A training course outline is prepared and will be conducted three times for three different groups.

6.4 GIS Training for Geology Department in Vanuatu

The 10 days training course delivered GIS handling, database handling and GPS handling. It was ensured that Forestry participated. The training was financed by the Deep Sea Minerals project and beneficiaries are spread over the Ministry of Lands and Survey, Department of Geology and Mines, Department of Forestry and Department of Lands Survey.

6.4.1 Outcome
The4 expected outcome is the actual utilisation of GIS and database rather than spread sheets and physical sketch maps.

6.4.2 Output
Capacity created to handle GIS with the components database, RS and GPS.

6.4.3 Activities
Theoretical training, hands-on exercises and field work was combined within 10 days.

6.5 On-The-Job Training at SPC-SOPAC

The general concept of training has changed, instead of short training courses in the Pacific States the GIS&RS Unit delivers increasingly at SOPAC training on-the-job. GIS officers are working for two to three months under supervision.

6.5.1 Activities
As a first step image interpreter go through the steps of image pre-processing which ensures that they fully understand the type of data prepared. Then they experience image segmentation to understand the process and see the limits. As a third step, the GIS officers conduct the image interpretation using their own data. Finally they learn how the vector data is converted to raster and the analysis is imported to the area database.

6.5.2 Output
This type of training produces three outputs (i) the GIS officers are trained and understand data and procedure, (ii) image data is analysed and (iii) a link is established between the GIS&RS Unit and the interpreter in the unit of the Pacific State. The number of officers trained is displayed in the appendix 1.

6.5.3 Outcome
The outcome expected is that the training is utilised and the interpretation is performed in the countries. It is also expected that the SOPAC GIS&RS Unit is contacted if problems in the countries block the performance.

7   Data Service

Data service in this content is the data handling which includes the purchase and pre-processing of image data and storage and inventory of all type of data. Normally image interpretation is also a type of data handling. Out of clarity data interpretation is handled in a separate chapter. Also data storage is handled under development as major development is currently necessary to carry out this job in a proper way.

7.1   Image Data Purchase

All Government bodies, NGOs, universities have to go through SOPAC if they want to purchase any image data from the American satellites IKONOS, QuickBird, GeoEye, WorldView-1 or WorldView-2 as the distributing companies merged to one company DigitalGlobe and SPC-SOPAC is the reseller. Only private companies have go through a reseller sitting in New Caledonia. SOPAC is also reseller for ALOS data.

In addition, it would be to uneconomic for Pacific Island Countries to have somebody who is: (i) always informed which satellite is appropriate for the application, (ii) which satellite data is available and (iii) what are the purchase procedures for the particular satellite.

7.1.1   Outcome
The image data application in Pacific states is growing and leads in many cases to better management of resources. Just third week of May at the DigitalGlobe Partner conference, SPC-SOPAC received the 2014 Partner Excellence Award is for the increasing number of image data used in Pacific Island Countries

7.1.2   Output
The GIS&RS Unit has been developed to the hub for image data in the Pacific. Due to the amount of image data special discount is provided by DigitalGlobe which is of high benefit for the Pacific Island Countries.

7.1.3   Activities
The GIS&RS Unit handles all requests for image data and keeps the conversation with the customers from Pacific states and the conversation with DigitalGlobe.

7.2   Image Data Pre-Processing

Before data delivered by DigitalGlobe can be used in GIS environment pre-processing is necessary, especially because atmospheric conditions are different to large landmasses like America, Australia Europe or Africa.

7.2.1   Outcome
The increased application of pan-sharpened image data due to high quality pre-processing is the measurable outcome of this process. At the DigitalGlobe Partner conference, SPC-SOPAC received also the 2014 Innovation Award for the type of image enhancement specific matching the demand of Pacific Island Countries. This award is judged against all others Asian Pacific countries including Australia and New Zealand.

7.2.2   Output
The output is the pre-processed and therefore enhanced image material.

7.2.3 Activities

Image data go through several steps before handed to the users: (i) image stitching joins the image tiles; (ii) ortho-correction ensures to activate the stored position parameters of the satellite during data recording and recognises the relief of the Earth surface; (iii) haze removal adjusts areas overlaid by haze to areas without haze, (iv) atmospheric correction removes other atmospheric influences. As the last two steps cannot be performed with pan-sharpened image data it is performed at SOPAC for the single image bands and then the (v) pan-sharpening process is executed at SOPAC. In this way the Pacific user is provided with an atmospherically corrected and pan-sharpened image[14].

7.2.4 Results

Every year approximately more than 30 image data sets run through this process, where image data for the USAID food security project had a major part. The amount is increasing.

7.3 Carry out Image Segmentation

Image segmentation through ERDAS Objective and now eCognition software was already explained in the "Method Development Section" of this report. As this task requires substantial time and computer hardware and software to run operationally it is mentioned here in the image pre-processing chapter.

7.3.1 Output

The output is the vector lines indicating the boundaries between different land cover classes. The boundaries are overlaid over the enhanced image data and have to be accepted or revised by the interpreters. As more accurate these boundaries reflect the reality as less boundaries have to be revised and as faster is the interpretation process.

7.3.2 Outcome

The outcome is that the image segmentation speeds up the interpretation process by factor 3 to 4.

7.3.3 Activities

To run the image segmentation process economically the image data is cut into tiles covering 5 x 5 km on the ground or a quarter of a map section of the 1:50,000 topographic maps which is the Fiji area reference. Currently the steps to run the eCognition software are still in refinery mode but once fully established it can be applied for all areas in Fiji.

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[14] Such a product is not available from the image data provider but needed for the Pacific. SPC-SOPAC therefore became the innovation award 2013 from DigitalGlobe.

8 Appendix 1 People Trained

TrainingParticipants2013								
StartDate	**EndDate**	**Description**	**VNAM**	**NAME**	**Gender**	**LAND**	**E-MAIL**	**ORKU**
07/01/13	21/12/13	IMG Analysis Land Cover Mapping 1:10,000	Romuluse (Jale)	Rajale	M	FJ	romu.rajale@yahoo.com	FORESTRY FJ
07/01/13	21/12/13	IMG Analysis Land Cover Mapping 1:10,000	Virisine	Lalasava	F	FJ	virisine.lalasava@govnet.gov.fj	AGRICULTURE
07/01/13	21/12/13	IMG Analysis Land Cover Mapping 1:10,000	Diana	Ralulu	M	FJ	dianaralulu@yahoo.com.au	AGR LRPD
23/01/13	25/01/13	Trimble and Garmin GPS Training	Sonu Sanjay	Dutt	M	FJ	sonu_dutt1@yahoo.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Vilisi	Ratukalou	F	FJ	vratukalou@gmail.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Avaitia	Nagalevu	M	FJ	vaitia.nagalevu@agriculture.gov.fj	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Kavaia	Veiqati	M	FJ	Phone: 3477044	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Joeli	Waradi	M	FJ	jwaradi@agriculture.gov.fj	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Are	Mataki	M	FJ	amataki@agriculture.gov.fj	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Solomoni Q.	Nagaunavou	M	FJ	snagaunavou@govnet.gov.fj	AGR LRPD
23/01/13	25/01/13	Trimble and Garmin GPS Training	Viliame	Tupua	M	FJ	vtupua@yahoo.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Simione	Sela	M	FJ	slalawailevu@govnet.gov.fj	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Saiasi	Waqa	M	FJ	Phone: 3320667	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Anjeshni	Narayan	F	FJ	anjeshni.narayan@gmail.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Senivalati	Vodo	M	FJ	senivalati.vido@yahoo.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Romuluse (Jale)	Rajale	M	FJ	romu.rajale@yahoo.com	FORESTRY FJ

StartDate	EndDate	Description	VNAM	NAME	Gender	LAND	E-MAIL	ORKU
		TrainingParticipants2013						
23/01/13	25/01/13	Trimble and Garmin GPS Training	Apisai	N	M	FJ	Phone: 6664425	--
12/03/13	07/05/13	Land Cover Mapping 1:50,000	Mana	Haridi	M	SB		--
15/03/13	18/05/13	Land Cover Mapping 1:50,000	Stanley	Lesinenea	M	SB	stanleynenea@y7mail.com	FORESTRY SB
05/06/13	22/12/13	IMG Analysis Land Cover Mapping 1:10,000	Losalini	Talamaikanace	F	FJ		--
05/06/13	06/08/13	Land Cover Mapping 1:50,000	Andrew	Melanolu	M	SB		--
08/06/13	31/08/13	On-the-Job Training Image Delineation Agriculture	Joe	Reti	M	WS		--
10/06/13	13/06/13	Basic GIS Training	Viliame	Rokovou	M	FJ		--
10/06/13	13/06/13	Basic GIS Training	Elimi	Kurusiga	M	FJ		--
10/06/13	13/06/13	Basic GIS Training	Tevita	Bulai	M	FJ		FOR
01/07/13	20/09/13	On-the-Job Training Image Delineation Forestry	Telesia	Sila	F	WS		--
08/07/13	10/07/13	Display of Coconut Palm Information	Maio	Tebania	M	KI	mtebania@gmail.com	AGRICULTURE
08/07/13	10/07/13	Display of Coconut Palm Information	Ieete	Timea	M	KI	teaita07@gmail.com	AGRICULTURE
08/07/13	10/07/13	Display of Coconut Palm Information	Tiua	Ieremia	M	KI	tiuaieremia@gmail.com	AGRICULTURE
09/09/13	13/09/13	Introduction to GIS and GPS	Laisiasa	Kurutani	F	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Savenaca	Lomayalewa	M	FJ		AGR LRPD
09/09/13	13/09/13	Introduction to GIS and GPS	Alacia	Tatau	F	FJ	alaciatatau@yahoo.com	AGR LRPD
09/09/13	13/09/13	Introduction to GIS and GPS	Jone	Vakarewa	M	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Ropate	Green	M	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Ilaitia	Seroma	M	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Gilbert	Lewanavanua	M	FJ		AGR LRPD
09/09/13	13/09/13	Introduction to GIS and GPS	Bola	Vatuwaliwali	M	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Saimone	Nalewabau	M	FJ		FOR

Training Participants 2014							
StartDate	**EndDate**	**Description**	**First Name**	**Family Name**	**Gender**	**CountryD**	**E-MAIL**	**Organisation**

StartDate	EndDate	Description	First Name	Family Name	Gender	CountryD	E-MAIL	Organisation

Training Participants 2014

StartDate	EndDate	Description	First Name	Family Name	Gender	CountryD	E-MAIL	Organisation
03/03/14	14/03/14	General GIS/RS/GPS Training	Richard	Biilly	M	VU	rbilly@vanuatu.gov.vu	LANDS
03/03/14	14/03/14	General GIS/RS/GPS Training	George	Talako Shem	M	VU	gshem@vanuatu.gov.vu	LAND DEPARTMENT
03/03/14	14/03/14	General GIS/RS/GPS Training	Rosine	Lawac	F	VU	rlawac@vanuatu.gov.vu	GEOLOGY MINES
03/03/14	14/03/14	General GIS/RS/GPS Training	Darrell	Tangalobani	M	VU	dtangalobani@vanuatu.gov.vu	LANDS
03/03/14	14/03/14	General GIS/RS/GPS Training	Phyllis	Berry	M	VU	phyllisk@gmail.com	FORESTRY
03/03/14	14/03/14	General GIS/RS/GPS Training	Brooks	Rakau	M	VU	brakau@vanuatu.gov.vu	GEOLOGY MINES
03/03/14	14/03/14	General GIS/RS/GPS Training	Christy	Haruel	M	VU	charuel@vanuatu.gov.vu	GEOLOGY MINES
03/03/14	14/03/14	General GIS/RS/GPS Training	Sandra	Natuka	F	VU	sandra.lawana@gmail.com	GEOLOGY MINES
03/03/14	14/03/14	General GIS/RS/GPS Training	Jimmy	Sano	M	VU		FORESTRY VU
03/03/14	14/03/14	General GIS/RS/GPS Training	Benjamin	Titus	M	VU	btitus@vanuatu.gov.vu	GEOLOGY MINES
10/03/14	14/03/14	IMG Rectification, Enhancement, Interpretation	Olita	Cawanikuve	F	FJ		FORESTRY FJ
10/03/14	14/03/14	IMG Rectification, Enhancement, Interpretation	Jerry	Buinimasi	M	FJ		LANDS FJ
10/03/14	14/03/14	IMG Rectification, Enhancement, Interpretation	Tevita	Vakatoga	M	FJ		LANDS
10/03/14	14/03/14	IMG Rectification, Enhancement, Interpretation	Ilaisa	Senikuraciri	M	FJ		FORESTRY FJ
24/03/14	25/03/14	Object Based IMG Classification	Olita	Cawanikuve	F	FJ		FORESTRY FJ
24/03/14	25/03/14	Object Based IMG Classification	Ilaisa	Senikuraciri	M	FJ		FORESTRY FJ

		Training Participants 2014						
StartDate	EndDate	Description	First Name	Family Name	Gender	CountryD	E-MAIL	Organisation
14/04/14	16/04/14	General GIS/RS/GPS Training	Dharamendra		M	FJ		AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Vilimaina	Civavonovono	M	FJ		AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Sakeasi	Ose	M	FJ	sakeasi.ose@agriculture.gov.fj	AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Ita	Tunidau	M	FJ	ita.tunidau@agriculture.gov.fj	AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Diana	Ralulu	M	FJ	dianaralulu@yahoo.com.au	AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Josefa	Satakala	M	FJ	josefa.satakala@agriculture.gov.fj	AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Alacia	Tatau	F	FJ	alaciatatau@yahoo.com	AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Aporosa	Tavuse	M	FJ	tavuse@yahoo.com	AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Jacoro	Waqatabu	M	FJ		AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Savenaca	Lomayalewa	M	FJ		AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Gilbert	Lewanavanua	M	FJ		AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Apisai	Yaranamua	M	FJ	apisaiyaranamua@agriculture.gov.fj	AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Samuela	Delai	M	FJ	samuela.delailoa@agriculture.gov.fj	AGR LRPD
14/04/14	16/04/14	General GIS/RS/GPS Training	Solomoni	Nagaunavou	M	FJ	snagaunavou@govnet.gov.fj	AGR LRPD
01/05/14	01/07/14	IMG rectification, enhancement, land cover classification	Save	Lomayalewa	M	FJ		AGR FJ
15/05/14	17/05/14	Landcover classification and stratification	Apisai	Yaranamua	M	FJ		AGR LRPD

Table 03: *Overview of people trained at GIS&RS Unit from January to May 2014*

Training Participants 2013
Start	**End**	**Description**	**First Name**	**Family Name**	**G.**	**N**	**E-MAIL**	**Organisation**
07/01/13	21/12/13	IMG Analysis Land Cover Mapping 1:10,000	Romuluse (Jale)	Rajale	M	FJ	romu.rajale@yahoo.com	FORESTRY FJ
07/01/13	21/12/13	IMG Analysis Land Cover Mapping 1:10,000	Virisine	Lalasava	F	FJ	virisine.lalasava@govnet.gov.fj	AGRICULTURE
07/01/13	21/12/13	IMG Analysis Land Cover Mapping 1:10,000	Diana	Ralulu	M	FJ	dianaralulu@yahoo.com.au	AGR LRPD
23/01/13	25/01/13	Trimble and Garmin GPS Training	Sonu Sanjay	Dutt	M	FJ	sonu_dutt1@yahoo.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Vilisi	Ratukalou	F	FJ	vratukalou@gmail.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Avaitia	Nagalevu	M	FJ	vaitia.nagalevu@agriculture.gov.fj	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Kavaia	Veiqati	M	FJ	Phone: 3477044	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Joeli	Waradi	M	FJ	jwaradi@agriculture.gov.fj	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Are	Mataki	M	FJ	amataki@agriculture.gov.fj	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Solomoni Q.	Nagaunavou	M	FJ	snagaunavou@govnet.gov.fj	AGR LRPD
23/01/13	25/01/13	Trimble and Garmin GPS Training	Viliame	Tupua	M	FJ	vtupua@yahoo.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Simione	Sela	M	FJ	slalawailevu@govnet.gov.fj	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Saiasi	Waqa	M	FJ	Phone: 3320667	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Anjeshni	Narayan	F	FJ	anjeshni.narayan@gmail.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Senivalati	Vodo	M	FJ	senivalati.vido@yahoo.com	--
23/01/13	25/01/13	Trimble and Garmin GPS Training	Romuluse (Jale)	Rajale	M	FJ	romu.rajale@yahoo.com	FORESTRY FJ
23/01/13	25/01/13	Trimble and Garmin GPS Training	Apisai	N	M	FJ	Phone: 6664425	--
12/03/13	07/05/13	Land Cover Mapping 1:50,000	Mana	Haridi	M	SB		--
15/03/13	18/05/13	Land Cover Mapping 1:50,000	Stanley	Lesinenea	M	SB	stanleynenea@y7mail.com	FORESTRY SB
05/06/13	22/12/13	IMG Analysis Land Cover Mapping 1:10,000	Losalini	Talamaikanace	F	FJ		--
05/06/13	06/08/13	Land Cover Mapping 1:50,000	Andrew	Melanolu	M	SB		--
08/06/13	31/08/13	On-the-Job Training Image Delineation Agriculture	Joe	Reti	M	WS		--
10/06/13	13/06/13	Basic GIS Training	Viliame	Rokovou	M	FJ		--

Training Participants 2013						
Start	**End**	**Description**	**First Name**	**Family Name**	**G.**	**N**	**E-MAIL**	**Organisation**

Start	End	Description	First Name	Family Name	G.	N	E-MAIL	Organisation
10/06/13	13/06/13	Basic GIS Training	Elimi	Kurusiga	M	FJ		--
10/06/13	13/06/13	Basic GIS Training	Tevita	Bulai	M	FJ		FOR
01/07/13	20/09/13	On-the-Job Training Image Delineation Forestry	Telesia	Sila	F	WS		--
08/07/13	10/07/13	Display of Coconut Palm Information	Maio	Tebania	M	KI	mtebania@gmail.com	AGRICULTURE
08/07/13	10/07/13	Display of Coconut Palm Information	Ieete	Timea	M	KI	teaita07@gmail.com	AGRICULTURE
08/07/13	10/07/13	Display of Coconut Palm Information	Tiua	Ieremia	M	KI	tiuaieremia@gmail.com	AGRICULTURE
09/09/13	13/09/13	Introduction to GIS and GPS	Laisiasa	Kurutani	F	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Savenaca	Lomayalewa	M	FJ		AGR LRPD
09/09/13	13/09/13	Introduction to GIS and GPS	Alacia	Tatau	F	FJ	alaciatatau@yahoo.com	AGR LRPD
09/09/13	13/09/13	Introduction to GIS and GPS	Jone	Vakarewa	M	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Ropate	Green	M	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Ilaitia	Seroma	M	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Gilbert	Lewanavanua	M	FJ		AGR LRPD
09/09/13	13/09/13	Introduction to GIS and GPS	Bola	Vatuwaliwali	M	FJ		FOR
09/09/13	13/09/13	Introduction to GIS and GPS	Saimone	Nalewabau	M	FJ		FOR
02/10/13	04/10/13	Basic Training for AGR-VET	Iliana	Tuivuna	F	FJ	tuivunailiana@yahoo.com	AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Steven	Angus	M	FJ		AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Epeli	Nalaga	M	FJ	pelynalaga@yahoo.com	AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Iosefo	Raqitawa	M	FJ		AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Vijendra	Sami	M	FJ	s11023194gmail.com	AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Marie	Kaitu'u	F	FJ		AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Jasveer	Singh	M	FJ		AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Surila	Chandra	F	FJ	surila_sharan@yahoo.com	AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Leo	Borja	M	FJ	borjavats@yahoo.com	AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Salesh	Chandra	M	FJ	s.chandrll@yahoo.com	AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Ronil	Prasad	M	FJ	ronrox_4u@yahoo.com	AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Ranjaleen	Chand	F	FJ	ranjaleenc@yahoo.com	AGR VET
02/10/13	04/10/13	Basic Training for AGR-VET	Elva	Borja	F	FJ		AGR VET

Training Participants 2013								
Start	End	Description	First Name	Family Name	G.	N	E-MAIL	Organisation
02/10/13	04/10/13	Basic Training for AGR-VET	Sera	Gonelevu	F	FJ	s_gonelevu@yahoo.com	AGR VET
14/10/13	06/12/13	Land Cover Change Detection	Tewaea	Keariki	M	KI	keariki@gmail.com	LANDS KI
14/10/13	06/12/13	Land Cover Change Detection	Buraoranti	Tokanikai	F	KI	bstokanikai@gmail.com	LANDS KI

Table 04: *Overview of people trained at GIS&RS Unit from January to December 2013*

9   Appendix 2 Mangrove Area Change Fiji

Map_ID	1991	2001	2007	Diff.
L26	432	436	436	4
L27	2,245	2,142	2,142	-103
L28	1,805	1,812	1,812	6
L29	405	381	381	-24
M26	6,116	6,040	6,040	-76
M27	0	0	0	0
M28	0	0	0	0
M29	517	515	515	-1
N26	1,128	1,128	1,128	-1
N27	0	0	0	0
N28	0	0	0	0
N29	1,655	1,652	1,652	-3
N32	264	264	263	-1
O23	1,881	1,879	1,839	-42
O24	2,434	2,426	2,416	-18
O26	0	0	0	0
O27	992	902	902	-90
O28	6,102	6,090	6,090	-13
O29	3,491	3,426	3,426	-65
O32	551	551	550	-1
P22	413	413	413	0
P23	3,039	3,039	3,039	0
P24	3,048	2,878	2,871	-177
P27	304	304	262	-42
Q22	3,475	3,475	3,465	-10
Q23	596	537	386	-210
Q24	145	145	145	0
Q26	0	0	0	0
Q28	0	0	0	0
R22	3,316	3,316	3,067	-249
R23	1,693	1,707	1,707	14
R24	702	702	552	-150
S21	232	232	232	-1
S22	115	115	115	0
S23	15	15	15	0
S24	0	0	0	0
SUM	47,109	46,520	45,859	-1,250

Table 05: *Change of mangrove area in Fiji*

MapID	NAFO	MANG	PIPL	HAPL	COCO	NOFO	WABO	MapSum
L26	31	432	1,391	0	0	3,660	114,486	120,000
L27	10,621	2,245	9,493	0	0	39,090	58,551	120,000
L28	20,220	1,805	32,656	764	0	49,413	15,142	120,000
L29	6,110	405	1,797	0	0	18,392	93,297	120,000
M26	5,297	6,116	2,091	0	0	36,305	70,192	120,000
M27	47,318	0	7,394	5,243	0	58,906	1,139	120,000
M28	78,039	0	0	2,348	0	38,962	651	120,000
M29	50,479	517	0	9,594	0	6,976	52,434	120,000
N26	21,943	1,128	2,009	0	0	40,107	54,812	120,000
N27	95,537	0	0	2,254	0	20,740	1,469	120,000
N28	105,323	0	0	0	0	13,683	994	120,000
N29	34,915	1,655	0	6,615	0	12,445	64,369	120,000
N32	18,907	264	0	0	0	6,780	94,049	120,000
O23	4,843	1,881	3,166	0	222	9,945	99,943	120,000
O24	26,456	2,434	6,829	0	1,491	11,996	70,794	120,000
O26	0	0	0	0	0	156	119,844	120,000
O27	36,197	992	0	3,565	0	13,165	66,081	120,000
O28	32,496	6,102	0	8,260	0	29,845	43,297	120,000
O29	2,528	3,491	0	76	0	7,579	106,326	120,000
O32	14,315	551	0	0	0	5,498	99,637	120,000
P22	207	413	0	0	87	753	118,541	120,000
P23	43,177	3,039	5,133	6,863	483	37,562	23,743	120,000
P24	50,013	3,048	76	4,584	2,309	10,625	49,345	120,000
P27	6,198	304	0	0	0	3,348	80,076	89,925
Q22	6,175	3,475	0	0	67	25,482	84,801	120,000
Q23	74,628	596	2,295	3,257	2,684	30,910	5,630	120,000
Q24	4,359	145	0	0	3,472	7,183	104,841	120,000
Q26	7,695	0	0	0	0	2,566	109,739	120,000
Q28	7,222	0	332	0	0	6,569	105,877	120,000
R22	51,539	3,316	1,133	1,029	2,040	23,334	37,609	120,000
R23	47,899	1,693	0	3,504	5,001	4,216	57,686	120,000
R24	5,176	702	0	0	3,031	2,286	108,805	120,000
S21	1,031	232	0	0	325	1,066	117,345	120,000
S22	2,063	115	0	0	299	461	117,062	120,000
S23	2,850	15	0	0	2,666	406	114,063	120,000
S24	32,197	0	0	0	9,231	751	77,821	120,000
SUM	954,007	47,109	75,794	57,956	33,409	581,161	2,540,489	4,289,925

Table 06: *Forest cover 1991, NAFO = Natural Forest, MANG = Mangrove, PIPL = Pine Plantation, HAPL = Hardwood Plantation, COCO = Coconut Palms, None Forest Area (Agriculture, Pasture, Settlements, etc.), WABO = Water Bodies*

MapID	NAFO	MANG	PIPL	HAPL	COCO	NOFO	WABO	MapSum
L26	32	436	1,324	0	0	3,723	114,486	120,000
L27	10,504	2,142	8,725	0	0	40,077	58,551	120,000
L28	21,313	1,812	33,086	0	0	48,648	15,142	120,000
L29	5,890	381	914	0	0	19,518	93,297	120,000
M26	5,316	6,040	2,121	0	0	36,332	70,192	120,000
M27	46,810	0	8,876	5,052	0	58,124	1,139	120,000
M28	79,816	0	0	0	0	39,533	651	120,000
M29	54,229	515	0	5,259	0	7,563	52,434	120,000
N26	21,911	1,128	2,009	0	0	40,139	54,812	120,000
N27	94,722	0	0	3,078	0	20,730	1,469	120,000
N28	105,311	0	0	0	0	13,695	994	120,000
N29	38,879	1,652	0	2,803	0	12,296	64,369	120,000
N32	18,757	264	440	0	0	6,490	94,049	120,000
O23	4,659	1,879	3,933	0	219	9,368	99,941	120,000
O24	23,667	2,426	10,058	0	1,428	11,629	70,793	120,000
O26	0	0	0	0	0	156	119,844	120,000
O27	39,421	902	0	0	0	13,597	66,081	120,000
O28	32,350	6,090	0	8,102	0	30,162	43,297	120,000
O29	2,353	3,426	0	0	0	7,894	106,326	120,000
O32	14,308	551	0	0	0	5,505	99,637	120,000
P22	207	413	0	0	87	753	118,541	120,000
P23	45,806	3,039	5,201	3,972	480	37,763	23,740	120,000
P24	48,459	2,878	1,173	6,029	2,266	9,852	49,344	120,000
P27	6,198	304	0	0	0	3,348	80,076	89,925
Q22	6,145	3,475	19	0	67	25,493	84,801	120,000
Q23	73,463	537	5,424	744	2,652	31,555	5,626	120,000
Q24	4,319	145	66	0	3,465	7,163	104,841	120,000
Q26	7,656	0	0	0	0	2,605	109,739	120,000
Q28	8,077	0	332	0	0	5,715	105,877	120,000
R22	52,441	3,316	1,649	0	2,029	22,957	37,609	120,000
R23	41,633	1,707	1,254	2,492	4,996	10,233	57,686	120,000
R24	3,408	702	16	0	3,031	4,038	108,805	120,000
S21	1,025	232	325	0	325	1,073	117,345	120,000
S22	2,066	115	299	0	299	458	117,062	120,000
S23	2,822	15	2,666	0	2,666	434	114,063	120,000
S24	27,787	0	9,231	0	9,231	5,161	77,821	120,000
SUM	951,759	46,520	86,619	37,530	33,241	593,778	2,540,477	4,289,925

Table 06: *Forest cover 2001, NAFO = Natural Forest, MANG = Mangrove, PIPL = Pine Plantation, HAPL = Hardwood Plantation, COCO = Coconut Palms, None Forest Area (Agriculture, Pasture, Settlements, etc.), WABO = Water Bodies*

MapID	NAFO	MANG	PIPL	HAPL	COCO	NOFO	WABO	MapSum
L26	32	436	1,324	0	0	3,723	114,486	120,000
L27	10,504	2,142	8,725	0	0	40,077	58,551	120,000
L28	21,313	1,812	33,086	764	0	48,648	15,142	120,000
L29	5,890	381	914	0	0	19,518	93,297	120,000
M26	5,316	6,040	2,121	0	0	36,332	70,192	120,000
M27	46,810	0	8,876	5,052	0	58,124	1,139	120,000
M28	79,816	0	0	2,348	0	39,533	651	120,000
M29	54,229	515	0	5,259	0	7,563	52,434	120,000
N26	21,911	1,128	2,009	0	0	40,139	54,812	120,000
N27	94,722	0	0	3,078	0	20,730	1,469	120,000
N28	105,311	0	0	0	0	13,695	994	120,000
N29	38,879	1,652	0	2,803	0	12,296	64,369	120,000
N32	18,754	263	440	0	0	6,494	94,049	120,000
O23	5,159	1,839	3,931	0	219	8,908	99,943	120,000
O24	25,580	2,416	10,057	0	1,428	9,725	70,794	120,000
O26	0	0	0	0	0	156	119,844	120,000
O27	39,421	902	0	3,565	0	13,597	66,081	120,000
O28	32,350	6,090	0	8,102	0	30,162	43,297	120,000
O29	2,353	3,426	0	76	0	7,894	106,326	120,000
O32	14,308	550	32	0	0	5,505	99,637	120,000
P22	203	413	0	0	87	757	118,541	120,000
P23	47,211	3,039	5,198	3,971	480	36,359	23,743	120,000
P24	50,589	2,871	1,171	6,029	2,266	7,729	49,345	120,000
P27	7,700	262	0	0	0	58,133	23,905	90,000
Q22	5,684	3,465	19	0	67	25,964	84,801	120,000
Q23	77,200	386	5,420	743	2,652	27,969	5,630	120,000
Q24	4,346	145	66	0	3,465	7,137	104,841	120,000
Q26	8,047	0	0	0	0	2,214	109,739	120,000
Q28	8,702	0	392	0	0	6,581	104,325	120,000
R22	52,298	3,067	1,649	0	2,029	23,349	37,609	120,000
R23	41,633	1,707	1,254	2,492	4,996	10,233	57,686	120,000
R24	3,319	552	16	0	3,031	4,278	108,805	120,000
S21	1,025	232	0	0	325	1,073	117,345	120,000
S22	2,066	115	0	0	299	458	117,062	120,000
S23	2,822	15	0	0	2,666	434	114,063	120,000
S24	27,787	0	0	0	9,231	5,161	77,821	120,000
SUM	963,288	45,859	86,669	37,529	33,241	640,647	2,482,766	4,290,000

Table 07: *Forest cover 2007, NAFO = Natural Forest, MANG = Mangrove, PIPL = Pine Plantation, HAPL = Hardwood Plantation, COCO = Coconut Palms, None Forest Area (Agriculture, Pasture, Settlements, etc.), WABO = Water Bodies*

10 Appendix 3 Coconut Palm Counting Results Kiribati

GILBERT GROUP					
MAKIN	20	47,328	7,137	2,565	**57,030**
BUTARITARI	20	41,870	61,304	19,992	**123,166**
MARAKEI	20	91,325	19,046	24,660	**135,031**
ABAIANG	20	96,933	28,165	28,810	**153,908**
TARAWA	40	179,310	16,432	19,584	**215,326**
MAIANA	20	145,530	21,812	21,060	**188,402**
KURIA	20	97,525	30,375	12,012	**139,912**
ARANUKA	20	109,792	31,133	14,212	**155,137**
ABEMAMA	20	76,874	137,864	46,939	**261,677**
NONOUTI	25	140,304	56,947	36,660	**233,911**
TABITEUEA	30	246,030	112,005	64,042	**442,077**
ONOTOA	20	79,289	47,056	11,880	**138,225**
BERU	20	67,208	78,280	25,254	**170,742**
NIKUNAU	20	159,720	64,722	17,980	**242,422**
TAMANA	20	50,826	11,830	3,248	**65,904**
ARORAE	20	74,908	3,912	5,046	**83,866**
BANABA	**NIL**	No Palms			
LINE GROUP					
CHRISTMAS ISLAND	20	153,863	164,719	133,722	**452,304**
FANNING ISLAND	20	259,904	8,856	9,794	**278,554**
WASHINGTON ISLAND	20	150,751	798	196	**151,745**
FLINT	20	50,912	1,218	1,079	**53,209**
CAROLINE	20	13,038	3,978	2,747	**19,763**
MALDEN	**NIL**	No Palms			
STARBUCK	**NIL**	No Palms			
VOSTOK	**NIL**	No Palms			
PHOENIX GROUP					
SYDNEY (MANRA)	20	16,310	1,170	550	**18,030**
GARDNER (NIKUMARORO)	20	17,582	2,754	1,180	**21,516**
HULL (ORONA)	20	24,274	1,176	606	**26,056**
KANTON (ABARIRINGA)	**NIL**	No Palms			
MCKEAN	**NIL**	No Palms			
ENDERBURY	**NIL**	No Palms			
PHOENIX (RAWAKI)	**NIL**	No Palms			
BIRNIE	**NIL**	No Palms			

Table 08: *The table shows the number of palms counted for each atoll in Kiribati. The total area for each of the three stratums is multiplied by the average number of palms in the sample plots. This table does not include the palms in settlement areas yet.*

11 Appendix 4 Vegetation Change Detection Kiribati

Atoll Name	Area 1969	Area 2011	Area Difference	Vegetation Status
GILBERT GROUP				
MAKIN	678	620	58	Decrease
BUTARITARI	1480	1527	47	Increase
MARAKEI	1341	1446	105	Increase
ABAIANG	1588	1634	46	Increase
TARAWA	2678	2918	240	Increase
MAIANA				Increase
KURIA				Increase
ARANUKA				Increase
ABEMAMA				Increase
NONOUTI				Increase
TABITEUEA				Increase
ONOTOA				Increase
BERU				Increase
NIKUNAU	1874	1865	9	Decrease
TAMANA	456	459	3	Increase
ARORAE	671	695	24	Increase
BANABA		Not	analysed	yet

Table 09: *The table shows the difference in vegetation cover where the increase is mainly in coconut palm area and mangrove cover. The atolls listed without figures are under final investigation, however, increase is counted. Banaba has to be analysed yet. For islands of the Line Group and Phoenix group historical vegetation maps are not identified yet.*